TEXTE
130/2022

Executive summary

Illegal treatment of end-of-life vehicels

Assessment of the environmental, micro- and macro-economic effects

by:

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TSR Recycling GmbH & Co. KG, Düsseldorf

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Abstract: Illegal treatment of end-of-life vehicels

Based on the results of this study, it is estimated that around 363,000 end-of-life vehicles are dismantled annually in Germany (reference year: 2018) by illegal dismantling actors, and around 73,000 end-of-life vehicles are illegally exported. Against this background, the research objective of this project, was to quantify the ecological and economic impacts caused by the illegal end-of-life vehicle recycling and the illegal export of end-of-life vehicles. Additionally, suitable, effective, and efficient measures aimed at minimising these impacts were to be derived. It can be concluded that illegal actors have relevant cost advantages in the dismantling of end-of-life vehicles. Illegal dismantling results in negative environmental impacts compared to dismantling in legal operations. A shift to authorised dismantling shows positive economic effects and would reduce environmental costs. A reduction in illegal dismantling activities can be achieved by means of various measures.

Kurzbeschreibung: Titel

Die Rechercheergebnisse der Studie deuten darauf hin, dass rund 363.000 Altfahrzeuge in Deutschland jährlich (Bezugsjahr: 2018) von nicht anerkannten Akteuren demontiert, rund 73.000 Altfahrzeuge illegal exportiert werden. Zielsetzung der Forschungsarbeiten in diesem Projekt war vor diesem Hintergrund die Quantifizierung der ökologischen und ökonomischen Auswirkungen durch die nicht anerkannte Altfahrzeugentsorgung und den illegalen Export von Altfahrzeugen sowie die Bewertung der Situation und Ableitung geeigneter, effektiver und effizienter Maßnahmen zur Minimierung der Auswirkungen. Es konnte gezeigt werden, dass nicht anerkannte Akteure bei der Demontage von Altfahrzeugen über relevante Kostenvorteile verfügen. Aus der illegalen Demontage resultieren negative Umweltwirkungen im Vergleich zur Demontage in anerkannten Betrieben. Eine Verlagerung in die anerkannte Demontage zeigt positive volkswirtschaftliche Effekte und würde Umweltkosten reduzieren. Anhand verschiedener Maßnahmen, welche im Einzelnen beschrieben werden, kann eine Reduzierung illegaler Demontageaktivitäten erreicht werden.

Table of content

List of figures ... 8
List of tables ... 9
List of abbreviations ... 11
Summary ... 12
Zusammenfassung ... 27
1 Background and goals of the study ... 42
2 Cost balance of the authorized treatment of end-of-life-vehicles ... 43
2.1 Authorized Dismantling Facilities ... 43
2.1.1 Structural diversity and business models of ATF ... 43
2.1.2 Approach ... 46
2.1.3 Costs and revenues in the baseline scenario ... 48
2.1.3.1 Dismantling times and labour costs ... 48
2.1.3.2 Further costs and revenues ... 50
2.1.3.3 Result for baseline scenario ... 50
2.1.4 Further scenarios ... 51
2.1.4.1 Overview labour costs and recovery costs/ revenues ... 52
2.1.4.2 Dismantling of plastics and glass ... 53
2.1.4.3 Spare parts extraction and metal dismantling ... 54
2.1.4.4 Electric vehicles ... 56
2.1.4.5 Gas vehicles ... 57
2.1.5 Costs and revenues in the scenarios ... 58
2.1.6 Throughput variation ... 59
2.2 Shredding plants ... 61
2.2.1 Approach ... 61
2.2.2 Cost and revenue situation of shredding plants ... 62
2.3 Outlook on future developments ... 63
3 Types and business models of unauthorized dismantling ... 68
3.1 Acquisition of end-of-life vehicles and whereabouts of partially dismantled vehicles or stripped vehicles ... 68
3.2 Actors involved in illegal dismantling and export ... 69
3.3 Derivation of common types ... 71
3.4 Relevance of the 4 types ... 73
4 Situation of the whereabouts of end-of-life vehicles ... 75

5 Comparison of the cost and revenue situation of authorised and illegal dismantling 77
5.1 ATF as a reference 77
5.2 Differences in cost and revenues 77
5.3 Results of the comparison of the cost and revenue structure 78
6 Macroeconomic effects of illegal dismantling 80
7 Ecological impacts and environmental costs of illegal dismantling 86
7.1 The climate impact of released refrigerants 86
7.2 Soil contamination due to waste oil 87
7.3 Conclusion 87
8 Assessment of impacts and recommendations for action 88
8.1 Avoiding illegal dismantling through improvements in enforcement 88
8.1.1 Simplified reporting options for suspected cases of illegal dismantling 89
8.1.2 Strengthened domestic enforcement in terms of personnel 90
8.1.3 Improved cooperation in enforcement 90
8.1.4 Distinction between end-of-life vehicles and used vehicles in Germany 91
8.2 Transfer of the Model of Compulsory Verification for Operators of Electronic Marketplaces under the ElektroG, VerpackG and BattG 91
8.2.1 The model of compulsory verification 91
8.2.2 Transferability to the sale of end-of-life vehicles via online marketplaces 92
8.3 Further measures against illegal end-of-life vehicle dismantling 95
8.4 Summary of measures 96
9 List of references 99

List of figures

Figure 1: Whereabouts of permanently decommissioned vehicles in Germany in 2018 14
Figure 2: Cost and revenue of ELV treatment in German authorised treatment facilities per ELV, throughput of 500 ELV/a, average prices of 2019/2020....16
Figure 3: Total costs and revenues of shredder plants per cost type 17
Figure 4: Simplified representation of the basic procedure of illegal dismantling 18
Figure 5: Common types of illegal dismantling 19
Figure 6: Quantity relevance of the common types and export 20
Figure 7: Costs and revenues of illegal dismantling compared to legal dismantling 21
Figure 8: Development of number of end-of-life vehicle and dismantling facilities....44
Figure 9: Size classes of end-of-life vehicle treatment facilities in Germany, 2013 44
Figure 10: Annual number of ELVs treated per employee vs. total annual number of ELVs treated....46
Figure 11: Visualisation of the data collection procedure towards the cost and revenue situation of legal dismantling facilities....47
Figure 12: Costs and revenues per ELV in German ATFs in the baseline scenario 51
Figure 13: Dismantling of glass and plastic (bumper) from ELVs 54
Figure 14: Costs and revenues for the Scenario „Spare parts extraction and metal dismantling“ 55
Figure 15: Costs and revenues for the scenario „electric vehicles“ 57
Figure 16: Cost and revenue of ELV treatment in German authorised treatment facilities per ELV, throughput of 500 ELV/a, average prices of 2019/2020....59
Figure 17: Balance of costs or revenues according to scenarios and ELV throughput in €/ELV (for negative values, the costs exceed the revenues). 60
Figure 18: Costs and revenues of shredding plants per cost type 63
Figure 19: Distribution of selected equipment components of new cars in Germany 64
Figure 20: Average material composition of decommissioned vehicles 2000/2030 65
Figure 21: Development of the price for stripped vehicles....66
Figure 22: Simplified representation of the basic procedure of illegal dismantling 69
Figure 23: Common types of illegal ELV dismantling 72

Figure 24: Illustration of the ELV-pathways for the four common types of unauthorized dismantling....73
Figure 25: Distribution of illegally treated ELVs to the common types of illegal treatment and export....74
Figure 26: Whereabouts of permanently decommissioned vehicles in Germany in 2018....76
Figure 27: Costs and revenues of illegal dismantling compared to legal dismantling in a reference ATF....79

List of tables

Table 1: Project structure and reporting structure....12
Table 2: Revenue in the different sectors....22
Table 3: Macroeconomic consequences of full treatment in authorised dismantling (with and without consumption shifting)....22
Table 4: Assessment a of measures....25
Table 5: Scenarios of ELV treatment....47
Table 6: Extract from the time determination carried out for operational commercial activities for end-of-life vehicle treatment and administrative activities in the baseline scenario....49
Table 7: Labour cost rates for the calculation of ELV treatment costs in German ATFs, 2019/2020....50
Table 8: Average costs and revenues for dismantled/separated components and materials in the baseline scenario, 2019/2020....50
Table 9: Additional treatment /handling time of ELVs in German ATFs and costs in the individual scenarios....52
Table 10: Average costs and revenues for dismantled/separated components and materials in the further scenarios, 2019/2020....53
Table 11: Specific treatment times for the “Electric Vehicle” scenario compared with the “Baseline Scenario”....56
Table 12: Overview of costs and revenues in the different scenarios [€/AFZ]....58
Table 13: Cost and revenue grid of shredding plants....62
Table 14: Differentiation of equipment types among illegal dismantling actors....70
Table 15: Assumed average ELV throughput of illegal dismantling actors....78
Table 16: Data and estimations for ELV whereabouts in Germany 2018 80

Table 17: Number of ELVs and revenue per ELV for the different whereabouts as input data for the macroeconomic calculation. 81
Table 18: Revenue in the different sectors 82
Table 19: Macroeconomic consequences of a complete shift of illegal ELV treatment to authorised dismantling (with and without consumption shifting).....84
Table 20: Estimation of refrigerant emissions due to improper depollution of ELVs in unauthorised dismantling in Germany (2018).....86
Table 21: Assessment of measures 97

List of abbreviations

A/C	Air Conditioning
ATF	Authorized treatment facility
AltfahrzeugV	Altfahrzeugverordnung = End-of-Life Vehicles Ordinance
BattG	Gesetz über das Inverkehrbringen, die Rücknahme und die umweltverträgliche Entsorgung von Batterien und Akkumulatoren (Batteriegesetz) = Law on the placing on the market, return and environmentally sound disposal of batteries and accumulators (Battery Law)
BBodSchV	Bundesbodenschutzverordnung = German Federal Soil Protection and Contaminated Sites Ordinance
$CO_{2eq.}$	Carbon dioxide equivalents
CoD	Certificate of Destruction
Cu	Copper
DIY	Do it yourself
ElektroG	Electrical and Electronic Equipment Act
ELV	End-of-life vehicle
EPR	Extended Producer Responsibility
EU	European Union
Fe	Iron
GESA	Gemeinsame Stelle Altfahrzeuge = joint agency for ELVs
GWP	Global Warming Potential
HV	High voltage
OEM	Original equipment manufacturers
SUV	Sports utility vehicle
VerpackG	Packaging Act
WEEE	Waste of Electrical and Electronic Equipment

Summary

The transfer, return and environmentally sound disposal of end-of-life vehicles in Germany are regulated by the EC End-of-Life Vehicles Directive and the German End-of-Life Vehicles Ordinance. According to the Federal Statistical Office (Destatis 2020b), around half a million end-of-life vehicles are accepted for treatment in authorised dismantling facilities in Germany every year. The accounting of the whereabouts of vehicles finally decommissioned in Germany, results in a statistical gap of vehicles with unknown whereabouts. This accounting is based on export figures and statistical figures on authorised ELV treatment. Reporting on the dismantling and fate of end-of-life vehicles is carried out annually by UBA and BMUV. These results are published in the annual reports on end-of-life vehicle treatment rates (see e.g. BMU und UBA 2020). A study by Sander et al. (2017) commissioned by the UBA concluded that the majority of vehicles with unknown whereabouts are dismantled in illegal dismantling facilities or are exported notwithstanding waste shipment law. This estimate has been updated based on the observations made in this project, confirming the relevance of illegal dismantling.

Against this background, the objective of the research performed in this project was to quantify the ecological and economic impacts of illegal end-of-life vehicle disposal and the illegal export of end-of-life vehicles, as well as to evaluate the situation and derive suitable measures.

Project and report structure

The project is divided into several work steps that build on each other and were lead-managed by different project partners. An overview of the work packages and responsibilities can be found in the following table.

Table 1: Project structure and reporting structure

Work package	Subject	Lead management
Cost balance of authorised ELV recycling	Cost balance of authorised ELV treatment facilities	RETEK
	Cost balance of Shredders	TSR
	Cost and revenue development and market price fluctions	Ökopol
Description of common types and business models of illegal dismantling	Literature review	Ökopol
	Legal situation, evaluation of court rulings	Prof. Schomerus
	Practical investigation	Ökopol
Determining the economic and ecological impacts of illegal dismantling	Stakeholder surveys	Ökopol
	Consolidation of findings: common types of illegal dismantling	Ökopol
	Quantity relevance of the common types	Ökopol
	Estimation of the quantity relevance	Ökopol

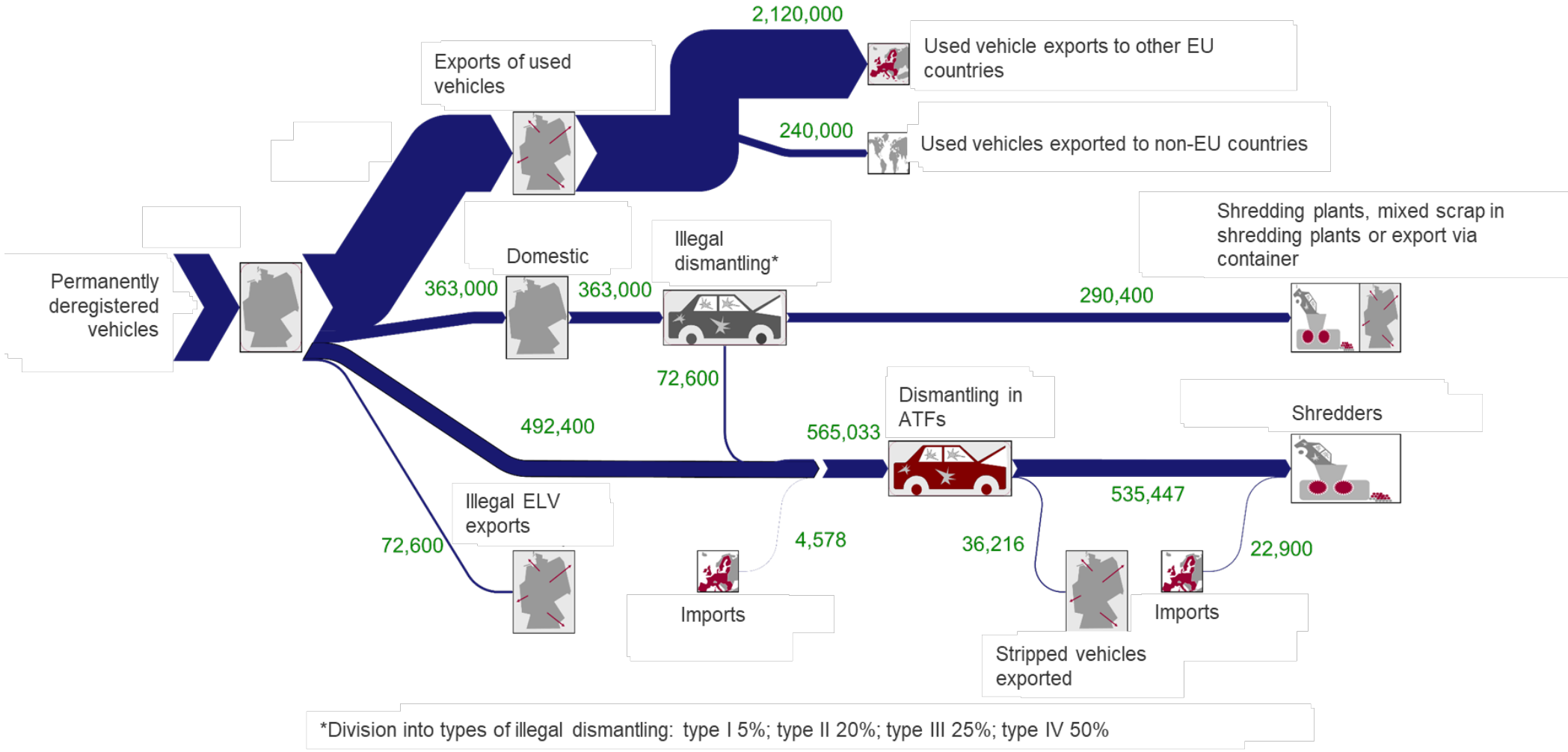
Work package	Subject	Lead management
	Comparison of the cost and revenue structure of authorised and illegal dismantling	Ökopol
	Socioeconomic impacts	VVA
	Environmental impacts	Ökopol
	Environmental costs	VVA
Evaluation of the impacts and recommendations for measures	Summary evaluation of the results and derivation of recommendations for measures	Ökopol

Situation of the whereabouts of end-of-life vehicles

As mentioned before, the annual reports on end-of-life vehicles (see e.g. BMU and UBA 2020), taking into account findings from Sander et al. (2017) reports on vehicle recycling rates. In this project, a validation of these end-of-life vehicles (ELV) figures has been carried out (see Figure 1). According to this, the statistical gap amounts to 363,000 vehicles. On the basis of the observations made, it is estimated that 20% of these, i.e. around 72,600 ELVs, are exported illegally. Furthermore, it is estimated that around 363,000 ELVs end up in illegal dismantling. This includes 72,600 vehicles that are subsequently treated in legal dismantling facilities. Accordingly, these 72,600 vehicles are not part of the statistical gap if included in the reporting of authorised dismantling facilities to Destatis. For the majority of ELVs from illegal dismantling, it can be assumed that these are ultimately recycled in shredder plants (possibly as mixed scrap). In addition, to a lesser extent, (partially) dismantled ELVs are also exported in containers along with spare parts, waste electronic equipment, etc.

In the competition between legal and illegal dismantling, there is a cost advantage for illegal operations. Whereas authorised facilities have to comply with the obligations of the End-of-Life Vehicles Ordinance in order to minimise harmful effects on the environment, illegal players can focus on activities that serve to generate revenue.

Figure 1: Whereabouts of permanently decommissioned vehicles in Germany in 2018



Cost and revenue situation of legal disassembly

The sector of authorised end-of-life vehicle dismantling facilities is very diverse. This is both in terms of the size and throughput of the individual players and in terms of their business models. Many authorised end-of-life vehicle dismantling facilities perform other business activities parallel. This leads to synergy effects such as:

- selling of new spare parts from alternative manufacturers,
- selling of used complete vehicles (accident-free and accident-damaged),
- motor vehicle repair (garages),
- towing and/or container services (which additionally take over the recyclables logistics to the shredder or metal processor),
- sale of metal.

Complementary business areas are necessary, especially for companies with very low ELV throughput, in order to be able to operate profitably. The diversity of structures and business models in the legal dismantling sector was initially taken into account by examining various scenarios:

- the treatment of 500 ELVs per year with internal combustion engines in accordance with the minimum legal obligations (basic scenario). This scenario does not consider the dismantling of glass, as exemptions according to No. 5 of the Annex to the End-of-Life Vehicles Ordinance can currently be regarded as the rule[1] and glass and plastic dismantling are addressed in specific scenarios;
- basic scenario plus extended material disassembly;
- basic scenario plus a focus on the extraction of spare parts;
- the treatment of electric vehicles in accordance with the minimum requirements;
- the treatment of gas-powered vehicles in accordance with the minimum requirements.

In addition, a variation in ELV throughput is considered. The starting point for the analysis is RETEK AG's cost and revenue situation. The specific cost and revenue structures of RETEK AG are supplemented by findings from surveys and discussions with other dismantling companies that operate regionally and structurally divergent. The data collection will mainly take place for the financial years 2019 and 2020.

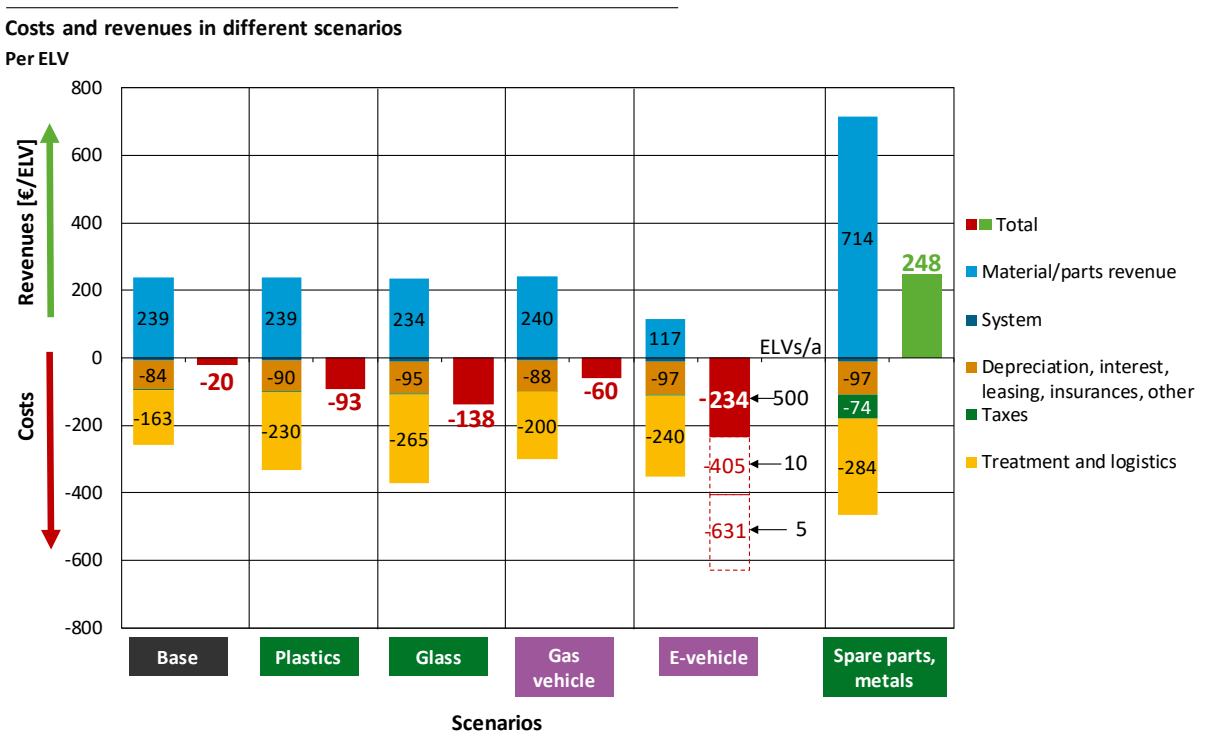
Based on the observations and modelling carried out, the picture shown in Figure 2 emerged. Revenue is generated in the scenarios with the extraction of spare parts. The disposal of electric vehicles is economically determined primarily by: the treatment costs, the lack of revenue from the catalytic converter, the increased system costs due to the additional training, and increased depreciation.

The "gas vehicles" scenario shows higher costs in treatment times (mainly due to the removal of the gas tank) and in system costs due to the need for additional training.

[1] This has been confirmed both in discussions with legal dismantling companies and in talks with representatives of the authorities.

In all scenarios, the logistics costs show the smallest share of the total costs per module. This is mainly due to the fact that the most mass-relevant parts of the vehicles are collected without additional (transport) costs.

Figure 2: Cost and revenue of ELV treatment in German authorised treatment facilities per ELV, throughput of 500 ELV/a, average prices of 2019/2020



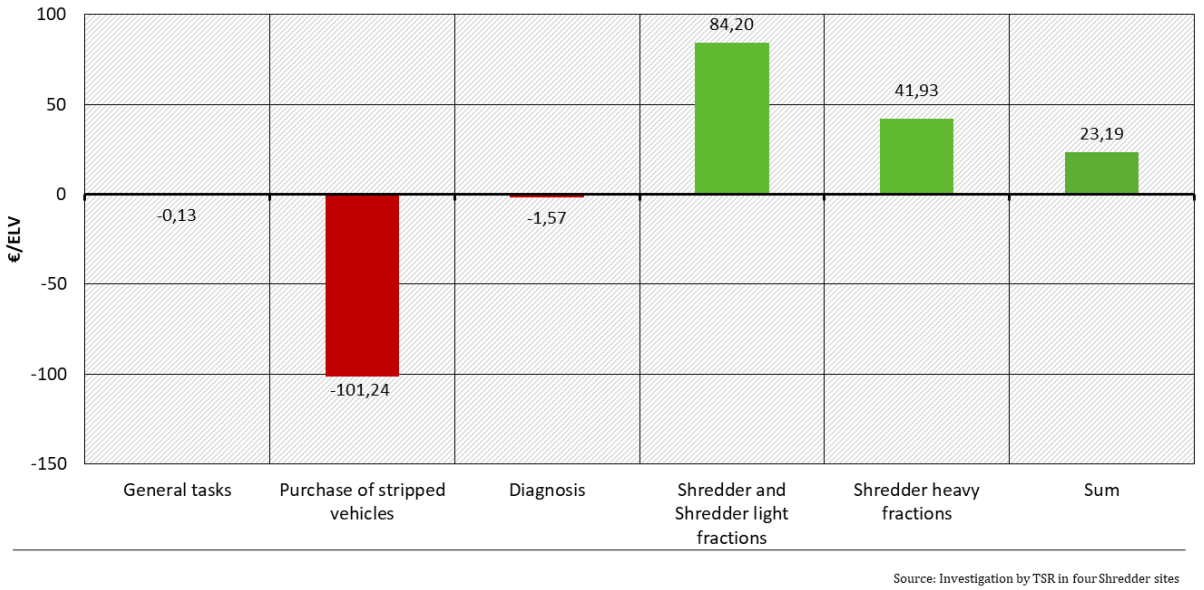
Source: Calculations by Ökopol and RETEK

Cost and revenue situation of shredder plants

In order to determine the cost and revenue situation for shredder plants, all relevant process steps from acceptance to disposal and recycling of the individual materials, i.e. including post-shredder treatment, were considered using the situation of TSR as an example. Also included in this analysis are costs for energy, personnel, certification and auditing, insurance costs and any costs for documentation. A shredder trial from 2016, presented in Sander et al. (2020), serves as the main data basis for the volume flows. The contents taken from the study with regard to the material output flows were supplemented, replaced or corrected with current data. A primary survey was conducted at the four shredder sites of TSR Recycling GmbH & Co KG.

For the shredder cost and revenue modelling, the input weight of the residual stripped vehicles, corresponds to the stripped vehicles weight in the base scenario of the dismantling facility. If the weights of the stripped vehicles differ, as is the case in the metal and spare parts dismantling scenarios, approximately 10 % of the costs presented in the shredding process can be regarded as fixed costs. Such costs are independent of the weight of the stripped vehicle (for example: costs of auditing/certification, quota determination, insurance, other costs, weighing, documentation, radioactivity measurement, reporting, storage).

Figure 3: Total costs and revenues of shredder plants per cost type



Source: Investigation by TSR in four Shredder sites

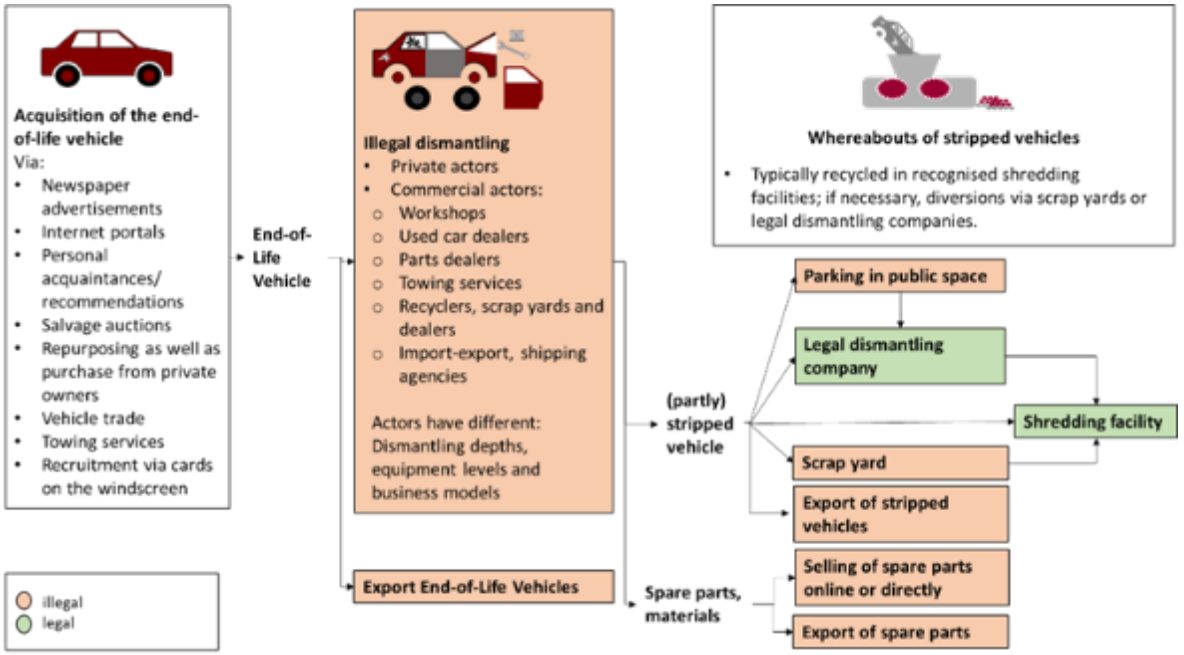
Actors of illegal dismantling

The common business practices and types of illegal dismantling actors were investigated using different methodological approaches. Finally, the resulting findings were compiled and consolidated. The central methodological approaches were:

- an evaluation of relevant previous studies,
- an evaluation of relevant court decisions,
- a practical survey divided into three steps,
  - Identification of suspected cases by means of: knowledge of market actors and managing authorities, evaluation of satellite images and on-site investigations,
  - Matching the information on the location of authorised dismantling companies as well as the GESA database (www.altfahrzeugstelle.de) and internet-based information such as individual websites and Ebay,
  - On-site inspection and where possible talks with site operators,
- Conducting stakeholder interviews (enforcement authorities, police/customs, dismantling companies, logistics companies).

Based on these different methodological approaches, a comprehensive picture of the common types and business models of illegal dismantling and ELV export could be obtained. The basic process of illegal dismantling is summarised in Figure 4.

Figure 4: Simplified representation of the basic procedure of illegal dismantling

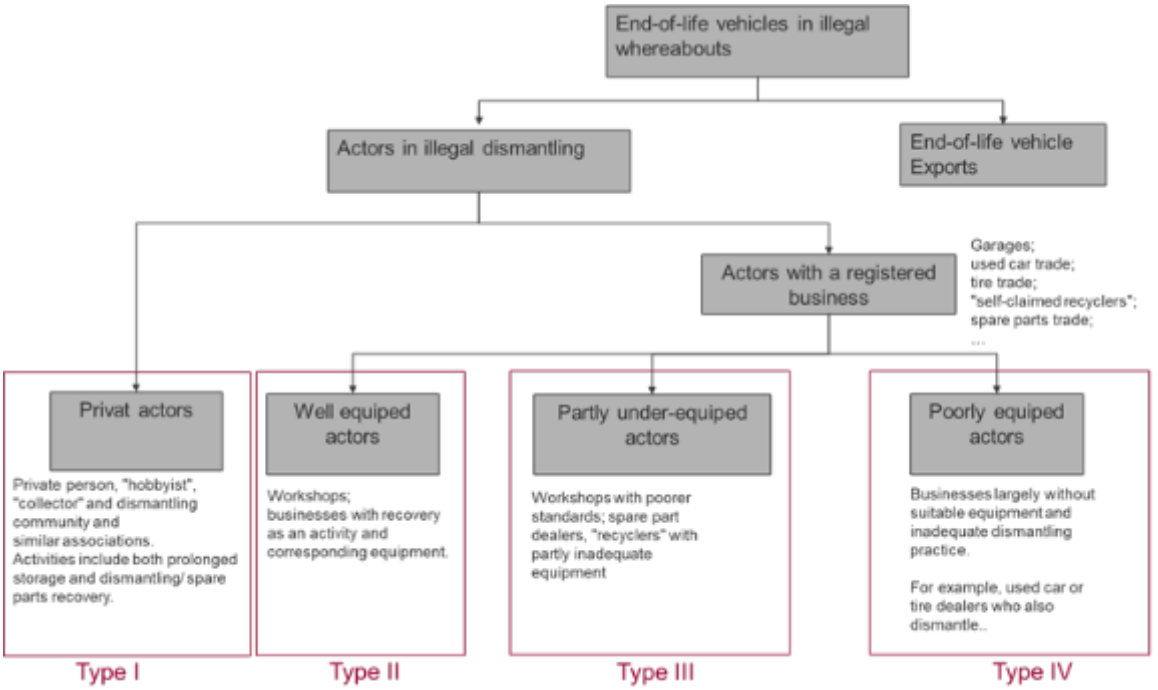


Source: Ökopol

For deriving common types of illegal dismantling (as subject of further consideration in the project), the focus lies on the equipment of the illegal actor. This is the decisive factor in relation to the ecological assessment of the common types of actors. In addition to three registered types with varying degrees of equipment, private actors are distinguished as a further common type. Most of the private actors are considered to be inadequately equipped. Nevertheless, there are cases where private actors could – according to the distinction made for the commercial actors - be assigned to partially inadequate or good equipped facilities. It, however, seems appropriate to consider private and commercial actors separately, based on ecological as well as economic differences. These differences have been considered in assessing the spread in impacts between both types of actors in the following investigations.

Against this background, the common types of illegal dismantling actors, as shown in Figure 5, are formulated.

Figure 5: Common types of illegal dismantling

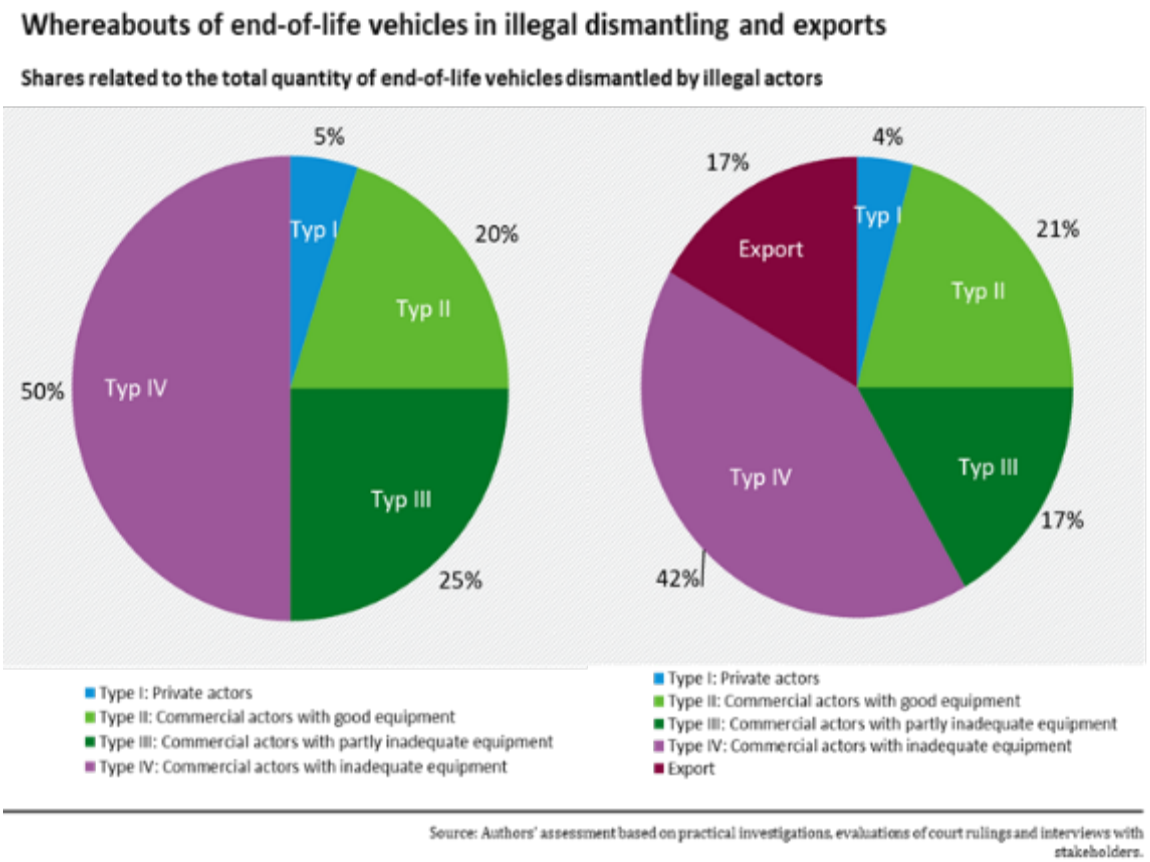


Source: Ökopol

Quantity relevance of the 4 types

Based on the practical investigation, the stakeholder interviews conducted and the evaluation of the court rulings, the quantity relevance of the four types was estimated (see Figure 6).

Figure 6: Quantity relevance of the common types and export



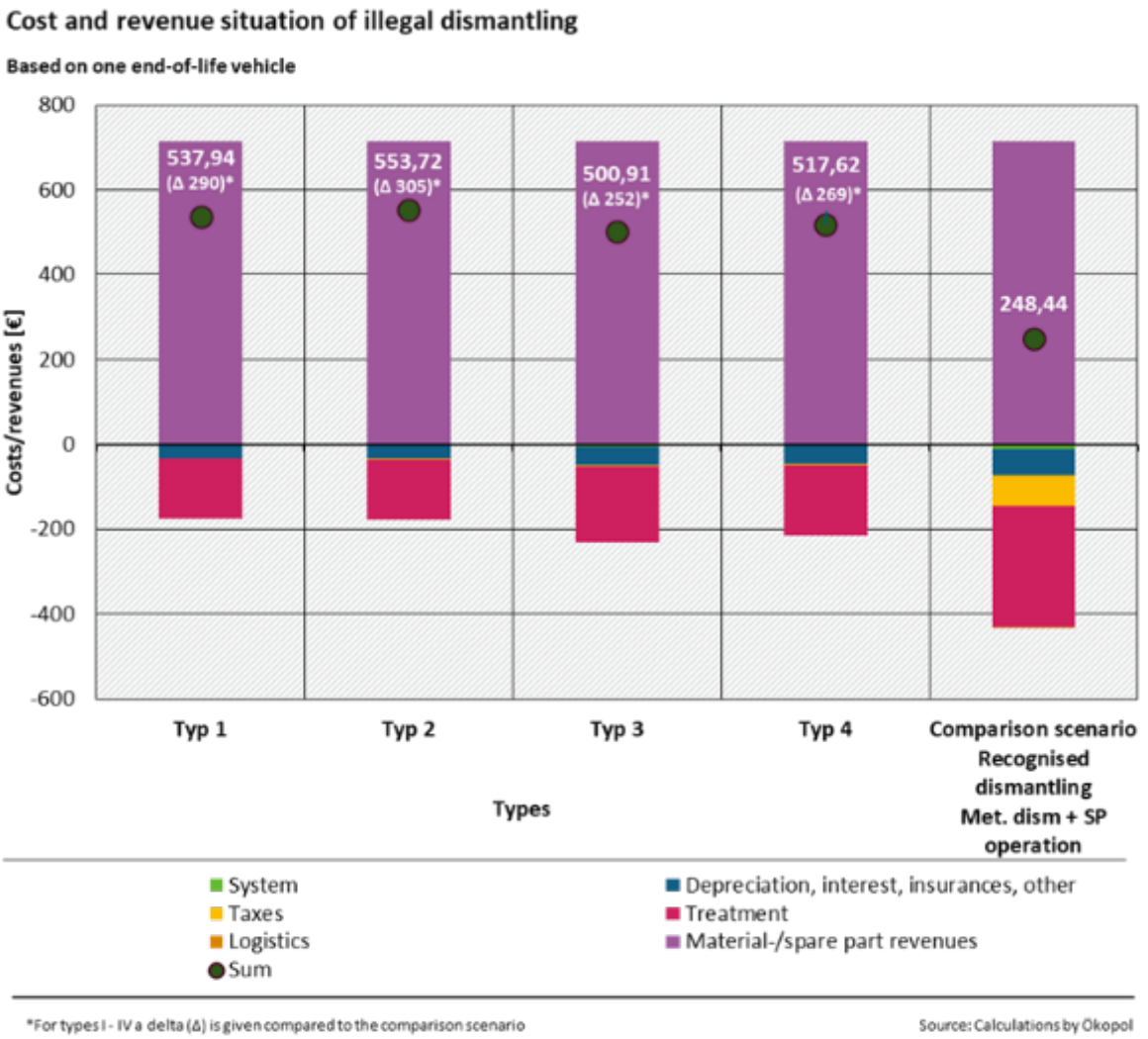
Left: Representation of the quantity distribution in illegal dismantling
Right: Representation of the quantity distribution in illegal dismantling and illegal exports

Comparison of the cost and revenue situation of legal and illegal dismantling

Based on the results of investigating the revenue and cost structure from authorised ELV recycling and the studies on the types and business models of illegal dismantling, a comparison of the cost and revenue structure between authorised and illegal ELV recycling is made. The legal "spare parts and metal dismantling" scenario was used as a basis in this comparison.

Across all differentiated cost categories, the four types of illegal dismantling have lower costs than an authorised dismantling facility. The treatment costs (personnel costs) per end-of-life vehicle are also significantly lower. As a result, the positive result per ELV is significantly higher in illegal dismantling than in legal dismantling (see Figure 7).

Figure 7: Costs and revenues of illegal dismantling compared to legal dismantling



Macroeconomic impact

Based on the findings of comparing the cost and revenue structure from legal to illegal dismantling as well as the findings on the quantity relevance, the direct added value was estimated for Germany. Every end-of-life vehicle that is exported (and thus not disposed of in Germany) or is not disposed of properly, results in a loss of value added for authorised dismantling facilities in Germany. In addition, the type of disposal also plays a role. A higher disposal quality will also have a greater impact on supplier companies, as more special tools or special services will have to be purchased.

Two scenarios were compared to determine the macroeconomic impact:

- Scenario A is the current situation according to the volume flows as shown in Figure 1and according to the volume distribution in Figure 6.
- In Scenario B, all 928,000 end-of-life vehicles are recycled in authorised dismantling facilities. This is the "policy" or "desired" scenario.

The turnover in the two scenarios is shown in Table 2:

Table 2: Revenue in the different sectors

Dismantling type	Revenue Scenario A (comparison scenario)	Revenue gain/loss in Scenario B (compared to the comparison scenario)
Repair and trade services motor vehicles (illegal dismantling 2, 3 and 4)	180 million euros	- 180 million euros
Treatment and disposal of waste and recovery of recyclable materials (legal dismantling)	379 million euros	+ 284 million euros
Expenditures on undeclared work (No sector - illegal dismantling (Type 1, 10 % of Type 2 and 30 % of Type 3)	51 million euros	- 51 million euros
Revenue (negative expenditure) for exported end-of-life vehicles (No sector)	-6 million euros	+ 6 million euros

In the case of a complete shift to legal dismantling (according to the "wish" or "policy" scenario), an additional **expenditure of 59 million euros** must be **financed.** It is decisive for the overall economic impact as to how this money is made available. Three possibilities were modelled:

- If consumers have to finance this additional sum completely, they will reduce their remaining expenditure, which in turn will lead to sales losses in many sectors.
- Alternatively, if we assume that the state provides the money through a subsidy (and does not otherwise reduce its spending), then there would not be such a shift in consumption and the overall economic consequences would be much more positive.
- In the last model, car manufacturers would bear the costs of these 59 million euros, which would lead to an increase in production costs in this sector. This would be analogous to new Extended Producer Responsibility (EPR) regulations.

Based on the revenue differences, the following values are calculated for the macroeconomic consequences:

Table 3: Macroeconomic consequences of full treatment in authorised dismantling (with and without consumption shifting)

Indicator	Difference to comparison scenario A in euros (consumers bear the extra expenses)	Difference to comparison scenario A in euros (state bears the extra expenditure)	Difference to comparison scenario A in euros (car manufacturers bear the extra expenses - EPR)
Additional value added in the German economy	EUR 37 million	EUR 85 million	EUR 28 million
Supplementary compensation of employees	EUR 19 million	EUR 46 million	EUR 15 million
Additional employment subject to social security contributions (FTE)	500	1.200	300

Indicator	Difference to comparison scenario A in euros (consumers bear the extra expenses)	Difference to comparison scenario A in euros (state bears the extra expenditure)	Difference to comparison scenario A in euros (car manufacturers bear the extra expenses - EPR)
Additional social security revenue	EUR 6 million	EUR 14 million	EUR 4 million
Additional product taxes	EUR 0.9 million	EUR 1.4 million	EUR 0.7 million
Additional income taxes [2]	2-3 million euros	5-8 million euros	1.5-2.5 million euros

The results show clearly how significant the assumption of financing the additional expenditure is. In the variants of financing by consumers or car manufacturers, the value-added gains are relatively small, whereas in the variant of government funding, significantly higher value-added gains are to be expected.

The other economic indicators depend on the estimates of added value, but other factors are also relevant:

- Compensation of employees and workplaces: the additional value added also leads to additional employee compensation and workplaces in relation to the value added.
- Social security payments: since payments into the social security funds are directly dependent on employee compensation, the same relationship applies here.
- Taxes: a similar relation also applies to the expected income taxes and product taxes. This means that the expected profits are a small part of the additional value added.

The economic effects of complete disposal are therefore highly dependent on how it is financed. In all three scenarios, however, positive economic effects result from the shift to legal dismantling. In addition to these positive economic effects, environmental costs would be avoided by avoiding illegal dismantling activities.

Ecological effects and environmental costs

The climate impact of refrigerants

The amount of refrigerants released in the illegal dismantling is estimated at 167,000 tonnes of CO_2 equivalents, corresponding to an environmental cost of **€32.6 million**.

Soil contamination due to waste oil

It was estimated that about 8,000 m^3 are polluted annually by illegal dismantling. Remediation costs were used to estimate the resulting environmental costs.

Assuming each of these m^2 costs 119.60 EUR to decontaminate, the annual damage (environmental costs) adds up to a total of **1 million EUR.**

Recommended measures

Based on the observations made, recommendations for measures to reduce illegal dismantling and its negative ecological and economic impacts were developed. These include:

[2] The tool does not calculate an income tax effect, as the ratio of income tax to revenue varies substantially in the individual sectors. An approximate estimate of the income tax effects has been calculated in this case. For 2017, the income tax revenue was 7.82 % of GDP. For this reason, we have used 6-9 % as an approximate interval.

- The strengthening of enforcement and
- The transfer of the model of compulsory verification to online marketplaces for vehicles.

In addition, further measures are mentioned which are not directly linked to the considerations carried out, but which nevertheless address the problem of illegal treatment of end-of-life vehicles.

A summary and evaluation of all recommended measures can be found in the following table.

Table 4: Assessment of measures

Measure	Aim	Addressee	Effort and costs	Implementation horizon	Level of legal implementation	Practical feasibility	Acceptance	Effectivness
(M1) Creation of simplified reporting possibilities for suspected cases of illegal dismantling	Avoidance of illegal dismantling	Federal government/ provinces or economic actors	For the creation of a reporting possibility (without follow-up activities): low	Short to medium term	None	Clarify responsibility and, if necessary, legal issues (data protection).	High	Simplified reporting options (online portal) can significantly simplify the identification of suspected cases. However, an effect only occurs when followed up with enforcement.
(M2) Strengthened enforcement in terms of personnel	Avoidance of illegal dismantling	Public authority actors at regional/ municipal level	High	Short to medium term	None	Rather questionable due to scarce resources among municipal actors	Authorities: limited due to additional effort / costs	Number of "successfully handled cases" roughly proportional to the staff deployed
(M3) Improved cooperation in enforcement	Avoidance of illegal dismantling	Public authority actors at regional/ municipal level	Low-medium	Short to medium term	None	Already practised in part; in part rather questionable due to scarce resources of municipal actors	Authorities: limited due to additional effort / costs	High potential to reduce illegal dismantling
(M4) Concretisation of the definition of end-of-life vehicles in the End-of-Life Vehicles Ordinance, in particular with regard to the removal of spare parts	Avoidance of illegal dismantling	Federal government	Low	Medium term	German End-of-Life Vehicles Ordinance	Feasable	Authorised dismantling facilities: high Other spare parts removing companies: low	Relocation of spare parts removal to authorised dismantling facilities; simplification of enforcement through clear criterion

Measure	Aim	Addressee	Effort and costs	Implementation horizon	Level of legal implementation	Practical feasibility	Acceptance	Effectivness
(M5) Application of the compulsory verficiation model for the waste status in online marketplaces for second-hand vehicle trading	Avoidance of illegal dismantling	Federal government	Additional effort for marketplaces due to new obligations; Inspection effort for authorities	Short to medium term	German End-of-Life Vehicles Ordinance	Difficult, because easily enforceable differentiation criteria are hard to find.	Online marketplaces: low Authorised dismantling facilities: high	Since the marketing of spare parts is largely handled online, a high potential for reducing illegal dismantling is seen here if implemented consequently.
(M6) Strengthening the Certificate of Destruction	Steering into authorised ELV treatment	Federal government / EU	Additional effort to change the vehicle registration system; reduced enforcement effort against illegal dismantlers.	Medium term	German Vehicle Registration Ordinance and others; European End-of-Life Vehicles Directive	Revision of vehicle registration system: not easy on national level, since new processes and proof criteria have to be developed, difficult on EU level due partial lack of competence at EU level	Authorised treatment facilitiers and car manufacturers : high.	Very effective in combination with the vehicle registration and deregistration system. However, hardly effective as a singular measure.
(M7) Strengthening extended producer responsibility	Strengthening the economic sustainability of legal dismantling	Federal government / EU	Only shifting of costs; no additional costs	Rather medium to long term	German End-of-Life Vehicles Ordinance	Feasable	Questionable for manufacturers and dismantlers	Financing security of dismantling activities would be ensured; additional ecologically beneficial dismantling activities could be financed

Zusammenfassung

Überlassung, Rücknahme und umweltverträgliche Entsorgung von Altfahrzeugen in Deutschland werden durch die EG-Altfahrzeug-Richtlinie[3] und die deutsche Altfahrzeugverordnung[4] geregelt. Laut Angaben des Statistischen Bundesamtes (Destatis 2020) werden jährlich rund eine halbe Million Altfahrzeuge in anerkannten Demontagebetrieben in Deutschland zur Behandlung angenommen. Die Bilanzierung des Verbleibs der in Deutschland endgültig außer Betrieb gesetzten Fahrzeuge anhand von Exportzahlen und statistischen Zahlen zur anerkannten Altfahrzeugverwertung ergibt eine statistische Lücke von Fahrzeugen mit unbekanntem Verbleib. Eine Berichterstattung bzgl. der Verwertung und des Verbleibs von Altfahrzeugen erfolgt jährlich durch UBA und BMUV in den Jahresberichten über die Altfahrzeugverwertungs-quoten (siehe bspw. BMU and UBA 2020). Eine Studie von Sander et al. (2017) im Auftrag des Umweltbundesamts kam zu dem Schluss, dass die Fahrzeuge mit unbekanntem Verbleib überwiegend in nicht anerkannten Demontagebetrieben zerlegt bzw. nicht gemäß Abfallverbringungsrecht exportiert werden. Auf Basis der Betrachtungen in diesem Projekt, ist eine Aktualisierung der hier getroffenen Abschätzungen erfolgt, welche die Relevanz der nicht anerkannten Demontage bestätigt.

Zielsetzung der Forschungsarbeiten in diesem Projekt war vor dem dargestellten Hintergrund die Quantifizierung der ökologischen und ökonomischen Auswirkungen durch die nicht anerkannte Altfahrzeugentsorgung und den illegalen Export von Altfahrzeugen sowie die Bewertung der Situation und Ableitung ausgewählter Maßnahmen.

Aufbau des Projekts und Berichtsstruktur

Das Projekt gliedert sich in die mehrere, aufeinander aufbauende Arbeitsschritte, die federführend von verschiedenen Projektpartner bearbeitet wurden. Eine Übersicht über die Arbeitspakete und die Bearbeitung findet sich in folgender Tabelle.

Tabelle 1: Projektaufbau

Arbeitspaket	Betrachtungsgegenstand	Federführung
Kostenbilanz der anerkannten Altfahrzeugverwertung	Kostenbilanz der anerkannten Demontagebetriebe	RETEK, Ökopol
	Kostenbilanz von Schredderanlagen	TSR
	Kosten- und Erlösentwicklung sowie Marktpreisschwankungen	Ökopol
Beschreibung gängiger Typen und Geschäftsmodelle der nicht anerkannten Demontage	Literaturauswertung	Ökopol
	Rechtliche Situation, Auswertung von Gerichtsentscheidungen	Prof. Schomerus
	Praktische Erhebung	Ökopol
	Akteursbefragung	Ökopol

[3] Richtlinie 2000/53/EG des Europäischen Parlaments und des Rates vom 18. September 2000 über Altfahrzeuge, zuletzt durch Richtlinie (EU) 2018/849 des Europäischen Parlaments und des Rates vom 30. Mai 2018 geändert.

[4] AltfahrzeugV, revised 6/21/2002 (BGBl. I S. 2214), zuletzt durch Artikel 118 der Verordnung vom 6/19/2020 (BGBl. I S. 1328) geändert.

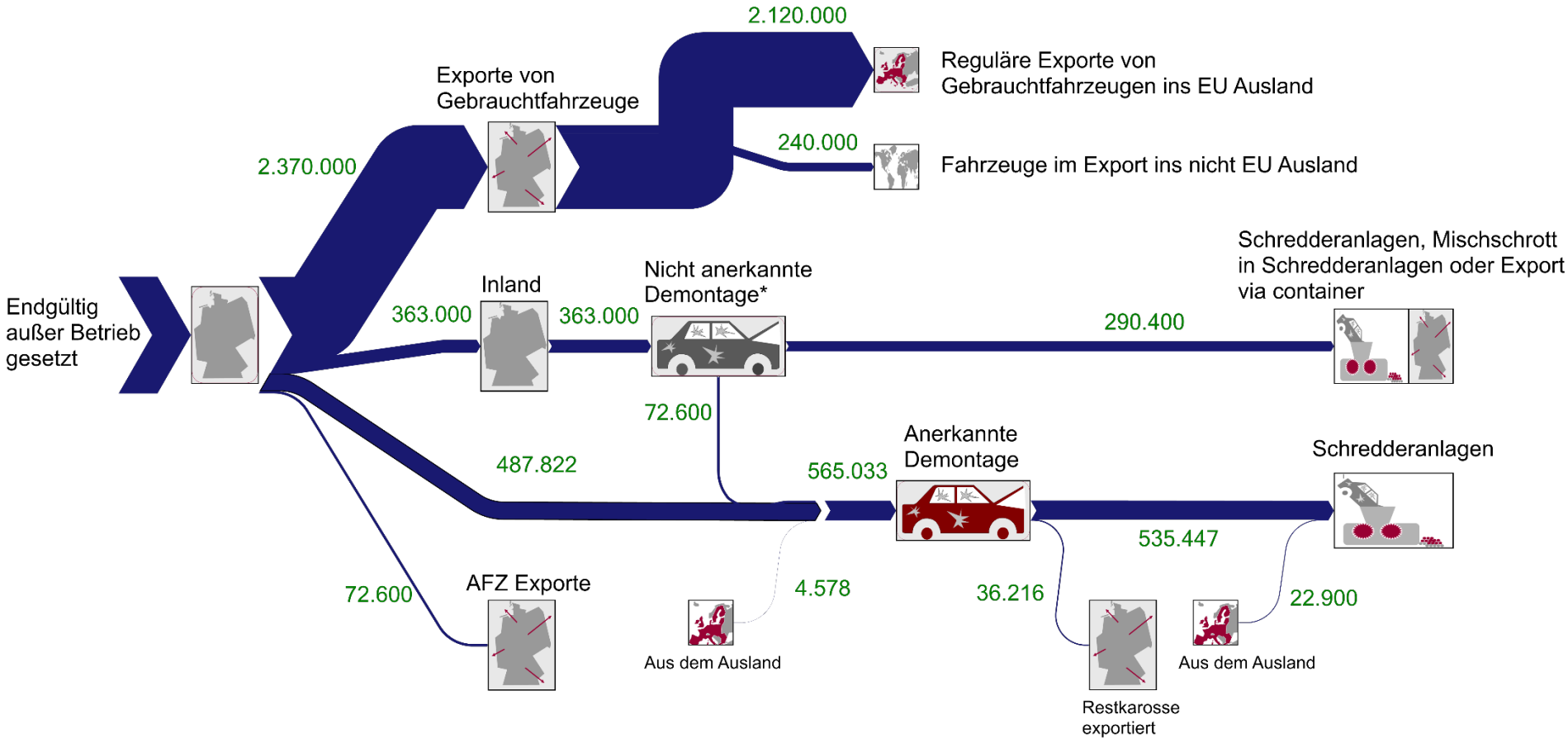
Arbeitspaket	Betrachtungsgegenstand	Federführung
Ermittlung der ökonomischen und ökologischen Auswirkungen der nicht anerkannten Demontage	Konsolidierung der Erkenntnisse: Gängige Typen der nicht anerkannten Demontage	Ökopol
	Mengenrelevanz der Modelltypen	Ökopol
	Abschätzung der Mengenrelevanz	Ökopol
	Vergleich der Kosten- und Erlösstruktur der anerkannten und nicht-anerkannten Demontage	Ökopol
	Volkswirtschaftliche Auswirkungen	VVA
	Ökologische Wirkungen	Ökopol
	Umweltkosten	VVA
Bewertung der Auswirkungen und Maßnahmenempfehlungen	Zusammenfassende Auswertung der Ergebnisse und Ableitung von Maßnahmenempfehlungen	Ökopol, Prof. Schomerus

Situation des Verbleibs von Altfahrzeugen

Wie eingangs erwähnt wird in den Jahresberichten über die Altfahrzeugverwertungsquoten (siehe bspw. BMU and UBA 2020) unter Berücksichtigung von Erkenntnissen von Sander et al. (2017) berichtet. Im Projekt ist eine Validierung der Zahlen zum Verbleib von Altfahrzeugen (AFZ) erfolgt (siehe Abbildung 1). Demnach wird die statistische Lücke auf 363.000 Fahrzeuge geschätzt. Auf Basis der durchgeführten Betrachtungen wird abgeschätzt, dass hiervon 20 %, also rund 72.600 AFZ illegal exportiert werden. Weiterhin wird abgeschätzt, dass rund 363.000 AFZ in die nicht anerkannte Demontage gehen. Hierin enthalten sind 72.600 Fahrzeuge, die anschließend in anerkannten Demontagebetrieben weiterbehandelt werden. Diese 72.600 Fahrzeuge wären entsprechend nicht Teil der statistischen Lücke, sofern diese in den Berichten der anerkannten Demontagebetriebe an Destatis enthalten sind. Für den wesentlichen Teil der AFZ aus nicht anerkannter Demontage ist anzunehmen, dass diese schließlich in Schredderanlagen (ggf. als Mischschrott) verwertet werden. Daneben findet in geringerem Umfang auch ein Export der (teil-) zerlegten AFZ in Containern mit Ersatzteilen, Elektronikaltgeräten u. ä. statt.

Im Wettbewerb zwischen der anerkannten und der nicht anerkannten Demontage besteht ein Kostenvorteil bei den nicht anerkannten Betrieben. Während bei anerkannten Betrieben relevante Kosten in Folge der Einhaltung der Vorgaben der AltfahrzeugV zur Minimierung schädlicher Auswirkungen auf die Umwelt einzuhalten sind, können nicht anerkannte Akteure auf die Tätigkeiten fokussieren, die der Erlöserzielung dienen.

Abbildung 1: Verbleib von endgültig außer Betrieb gesetzten Fahrzeugen im Jahr 2018 in Deutschland



*Aufteilung auf Typen der illegalen Demontage: Typ I 5%; Typ II 20%; Typ III 25 %; Typ IV 50 %.

Kosten- und Erlössituation der anerkannten Demontage

Die Branche der anerkannten Altfahrzeugdemontagebetriebe ist sehr vielfältig geprägt sowohl in Bezug auf die Größe bzw. den Durchsatz der einzelnen Akteure als auch bzgl. derer Geschäftsmodelle. Viele anerkannte Altfahrzeugdemontagebetriebe unterhalten parallel weitere Geschäftsfelder, die zu Synergieeffekten führen wie z. B.:

- Handel mit neuen Ersatzteilen alternativer Hersteller,
- Handel mit gebrauchten Komplettfahrzeugen (unfallfrei und verunfallt),
- Kfz-Reparatur(-werkstätten),
- Abschlepp- und/oder Containerdienste (die zusätzlich die Wertstofflogistik zum Schredder oder Metallaufbereiter übernehmen),
- Metallhandel.

Ergänzende Geschäftsfelder sind vor allem bei Betrieben mit sehr geringem Altfahrzeugdurchsatz notwendig, um gewinnbringend arbeiten zu können. Der Struktur- und Geschäftsmodellvielfalt in der anerkannten Demontage wurde zunächst dadurch Rechnung getragen, dass verschiedene Szenarien untersucht wurden:

- die Behandlung von 500 Altfahrzeugen pro Jahr mit Verbrennungsmotor gemäß den rechtlichen Mindestanforderungen (Basisszenario); dabei betrachtet dieses Szenario nicht die Demontage von Glas, da Ausnahmegenehmigungen nach Nr. 5 des Anhangs der AltfahrzeugV aktuell als der Regelfall angesehen werden können[5] und die Glas- und Kunststoffdemontage in spezifischen Szenarien thematisiert werden;
- Basisszenario plus erweiterte Materialdemontage;
- Basisszenario plus ein Fokus auf die Gewinnung von Ersatzteilen;
- die Behandlung von Elektro-Fahrzeugen entsprechend den Mindestanforderungen;
- die Behandlung von gasbetriebenen Fahrzeugen entsprechend den Mindestanforderungen.

Ergänzend ist eine Durchsatzvariation erfolgt. Ausgangspunkt der Betrachtung ist die Kosten- und Erlössituation der RETEK AG. Die spezifischen Kosten- und Erlösstrukturen der RETEK AG werden ergänzt um Erkenntnisse aus Befragungen und Gesprächen mit weiteren regional und strukturell divergent arbeitenden Demontagebetrieben. Die Datenerhebung erfolgt im Wesentlichen für die Geschäftsjahre 2019 und 2020.

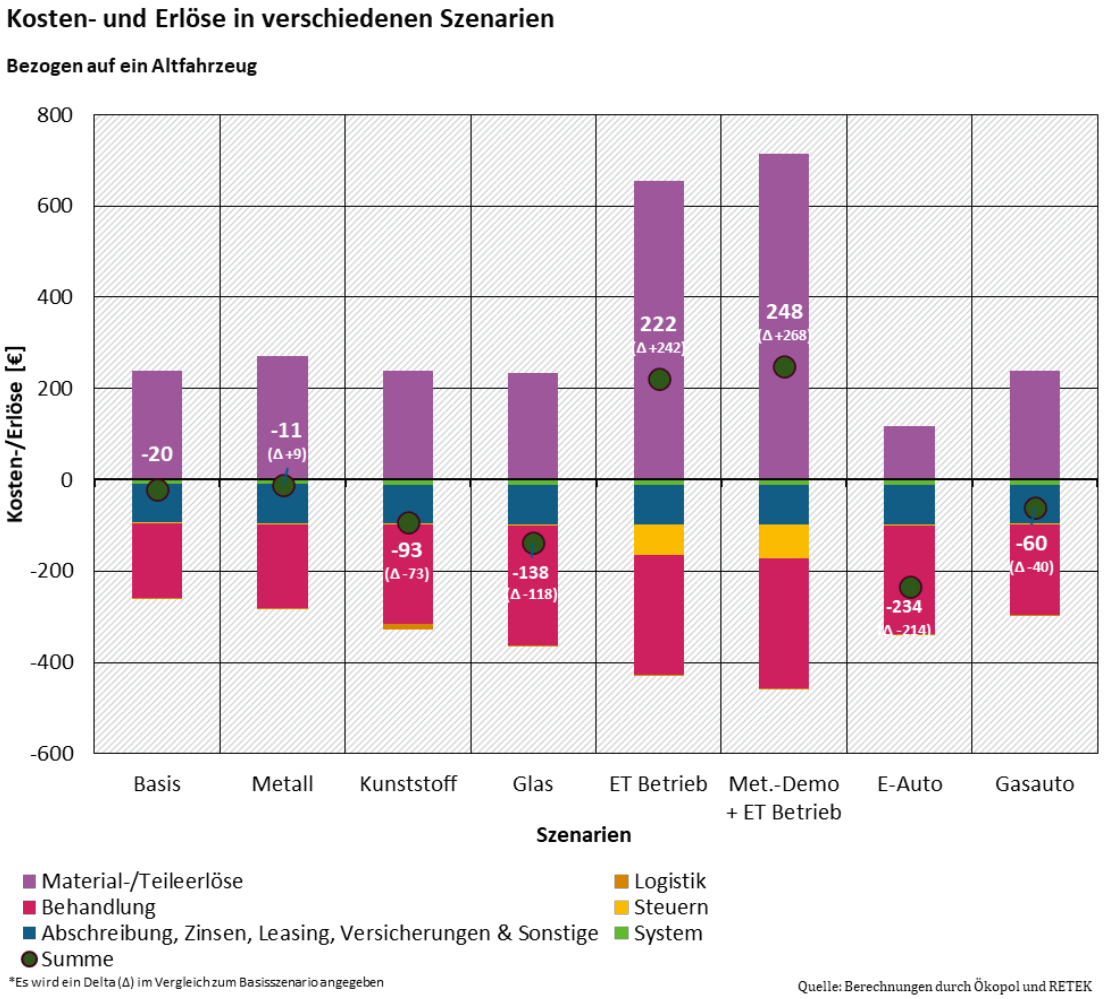
Auf Basis der durchgeführten Betrachtungen und Modellierungen zeigt sich das in Abbildung 2 dargestellte Bild. Eine Erlöserzielung erfolgt in den Szenarien mit Ersatzteilentnahme. Die Entsorgung von E-Autos wird ökonomisch vor allem durch die Behandlungskosten bestimmt, durch das Fehlen der Erlöse aus dem Katalysator, die durch die zusätzliche Fortbildung erhöhten Systemkosten sowie erhöhten Abschreibungen.

Das Szenario „Gasfahrzeuge“ zeigt höhere Kosten bei den Behandlungszeiten (vor allem durch den Ausbau des Gastanks) und bei den Systemkosten durch die Notwendigkeit zusätzlicher Fortbildung.

[5] Dies hat sich sowohl in den Gesprächen mit anerkannten Demontagebetrieben als auch bei Gesprächen mit Behördenvertretern bestätigt.

In allen Szenarien zeigen die Logistikkosten den kleinsten Anteil an den Gesamtkosten je Modul. Dies ist vor allem dadurch begründet, dass die massenrelevantesten Teile der Fahrzeuge frei Station abgeholt werden.

Abbildung 2: Kosten- und Erlöse in der anerkannten Demontage



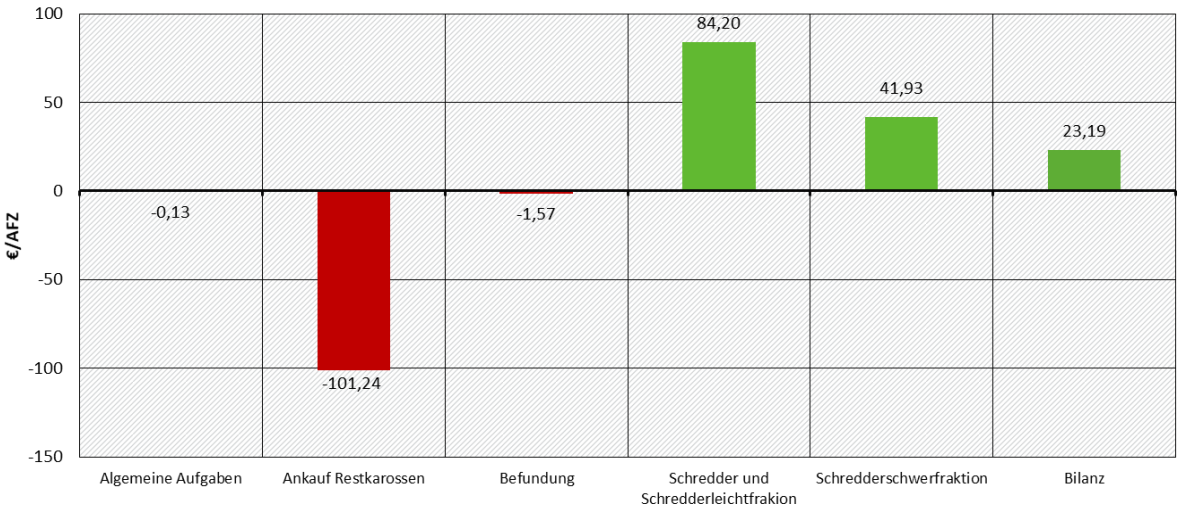
Kosten- und Erlössituation von Schredderanlagen

Zur Ermittlung der Kosten- und Erlössituation bei Schredderanlagen wurden am Beispiel der Situation bei TSR alle relevanten Prozessschritte von der Annahme bis hin zur Entsorgung und Verwertung der einzelnen Materialien, also inklusive Post-Schredder-Behandlung betrachtet. Anteilig in dieser Betrachtung enthalten sind ebenfalls Kosten für Energie, Personal, Zertifizierung und Auditierung, Kosten für Versicherungen sowie jegliche Kosten für Dokumentationen. Als wesentliche Datengrundlage zu den Mengenströmen dient ein Schredderversuch aus dem Jahr 2016, dargestellt in Sander et al. (2020). Die aus der Studie entnommenen Inhalte, hinsichtlich der Material-Outputströme, wurden durch aktuelle ergänzt, respektive ersetzt oder korrigiert. Eine Primärerhebung fand an den vier Schredderstandorten der TSR Recycling GmbH & Co. KG statt.

Das Eingangsgewicht der Restkarossen in dieser Kosten- und Erlösmodellierung für den Schredder entspricht dem Restkarossengewicht im Basisszenario für die Modellierung bei den Demontagebetrieben. Bei abweichenden Gewichten der Restkarossen, wie dies z. B. in den Szenarien Metall- und Ersatzteildemontage der Fall ist können ca. 10 % der dargestellten Kosten im Schredderprozess als Fixkosten angesehen werden, die unabhängig vom Gewicht der

Restkarosse sind (Kosten Auditierung / Zertifizierung, Quotenermittlungen, Versicherungen, sonstige Kosten, Verwiegung, Dokumentation, Radioaktivitätsmessung, Befundung, Einlagerung).

Abbildung 3: Gesamtkosten und -Erlösraster von Schredderanlagen pro Kostenart



Quelle: Erhebung durch TSR in vier Schredderstandorten

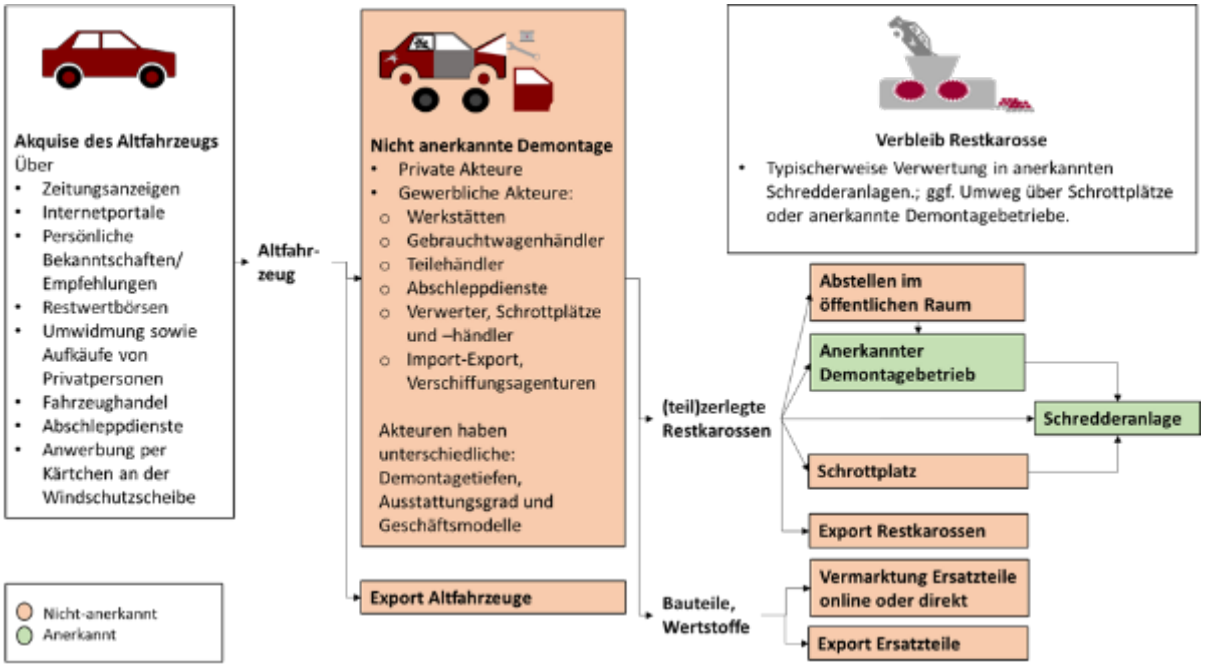
Akteure der illegalen Demontage

Die gängigen Geschäftspraktiken und –typen der Akteure der illegalen Demontage wurden anhand verschiedener methodischer Zugänge untersucht, deren Erkenntnisse schließlich zusammengetragen und konsolidiert wurden. Die zentralen methodischen Herangehensweisen waren

- eine Auswertung einschlägiger früherer Studien,
- eine Auswertung von einschlägigen Gerichtsurteilen,
- eine praktische Erhebung, gegliedert in drei Schritte,
  - Identifikation von Verdachtsfällen über Kenntnisse von Marktteilnehmenden und verwaltende Behörden, Satellitenbildauswertung, Vor-Ort-Kenntnisse,
  - Abgleich der Informationen mit Informationen zur Lage von anerkannten Demontagebetrieben sowie der GESA-Liste (www.altfahrzeugstelle.de) und internetbasierten Informationen wie z. B. individuelle Webseiten und Ebay,
  - Vor-Ort-Inaugenscheinnahme, ggf. Gespräche mit Platzbetreiberinnen und -betreibern falls möglich,
- Durchführung von Akteursinterviews (Vollzugsbehörden, Polizei/Zoll, Demontagebetriebe, Logistikunternehmen).

Auf Grundlage dieser verschiedenen methodischen Zugänge konnte ein umfassendes Bild zu den verschiedenen gängigen Typen und Geschäftsmodellen der nicht anerkannten Demontage und des Exports von Altfahrzeugen gewonnen werden. Der grundsätzliche Ablauf der nicht anerkannten Demontage ist in Abbildung 4 zusammenfassend dargestellt.

Abbildung 4: Vereinfachte Darstellung des grundsätzlichen Ablaufs der nicht anerkannten Demontage

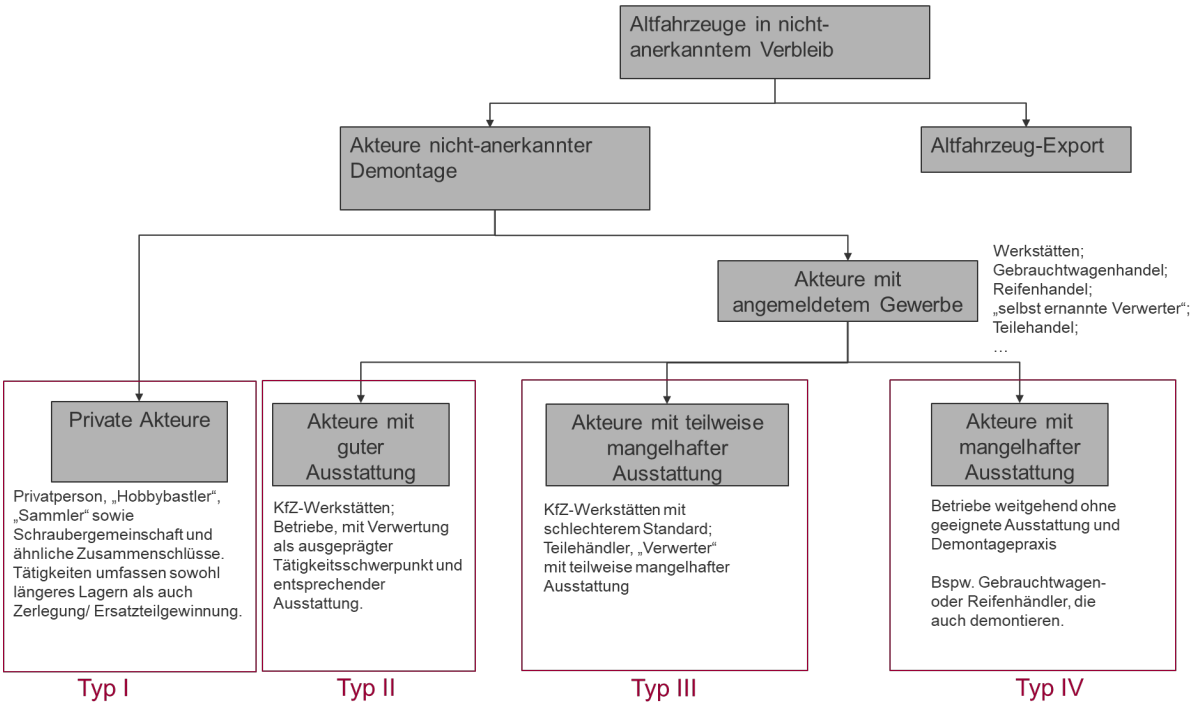


Quelle: Ökopol

Für die Ableitung von Modelltypen der nicht anerkannten Demontage (als Gegenstand der weiteren Betrachtung im Projekt) ist eine Fokussierung auf die Ausstattung erfolgt, da diese in Bezug auf die ökologische Bewertung der Typen ausschlaggebend ist. Neben drei Typen unterschiedlicher Ausstattung mit angemeldetem Gewerbe sind– als weiterer Modelltyp – die privaten Akteure zu unterscheiden. Diese haben zu einem großen Teil eine mangelhafte Ausstattung, wobei es hier durchaus auch Fälle gibt, die – mit Blick auf die bei den gewerblichen Akteuren vorgenommene Unterscheidung – der teilweise mangelhaften oder guten Ausstattung zuzuordnen wären. Hier jedoch erscheint es zweckmäßig, die vorkommenden Unterschiede bei den ökologischen Aspekten in der weiteren Betrachtung durch Spannbreiten abzudecken und diese aufgrund der relevanten ökonomischen Unterschiede klar von den gewerblichen Akteuren getrennt zu betrachten.

Vor diesem Hintergrund wurden die in Abbildung 5 dargestellten Modelltypen für Akteure der nicht anerkannten Demontage formuliert.

Abbildung 5: Modelltypen der nicht anerkannten Demontage

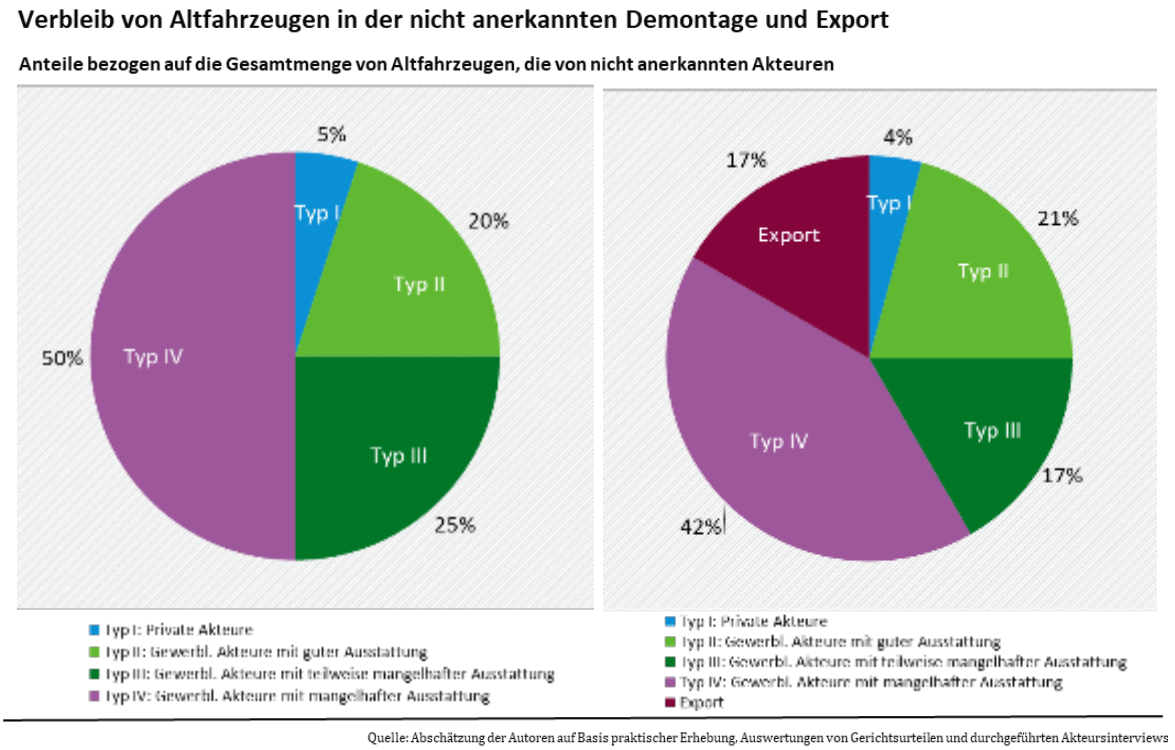


Quelle: Ökopol,- Eigene Darstellung

Mengenrelevanz der 4 Typen

Auf Grundlage der praktischen Erhebung, den durchgeführten Akteursinterviews und der Auswertung der Gerichtsurteile wurde die Mengenrelevanz der vier Typen abgeschätzt (siehe Abbildung 6).

Abbildung 6: Mengenrelevanz der Modelltypen und des Exports



Quelle: Abschätzung der Autoren auf Basis praktischer Erhebung, Auswertungen von Gerichtsurteilen und durchgeführten Akteursinterviews

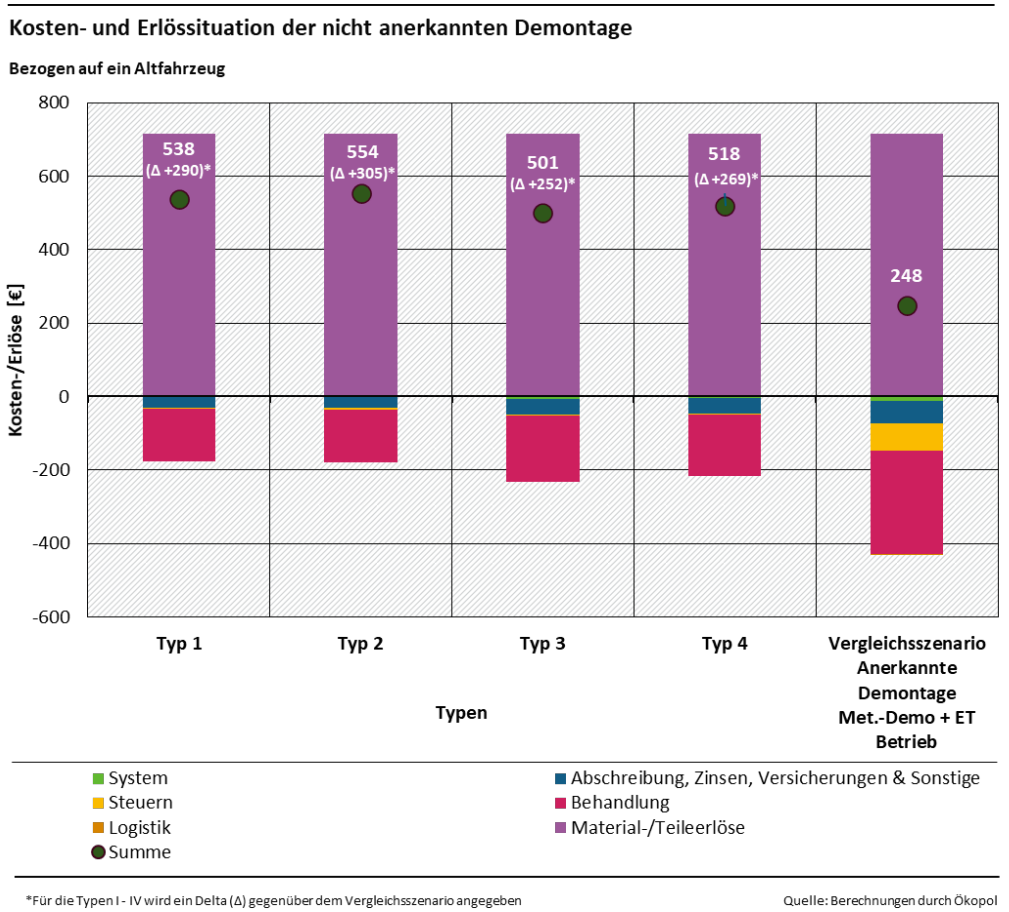
Links: Darstellung der Mengenverteilung in der nicht anerkannten Demontage
Rechts: Darstellung der Mengenverteilung in nicht anerkannter Demontage und illegalen Exporten

Vergleich der Kosten- und Erlössituation von anerkannter und nicht anerkannter Demontage

Aufbauend auf den Ergebnissen der Untersuchung der Erlös- und Kostenstruktur der anerkannten Altfahrzeugverwertung und den Untersuchungen zu den Typen und Geschäftsmodellen der nicht anerkannten Demontage erfolgt ein Vergleich der Kosten- und Erlösstruktur der anerkannten und der nicht anerkannten Altfahrzeugverwertung. Als Vergleichsgrundlage wurde das Szenario „Metalldemontage und Ersatzteilvermarktung“ aus der Betrachtung der Kosten- und Erlösstruktur der anerkannten Demontage herangezogen.

Über alle unterschiedenen Kostenkategorien bestehen bei den vier Typen der nicht-anerkannten Demontage geringere Kosten gegenüber der Demontage in einem anerkannten Demontagebetrieb. Auch die Behandlungskosten (Personalaufwand) pro Altfahrzeug fallen deutlich geringer aus. Im Ergebnis fällt das positive Ergebnis pro AFZ in der nicht anerkannten Demontage deutlich höher aus als in der anerkannten Demontage (vgl. Abbildung 7).

Abbildung 7: Kosten und Erlöse der nicht anerkannten Demontage im Vergleich mit der anerkannten Demontage



Volkswirtschaftliche Auswirkungen

Auf Basis der Erkenntnisse zur Kosten- und Erlösstruktur der nicht anerkannten Demontage im Vergleich zu anerkannten Demontage und der Erkenntnisse zum Mengengerüst kann die direkte Wirkung auf die Wertschöpfung in Deutschland gut abgeschätzt werden. Jedes Altfahrzeug, das exportiert wird (und damit nicht in Deutschland entsorgt wird) oder nicht ordnungsgemäß entsorgt wird, hat einen Verlust von Wertschöpfung in Deutschland zur Folge, der bei den anerkannten Demontagebetrieben entstehen würde. Zusätzlich spielt auch die Art der Entsorgung eine Rolle. Eine qualitativ hochwertigere Entsorgung wird auch eine größere Wirkung auf Zulieferbetriebe haben, da mehr Spezialwerkzeug oder Spezialdienstleistungen eingekauft werden müssen.

Für die Ermittlung der volkswirtschaftlichen Auswirkungen wurden zwei Szenarien verglichen:

- Szenario A ist dabei die derzeitige Situation entsprechend der Mengenströme wie sie in Abbildung 1 dargestellt sind und entsprechend der Mengenverteilung aus Abbildung 6.
- In Szenario B werden alle 928.000 Altfahrzeuge in der anerkannten Demontage verwertet. Dies ist das „Politik“- oder „Wunsch“-Szenario.

Die Umsätze in den beiden Szenarien sind in Tabelle 2 dargestellt.

Tabelle 2: Umsätze in den verschiedenen Branchen

Demontagetyp	Umsatz Szenario A (Vergleichsszenario)	Umsatzgewinn/-verlust in Szenario B (im Vergleich zum Vergleichsszenario)
Reparatur und Handelsleistungen KfZ (illegale Demontage 2, 3 und 4)	180 Millionen Euro	- 180 Millionen Euro
Behandlung und Beseitigung von Abfällen sowie zur Rückgewinnung von Wertstoffen (anerkannte Demontage)	379 Millionen Euro	+ 284 Millionen Euro
Ausgaben für Leistungen in Schwarzarbeit (Kein Sektor – illegale Demontage (Typ 1, 10 % von Typ 2 und 30 % von Typ 3)	51 Millionen Euro	- 51 Millionen Euro
Einnahmen (negative Ausgaben) für exportierte Altfahrzeuge (Kein Sektor)	-6 Millionen Euro	+ 6 Millionen Euro

Bei einer kompletten Verlagerung in die anerkannte Demontage (entsprechend dem „Wunsch"- oder „Politik"-Szenario) müssen zusätzliche **Ausgaben von 59 Millionen Euro finanziert** werden. Wie dieses Geld bereitgestellt wird, ist dabei entscheidend für die gesamtwirtschaftliche Wirkung. Drei Möglichkeiten wurden modelliert:

- Wenn die Konsumenten diese zusätzliche Summe komplett finanzieren müssen, werden Sie Ihre restlichen Ausgaben reduzieren, was wiederum zu Umsatzverlusten in vielen Branchen führt.
- Geht man jedoch alternativ davon aus, dass der Staat das Geld mittels einer Förderung zur Verfügung stellt (und seine Ausgaben nicht anderweitig reduziert), dann würde es nicht zu so einer Konsumverschiebung kommen und die gesamtwirtschaftlichen Folgen wären deutlich positiver.
- Im letzten Modell würden die KFZ-Hersteller die Kosten dieser 59 Millionen Euro tragen, was zu einer Steigerung der Produktionskosten in diesem Sektor führen würde. Dies wäre analog zu neuen Extended Producer Responsibility (EPR) Regelungen.

Auf Basis der Umsatzdifferenzen werden die folgenden Werte für die gesamtwirtschaftlichen Folgen errechnet:

Tabelle 3: Gesamtwirtschaftliche Folgen einer vollständigen Verwertung in der anerkannten Demontage (mit und ohne Konsumverschiebung)

Indikator	Differenz zu Vergleichsszenario A in Euro (Konsumenten tragen die Extraausgaben)	Differenz zu Vergleichsszenario A in Euro (Staat trägt die Extraausgaben)	Differenz zu Vergleichsszenario A in Euro (KFZ Hersteller tragen die Extraausgaben - EPR)
Zusätzliche Wertschöpfung in der deutschen Volkswirtschaft	37 Millionen EUR	85 Millionen EUR	28 Millionen EUR
Zusätzliche Arbeitnehmerentgelte	19 Millionen EUR	46 Millionen EUR	15 Millionen EUR

Indikator	Differenz zu Vergleichsszenario A in Euro (Konsumenten tragen die Extraausgaben)	Differenz zu Vergleichsszenario A in Euro (Staat trägt die Extraausgaben)	Differenz zu Vergleichsszenario A in Euro (KFZ Hersteller tragen die Extraausgaben - EPR)
Zusätzliche SV-pflichtige Beschäftigung (FTE)	500	1.200	300
Zusätzliche Sozialversicherungseinnahmen	6 Millionen EUR	14 Millionen EUR	4 Millionen EUR
Zusätzliche Produktsteuern	0,9 Millionen EUR	1,4 Millionen EUR	0,7 Millionen EUR
Zusätzliche Einkommenssteuern[6]	2-3 Millionen Euro	5-8 Millionen Euro	1,5-2,5 Millionen Euro

Die Ergebnisse zeigen sehr deutlich wie zentral die Annahme der Finanzierung der zusätzlichen Ausgaben ist. In den Varianten einer Finanzierung durch die Konsumenten oder die KFZ-Hersteller sind die Wertschöpfungsgewinne relativ klein, während in der Variante einer staatlichen Förderung deutlich höhere Wertschöpfungsgewinne zu erwarten sind.

Die anderen wirtschaftlichen Kenngrößen hängen von den Schätzungen der Wertschöpfung aber es sind auch andere Faktoren relevant:

- Arbeitnehmerentgelte und Arbeitsplätze: Die zusätzliche Wertschöpfung führt auch zu zusätzlichen Arbeitnehmerentgelten und Arbeitsplätzen in Relation zur Wertschöpfung.
- Sozialverssicherungszahlungen: Da die Einzahlungen in die Sozialversicherungskassen direkt von den Arbeitnehmerentgelten abhängen gilt hier auch die gleiche Relation.
- Steuern: Auch bei den zu erwartenden Einkommenssteuern und Produktsteuern gilt eine ähnliche Relation. Das heißt die zu erwartenden Gewinne sind ein kleiner Teil der zusätzlichen Wertschöpfung.

Die wirtschaftlichen Wirkungen einer vollständigen Entsorgung sind demnach sehr stark davon abhängig wie diese finanziert wird. In allen drei Szenarien ergeben sich jedoch positive volkswirtschaftliche Effekte durch die Verlagerung in die anerkannte Demontage. Zusätzlich zu diesen positiven volkswirtschaftlichen Effekten würden durch die Vermeidung illegaler Demontageaktivitäten Umweltkosten vermieden.

Ökologische Wirkungen und Umweltkosten

Die Klimawirkung von Kältemitteln

Die Menge der in der nicht anerkannten Demontage freigesetzten Kältemittel wird auf 167.000 Tonnen CO_2 Äquivalente geschätzt, dies entspricht Umweltkosten in Höhe von **32,6 Millionen €**.

[6] Das Werkzeug errechnet keine Einkommenssteuerwirkung, da die Relation von Einkommensteuer zu Umsatz in den einzelnen Branchen sehr unterschiedlich ist. Als kleine Annäherung wurde jedoch eine Relationsrechnung durchgeführt. Für das Jahr 2017 war das Aufkommen der Einkommenssteuer 7,82% des Bruttoinlandproduktes. Aus dem Grund haben wir 6-9 % als ungefähres Intervall verwendet.

Bodenverunreinigungen durch Altöl

Es wurde abgeschätzt, dass jährlich etwa 8.000 m^3 durch die illegale Demontage verunreinigt werden. Für die Abschätzung der hieraus resultierenden Umweltkosten wurden die Sanierungskosten herangezogen.

Angenommen eine Sanierung jedes dieser m^3 kostet 119,60 EUR addiert sich der jährliche Schaden (Umweltkosten) zu insgesamt rund **1 Millionen EUR**.

Maßnahmenempfehlungen

Auf Basis der durchgeführten Betrachtungen wurden Maßnahmenempfehlungen zur Verringerung der nicht anerkannten Demontage und ihrer negativen ökologischen und ökonomischen Auswirkungen entwickelt. Diese umfassen:

- Die Stärkung des Vollzugs und
- Die Übertragung des Modells der Prüfpflichten auf Onlinemarktplätze für Fahrzeuge

Daneben werden weitere Maßnahmen genannt, welche nicht unmittelbar an die durchgeführten Betrachtungen anknüpfen, aber dennoch das Problem der illegalen Verwertung von Altfahrzeugen adressieren.

Eine zusammenfassende Bewertung aller empfohlenen Maßnahmen findet sich in nachfolgender Tabelle.

Tabelle 4: Bewertung der Maßnahmen

Maßnahme	Ziel	Adressat	Aufwand und Kosten	Umsetzungshorizont	Ebene der rechtlichen Umsetzung	Praktische Umsetzbarkeit	Akzeptanz	Effektivität
(M1) Schaffung von vereinfachten Meldemöglichkeiten für Verdachtsfälle illegaler Demontage	Vermeidung illegaler Demontage	Bund/Länder oder Wirtschaftsakteure	Für Schaffung einer Meldemöglichkeit (ohne Folgetätigkeiten): gering	Kurz- bis mittelfristig	Keine	Zuständigkeit zu klären sowie ggf. rechtliche Fragen (Datenschutz)	Hoch	Vereinfachte Meldemöglichkeiten (Onlineportal) können die Identifizierung von Verdachtsfällen deutlich vereinfachen. Ein Effekt stellt sich jedoch nur bei folgendem Vollzug ein.
(M2) Personell gestärkter Vollzug	Vermeidung illegaler Demontage	Behördliche Akteure auf regionaler/ kommunaler Ebene	Hoch	Kurz- bis mittelfristig	Keine	Eher fraglich aufgrund knapper Mittel bei kommunalen Akteuren	Behörden: eingeschränkt wegen zusätzlichen Aufwands / Kosten	Zahl der „erfolgreich bearbeiteten Fälle“ grob proportional zum eingesetzten Personal
(M3) Verbesserte Kooperation im Vollzug	Vermeidung illegaler Demontage	Behördliche Akteure auf regionaler/ kommunaler Ebene	Gering-Mittel	Kurz- bis mittelfristig	keine	Teilweise bereits praktiziert; teilweise eher fraglich aufgrund knapper Mittel bei kommunalen Akteuren	Behörden: eingeschränkt wegen zusätzlichen Aufwands / Kosten	Hohes Potenzial zur Verringerung illegaler Demontage.
(M4) Konkretisierung des Altfahrzeugbefriffs in AltfahrzeugV, insbesondere bzgl. Ersatzteilentnahme	Vermeidung illegaler Demontage	Bund	Gering	Mittelfristig	AltfahrzeugV	möglich	Anerkannte Demontagebetriebe: hoch Andere ersatzteilentnehmende Betriebe: niedrig	Verlagerung der Ersatzteilentnahme zu anerkannten Demontagebetrieben; Vereinfachung des Vollzugs durch klares Kriterium

Maßnahme	Ziel	Adressat	Aufwand und Kosten	Umsetzungshorizont	Ebene der rechtlichen Umsetzung	Praktische Umsetzbarkeit	Akzeptanz	Effektivität
(M5) Übertragung des Modells der Prüf-pflichten auf Abfalleigenschaft bei Online-Marktplätzen für Gebrauchtfahrzeug-handel	Vermeidung illegaler Demontage	Bund	Zusätzlicher Aufwand für Marktplätze durch neue Pflichten; Kontrollaufwand bei Behörden	Kurz – bis mittelfristig	AltfahrzeugV	Schwierig, weil leicht vollziehbare Abgrenzungskriterien schwer zu finden.	Onlinemarktplätze: gering Anerkannte Demontagebetriebe: hoch	Da die Vermarktung von Ersatzteilen zu einem großen Teil online erfolgt, wird hier bei konsequenter Umsetzung ein hohes Potenzial zur Verringerung illegaler Demontage gesehen.
(M6) „Stärkung des Verwertungsnach-weises“	Lenkung in die anerkannte Altfahrzeug-verwertung	Bund / EU	Zusätzlicher Aufwand bei Änderung des Kfz-Zulassungs-systems; geringerer Auf-wand für Vollzug gegen illegale Demontage	Mittelfristig	Fahrzeug-zulassungs-verordnung u.a.; Altfahrzeug-Richtlinie	Änderung des Kfz-Zulassungssystems auf deutscher Ebene nicht leicht, da neue Routinen und Nachweise entwickelt werden müssen, auf EU-Ebene schwierig wegen tlw. fehlender EU-Zuständigkeit	Anerkannte De-montagebetriebe und Fahrzeughersteller: hoch.	Sehr wirksam, wenn im Zusammenspiel mit dem Kfz-Zulassungs- bzw. Abmeldesystem. Dagegen als singuläre Maßnahme kaum wirksam.
(M7) Stärkung der Produktver-antwortung	Stärkung der finanziellen Tragfähigkeit der legalen Autoverwertung	Bund / EU	Nur Verlagerung der Kosten; keine zusätzlichen Kosten	Eher mittel- bis langfristig	Altfahrzeug-RL	möglich	Bei Herstellern und Demontagebetrieben fraglich	Finanzierungssicherheit von Demontageaktivitäten würde sichergestellt; zusätzliche ökologisch vorteilhafte Demontageaktivitäten könnten finanziert werden

1 Background and goals of the study

The transfer, return and environmentally sound disposal of end-of-life vehicles in Germany are regulated by the EC End-of-Life Vehicles Directive and the German End-of-Life Vehicles Ordinance. According to the Federal Statistical Office (Destatis 2020), around half a million end-of-life vehicles are accepted for treatment in authorised dismantling facilities in Germany every year. The accounting of the whereabouts of vehicles finally decommissioned in Germany, results in a statistical gap of vehicles with unknown whereabouts. This accounting is based on export estimates and statistical figures on authorised ELV treatment. Reporting on the dismantling and fate of end-of-life vehicles is carried out annually by UBA and BMUV.

A study by Sander et al. (2017) commissioned by the UBA concluded that the majority of vehicles with unknown whereabouts are dismantled in illegal dismantling facilities or are exported notwithstanding waste shipment law. This estimate has been updated based on the observations made in this project, confirming the relevance of illegal dismantling.

Against this background, the objective of the research performed in this project was to quantify the ecological and economic impacts of illegal end-of-life vehicle disposal and the illegal export of end-of-life vehicles, as well as to evaluate the situation and derive suitable measures.

In this regard, the following hypothesis concerning non authorized dismantling and illegal exports are evaluated:

- The unauthorized dismantling and illegal export of end-of-life vehicles can be associated with significant negative environmental and economic risks and can impair the effectiveness and economic viability of the authorized dismantling of end-of-life vehicles. Examples of possible environmental risks include the discharge of waste oil and other operating fluids into the soil or water bodies, and the release of climate-relevant refrigerants into the environment.
- The pressure resulting from competition with unauthorized dismantling facilities and illegal export also affects the profitability of ATFs and limits the economic feasibility of activities such as higher-value recycling, e.g. dismantling of glass and large plastic components.
- Furthermore, the unauthorized dismantling and illegal export of end-of-life vehicles also cause negative macro economic effects, which include environmental costs as well as losses in tax revenue and social contributions.

The context of the planned use of the results is, in addition to the creation of a data and knowledge base, to provide an input to the process of revising the EU End-of-Life Vehicles Directive and the subsequent implementation in national law as well as the discussions on the further development of producer responsibility and high-quality end-of-life vehicle recycling

2 Cost balance of the authorized treatment of end-of-life-vehicles

In this section, the results of the analyses of the cost balance of authorized treatment of end-of-life vehicles are presented. The analyses are divided into an examination of the cost balance of authorized treatment facilities (ATF) and of shredder plants. In a following step, possible future developments of the cost and revenue situation of ELV dismantling and recycling are considered.

2.1 Authorized Dismantling Facilities

In this step, the costs and revenues of the treatment of end-of-life vehicles in ATF are determined. The costs and revenues are presented in a differentiated manner and converted into a specific amount per end-of-life vehicle or as annual costs.

2.1.1 Structural diversity and business models of ATF

The sector of authorised end-of-life vehicle treatment facilities is very diverse. In 2018, 1,154 ATFs were certified under the German ELV Ordinance. The ATFs differ in size and main business activities. The range of throughputs lies between less than 250 ELVs per year (or less than five ELVs per week) and several thousand ELVs per year. In 2018, 565,033 ELVs were accepted by 1,154 ATFs, which equates to an average of 490 ELVs/ATF.

The throughput volumes vary from less than 250 vehicles per year (or less than five end-of-life vehicles per week) to several thousand vehicles per anno (see Figure 8, Figure 9).

Figure 8: Development of number of end-of-life vehicle and dismantling facilities

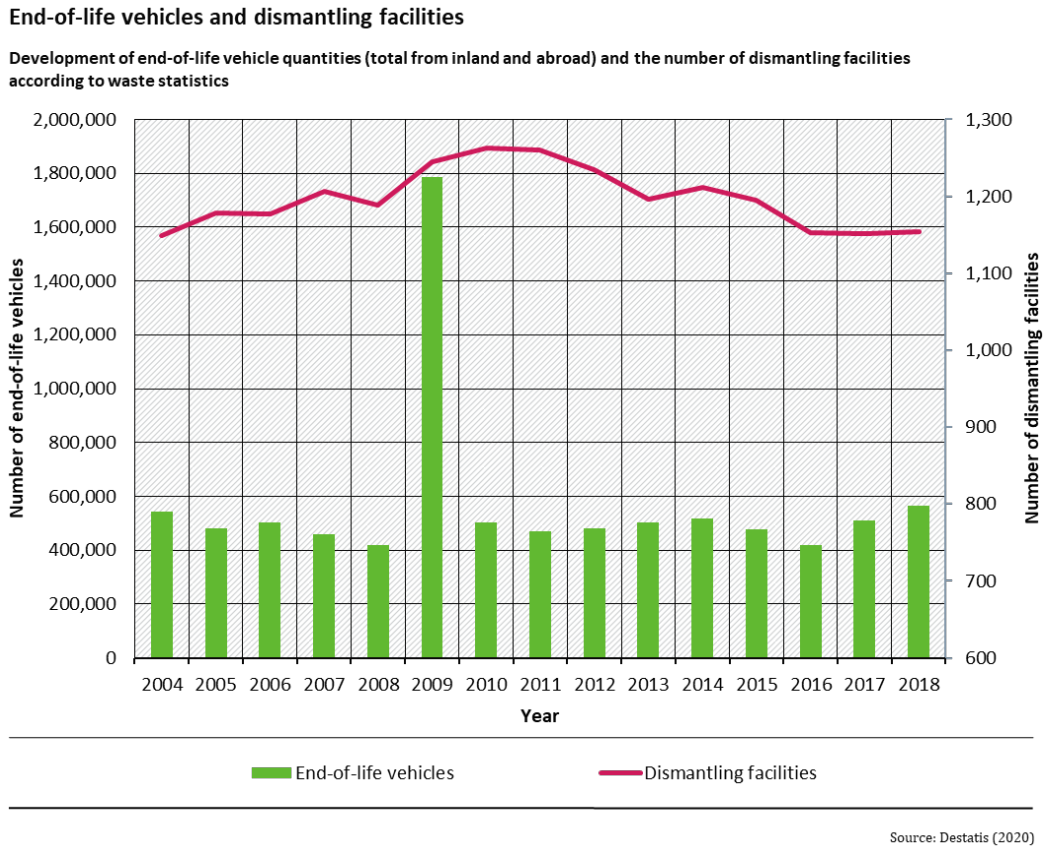
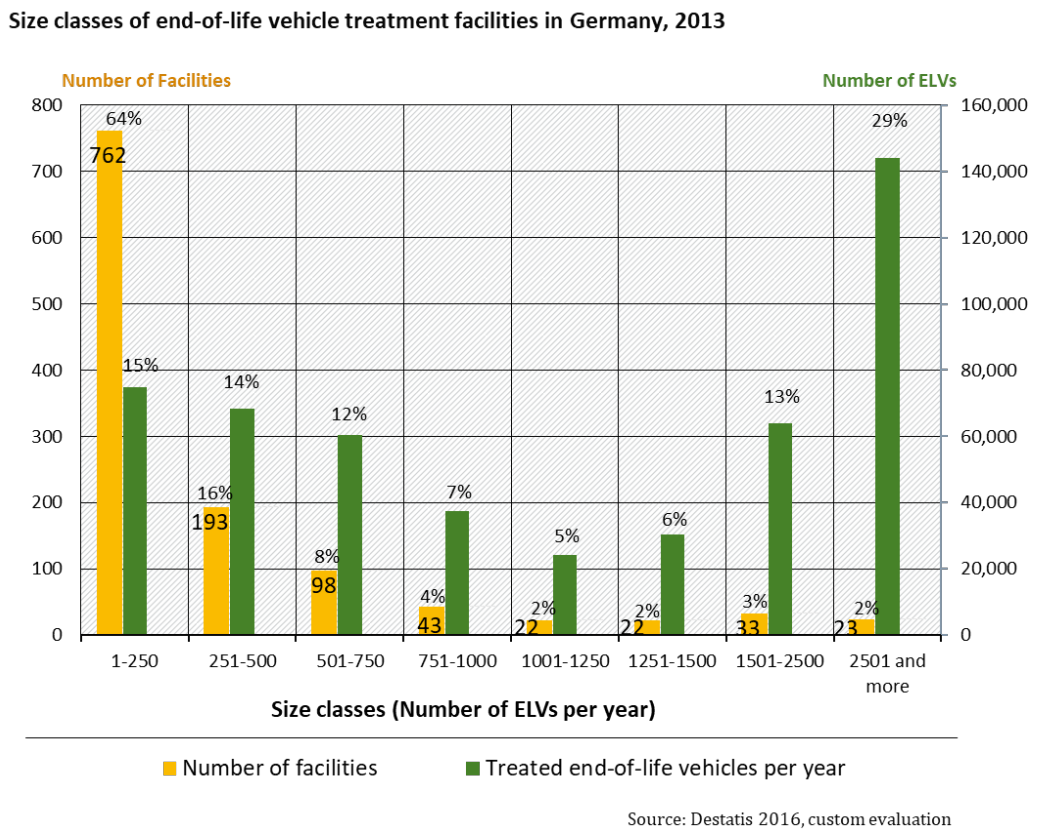


Figure 9: Size classes of end-of-life vehicle treatment facilities in Germany, 2013



Many ATFs maintain other business areas in parallel, which lead to synergy effects such as:

- Trade in new spare parts from non-OEMs,
- Trade in used full vehicles (accident-free and accident-damaged including salvage vehicles),
- Automotive repair (workshops),
- Towing and/or container services (which additionally take over the logistics of recyclables to the shredder or metal processor),
- Metal trade.

Complementary business fields are necessary, especially for ATF with very low end-of-life vehicle throughput, in order to be able to work profitably.

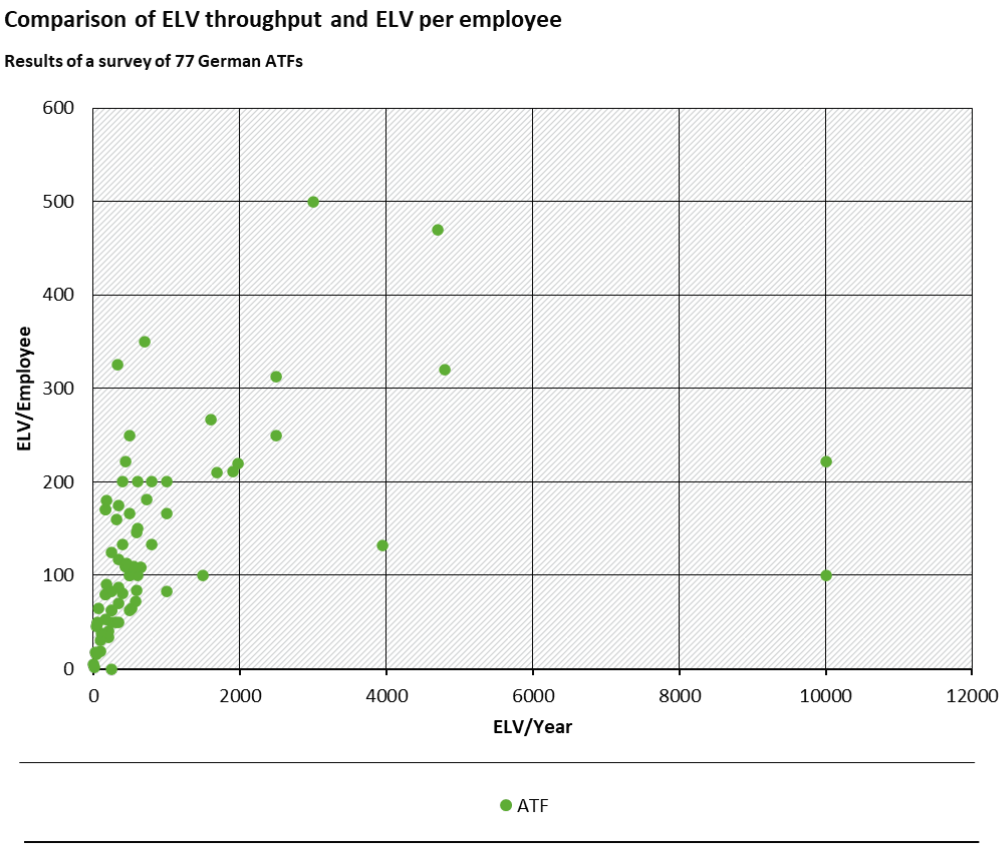
Shredders sometimes provide the service of "end-of-life vehicle dismantling" in addition to their main business. Due to the existing infrastructure and the required recognition according to the End-of-Life Vehicles Ordinance (AltfahrzeugV) for the shredder activity, the recognition of dismantling according to the End-of-Life Vehicles Ordinance can be realized with relatively little effort.

In the scenarios examined, the core business of the recognized dismantling companies is considered. A further diversification by other business areas would not lead to results that would show an appropriate balance between relevance and effort in the context of the revision of the ELV Directive.

The analyses of the cost and revenue situation have also shown that there are relevant differences between the various actors in authorised dismantling, especially with regard to the necessary personnel deployment. For example, treatment times and the share of productive/unproductive times in the working time can differ between the ATFs. This can be due to the specific business model (e.g. depth of dismantling, focus on certain vehicle types) as well as the size of the company, i.e. there is a correlation between the total number of ELVs treated annually and the number of ELVs treated annually per employee.

A survey of dismantling companies has shown that there is a correlation between the total number of end-of-life vehicles treated per year and the number of end-of-life vehicles treated per employee per year, even if there are some "outliers" (see Figure 12).

Figure 10: Annual number of ELVs treated per employee vs. total annual number of ELVs treated



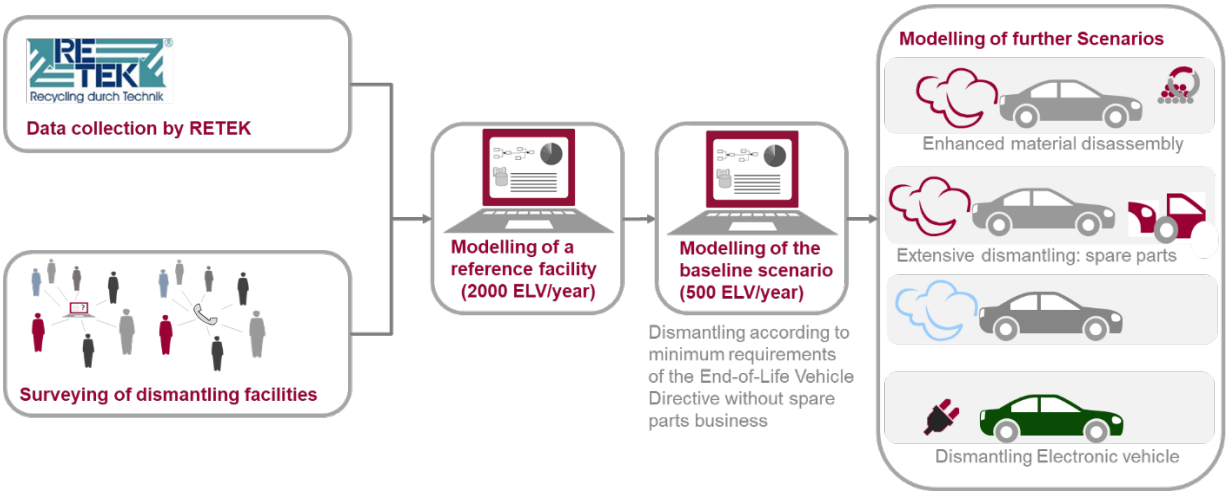
Source: Survey by RETEK, 2020

2.1.2 Approach

The approach to determine the costs and revenues of the authorized dismantling consists of several steps (see Figure 11).

The starting point for the analysis is the cost and revenue situation at RETEK. The specific cost and revenue structures of RETEK AG are supplemented by findings from surveys and discussions with other regionally and structurally divergent ATF. The data collection is mainly carried out for the fiscal years 2019 and 2020. Based on these two information accesses, the modelling of a reference operation with a throughput of 2000 end-of-life vehicles per year is then carried out. The baseline scenario builds on the model of the reference scenario. It forms the starting point for the development of the other scenarios and includes only the minimum dismantling required by the End-of-Life Vehicles Ordinance. The throughput of the baseline scenario and the other scenarios based on it is set at 500 ELV/a in line with the average size of recognized dismantling operations in Germany.

Figure 11: Visualisation of the data collection procedure towards the cost and revenue situation of legal dismantling facilities



Source: Ökopol

The variety of structures and business models in authorised treatment facilities was taken into account by considering different scenarios of ELV treatment, as listed and characterized in Table 5. Compared with the baseline scenario, the further scenarios cover business models with extended dismantling (plastics, glass, metals, spare parts) as well as the treatment of ELVs with alternative fuels (electric vehicles, gas vehicles).

Table 5: Scenarios of ELV treatment

Scenario	Characterisation
Baseline	▶ 500 ELVs per year ▶ treatment of ELVs with combustion engines ▶ in accordance with the minimum legal requirements: depollution, dismantling, logistics ▶ without dismantling of plastics and glass ▶ without dismantling of spare parts
Plastics	▶ Baseline + dismantling of large plastics components: front and rear bumper, wheel arch closures
Glass	▶ Baseline + dismantling of vehicle glass: Laminated safety glass: windscreen glass, door glass. Toughened safety glass: fixed side windows, rear screen glass
Spare Parts + Metal	▶ Baseline + dismantling of spare parts by ATF staff + dismantling of metal components: engine, starter motor, gear box, axles; alternator; copper components
Electric vehicles	▶ Baseline, but exclusively electric vehicles instead of conventional ELVs: mainly: battery instead of fuel tank, no catalytic converter, no engine oil, less gear box oil

Scenario	Characterisation
Gas vehicles	► Baseline, but exclusively CNG/ LPG instead of conventional ELVs gas tank instead of fuel tank

RETEK AG's cost and revenue situation has been the starting point for the analysis. This basis has been complemented by findings from surveys and discussions with other regionally and structurally divergent authorised treatment facilities.

Operating times vary from ATF to ATF and even from ELV to ELV depending on, e.g., model, condition, and equipment. So do the market prices for spare parts, valuable components, and waste disposal. The authors defined average values, validated by expert judgement.

2.1.3 Costs and revenues in the baseline scenario

The following types of costs and revenues have been considered in this evaluation:

- Labour costs: largely determined by the dismantling times.
- System costs: costs subject to, amongst others: formalities related to registration of the business, the provision of specialist knowledge or periodic inspections.
- Depreciation costs: involves the value reduction of investments over time, such as equipment and machinery.
- Insurance costs: are fixed costs resulting from obligatory or voluntary insurances, like: liability insurance or industrial property insurance.
- Taxes: e.g., amongst others: vehicle tax, property tax or business tax. (Note: income tax of employees is included in labour costs.)
- Costs for ELV purchase and recovery or disposal of separated materials, components and waste.
- Revenues from the recovery of separated/ dismantled materials and components, the sale of spare parts and stripped vehicle hulks.
- Further/ other costs: involve, amongst others: logistics, administrative or cleaning costs.

2.1.3.1 Dismantling times and labour costs

The cost situation in the baseline scenario is predominantly determined by labour costs (-163 €/ELV). Therefore, the durations of the individual work steps are shown in Table 6. To calculate the dismantling costs, the handling times were multiplied with the labour cost rates, but only considering the real “productive time”, see Table 7. Labour costs may vary among the Member States.

Table 6: Extract from the time determination carried out for operational commercial activities for end-of-life vehicle treatment and administrative activities in the baseline scenario

Subject to ELV Directive	Position	Average handling time in min/ELV	Remarks
Acquisition and preparation	ELV acquisition, assessment and labelling, organisation and set-up time and internal logistics	16	
Depollution Annex I ELV Directive, No. 3	Removal of batteries	6	Lead-acid batteries: Wide range of dismantling times, between 3 min. to 15 min.
	Oil filter disassembly	2	
	Removal and neutralisation of pyrotechnics or detonation in the vehicle	15	Mean value based on own dismantling experience and supplementary validation.
	Oil removal (engine, gearbox, steering gear, differential if applicable, transfer case)	18	Parallel processes
	Removal of shock absorber oil	16	When not a potential spare part
	Refrigerant removal (only connect and disconnect the unit)	5 (6 minutes * 75 %)	Currently - according to the stakeholder survey - only in about 75 % of ELVs, therefore, weighted handling times
	Removal of other fluids	24	Brake fluid (incl. clutch slave cylinder), coolant, windshield washer fluid and fuel (strongly fill level dependent, 6 min. regarded as average)
Dismantling Annex I ELV Directive No. 4	Removal of four wheels and spare wheel and Wheel logistics	14	
	Further dismantling of five tyres from rim (without wheel press)	10	When not potential spare parts
	Removal of catalytic converter	8	
	Transport to stripped vehicle storage area and loading for transport	5	
	Sum	**139**	**= -153 €/ELV labour costs**
Administration for ELV Directive	Administration	9	For example: Issuing of CoD, waste statistics, documentation
	Total baseline scenario	**148**	**= -163 €/ELV labour costs**

Table 7: Labour cost rates for the calculation of ELV treatment costs in German ATFs, 2019/2020

	1 Full time equivalent	„Productive time“
Working hours	1,612 hours/year	548 hours/year (34 %)
Gross labour costs	20 to 38 €/hour	50 to 90 €/hour$_{productive}$

2.1.3.2 Further costs and revenues

For the baseline scenario, the average cost of purchasing ELVs was estimated at 30 €/ELV. The revenues (or costs) for a couple of dismantled components or materials are shown in Table 8. Furthermore, the high technical standards in ATFs respectively the system costs have a significant impact on the cost situation. These are, for example, 13 €/ELV for the facilities including the oil-impermeable surfaces as well as 5 €/ELV for de-pollution equipment. Further types of costs are shown in section 2.1.3.3.

Table 8: Average costs and revenues for dismantled/separated components and materials in the baseline scenario, 2019/2020

Material	Recovery costs (–) or revenues (+) per ELV
Lead-acid battery	+ 8 €
Refrigerant	0 €
Waste oil and other fluids	0 € (1)
Oil filter	- 0.07 €
Tyres	0 € (2)
Catalyst	+ 138 €
Rims (80 % steel, 20 % Al)	+ 21 €
Hulk, stripped vehicle	+ 101 €
SUM	+ 268 €

(1) Depending on the amount, waste oils are collected at site by specialized recyclers against a small fee or revenue.

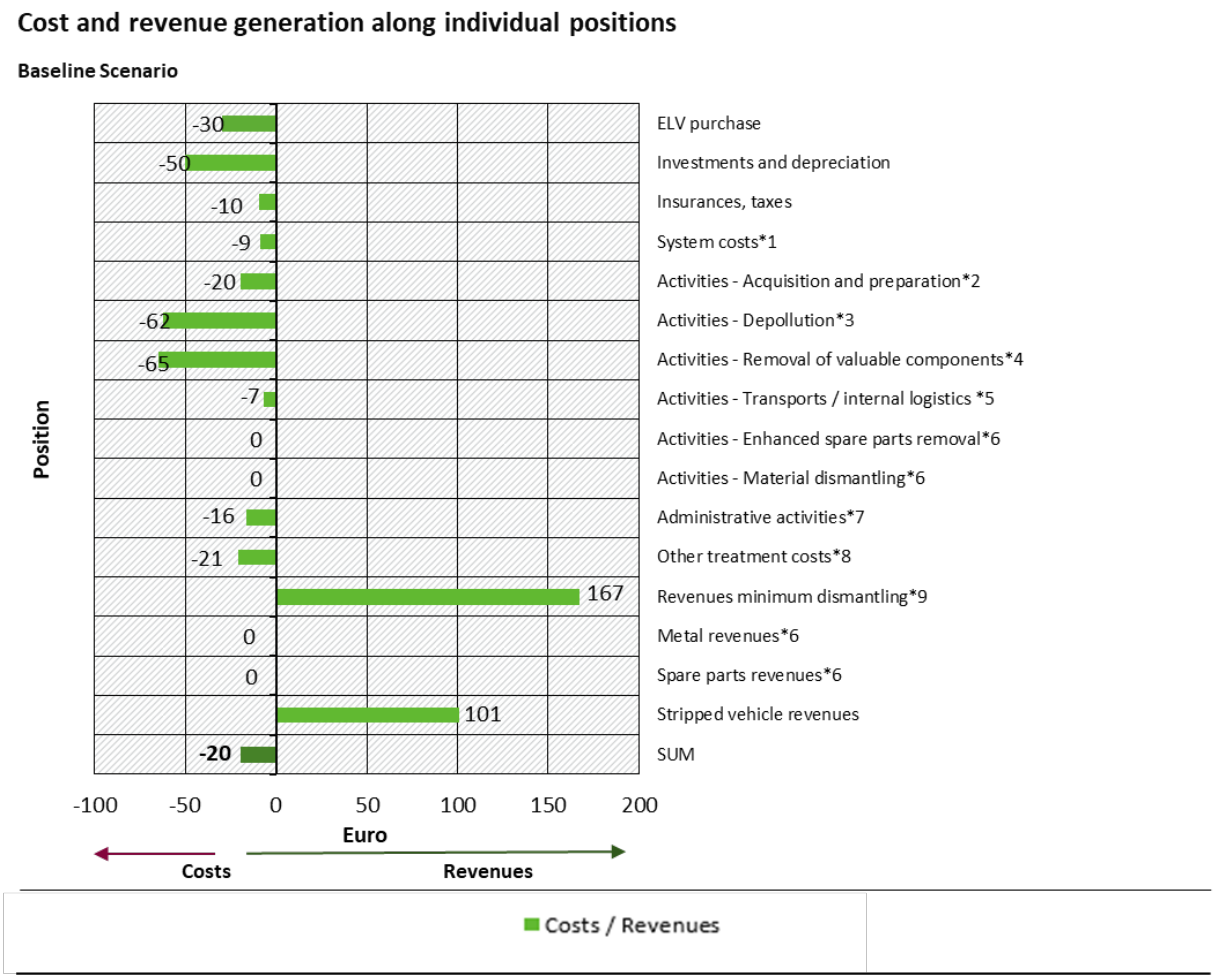
(2) As a result of 25% reuse, 25% refurbishment and 50% energy recovery of the tyres.

The revenues in the baseline scenario are mainly determined by the catalyst (138.47 €/ELV or 23,078 €/t for a mix of 93 % ceramic catalysts and 7 % metal catalysts) and by the rims (21 €/ELV for an average mix of 80 % steel rims and 20 % aluminium rims). In addition, the lead-acid battery contributes 8 €/ELV to the total revenue from material sales.

2.1.3.3 Result for baseline scenario

For the baseline scenario (“minimum dismantling” without separation of spare parts), the costs and revenues are shown in Figure 12. In total, this results in costs of 20 €/ELV, i.e. the average revenues of German ATFs in the baseline scenario do not cover the average costs for the ELV treatment.

Figure 12: Costs and revenues per ELV in German ATFs in the baseline scenario



*1 System costs: Compulsory membership, duties for operating an end-of-life vehicle and waste treatment plant, functional and leak tests
*2 Vehicle acquisition, classification, assessment and labelling, organisation and set-up time, oil filter removal
*3 Depollution: Extraction of fluids
*4 Removal of battery, removal of wheels, wheel logistics, removal of catalytic converter, fuel removal
*5 Transport to the stripped vehicle storage area, loading to the shredder, other logistics
*6 No enhanced spare parts removal and no material dismantling in baseline scenario.
*7 Administrative activities: Statistics etc., external accounting, advertising costs
*8 Other treatment costs: Disposal, operating materials, cleaning, etc.
*9 Lead-acid battery, tyres, steel rims, aluminium rims, catalytic converter
Source: RETEK / Ökopol

2.1.4 Further scenarios

This section describes differences in costs and revenues of the further scenarios of ELV treatment compared to the baseline scenario. A general description of the scenarios is given in Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**, more technical details can be found in sections 2.1.4.2 to 2.1.4.5, the results of the cost-revenue analysis are given in Chapter 2.1.5.

2.1.4.1 Overview labour costs and recovery costs/ revenues

Due to the significant influence of labour costs on the overall economic result of end-of-life vehicle treatment, Table 9 shows an overview of this cost factor for the additional treatment and dismantling steps in the scenarios in comparison to the "Baseline Scenario".

Table 9: Additional treatment /handling time of ELVs in German ATFs and costs in the individual scenarios

Scenario	Position	Average additional handling time in min/ELV	Additional treatment/ handling costs per ELV per scenario	Remarks
Plastic dismantling	Separation of large plastic parts	52	Sum: -57 €	Front bumper, rear bumper and wheel housing liners
Glass dismantling	Separation of large glass parts	91	Sum: -100 €	Front, side and rear windows; exemplary case for high effort dismantling; other ELV and other dismantling approaches may result in lower efforts
Spare parts removal	Removal of spare parts by ATF staff	112		200 kg of spare parts dismantled
and metal dismantling	Dismantling of the drive unit	3		
	Further dismantling of axles, engine, and starter motor. Rest: gearbox (no additional dismantling time),	9		
	Alternator dismantling	3	Sum: -136 €	
Electric vehicle	Classification of the HV vehicle & battery	5		
	Removal of HV battery	90		
	Omitted steps of the baseline scenario	- 25	Sum: -79	Otherwise in the baseline scenario removal of: Catalytic converter, fuels, oil filter. And reduced time for removal of radiator fluid and transmission oil, see Table 11
Gas vehicle	Classification of the vehicle	5		
	Removal and draining of the gas tank	30		

Scenario	Position	Average additional handling time in min/ELV	Additional treatment/ handling costs per ELV per scenario	Remarks
	Omitted steps of the baseline scenario	- 1	Sum: -37 €	Reduced time for fuel removal (5 instead of 6 minutes)

Source: Data are based on practical experience and findings of RETEK AG.

The materials separated in the respective scenarios have to be recovered. The dismantled plastics, e.g., have a positive value, but the glass has a slightly negative value, see Table 10. It has to be considered that the revenues for the stripped vehicle will be reduced compared with the baseline scenario by the amount of dismantled materials.

Table 10: Average costs and revenues for dismantled/separated components and materials in the further scenarios, 2019/2020

Scenario	Separated material	Costs (–) and revenues (+) for material recovery [Euro/tonne]	Costs (–) and revenues (+) for material recovery [Euro/ELV]
Plastics dismantling	16 kg plastics (- 16 kg stripped vehicle*)	+ 160 €/t - 110 €/t	+ 2.56 €/ELV - 1.76 €/ELV
Glass dismantling	38 kg glass (- 38 kg stripped vehicle*)	- 10 €/t - 110 €/t	- 0.38 €/ELV - 4.18 €/ELV
Spare parts + metals	200 kg spare parts; 240 kg metal parts (-440 kg stripped vehicle*)		+ 500 €/ELV + 84 €/ELV - 58 €/ELV
Electric vehicle	HV battery; (- omitted steps of baseline scenario, e.g. no catalyst etc.)		0 €/ELV - 146 €/ELV

* The revenues for the stripped vehicles are reduced because it is lighter after dismantling.

2.1.4.2 Dismantling of plastics and glass

Since in many German ATFs large plastic parts and the glass panes are not dismantled, exemplary dismantling activities were carried out to obtain information (Figure 13).

Figure 13: Dismantling of glass and plastic (bumper) from ELVs

Source: RETEK

For the "Dismantling of Plastics" scenario, in addition to meeting the minimum requirements of the "Baseline Scenario", 16 kg of plastic was dismantled. It comprised the dismantling of the front and rear bumpers and the wheel arch closures. Increased labour costs of additionally 67 €/ELV result from the additional treatment time of +52 minutes compared with the "Baseline Scenario".

Revenues from selling the dismantled plastics have been 160 €/t. In the current practice, in which low-plastic stripped vehicles are not being paid differently at the shredder than high-plastic ones, a reduced revenue from the lighter stripped vehicle (110 €/t) must be offset accordingly.

In the "Dismantling of Glass" scenario, 38 kg of glass was dismantled beyond the "Baseline Scenario". The additional labour costs for dismantling of glass increased by 102 €/ELV. The extra dismantling time of 91 minutes per ELV represents an exemplary case with high efforts:

- The investigated ELV was equipped with laminated safety glass. Therefore, the door glass had to be manually disassembled instead of breaking the glass by means of a destructive approach.
- The windscreen was completely removed using a cutting wire.

ELVs with less or different glass or the application of other removal techniques may result in lower dismantling times and labour costs.

In the case of glass removal, an additional payment of 10 €/t must be made for recycling; at the same time, the revenues for the stripped vehicles from weight removal (38 kg/ELV) are slightly reduced by -4 €/ELV.

2.1.4.3 Spare parts extraction and metal dismantling

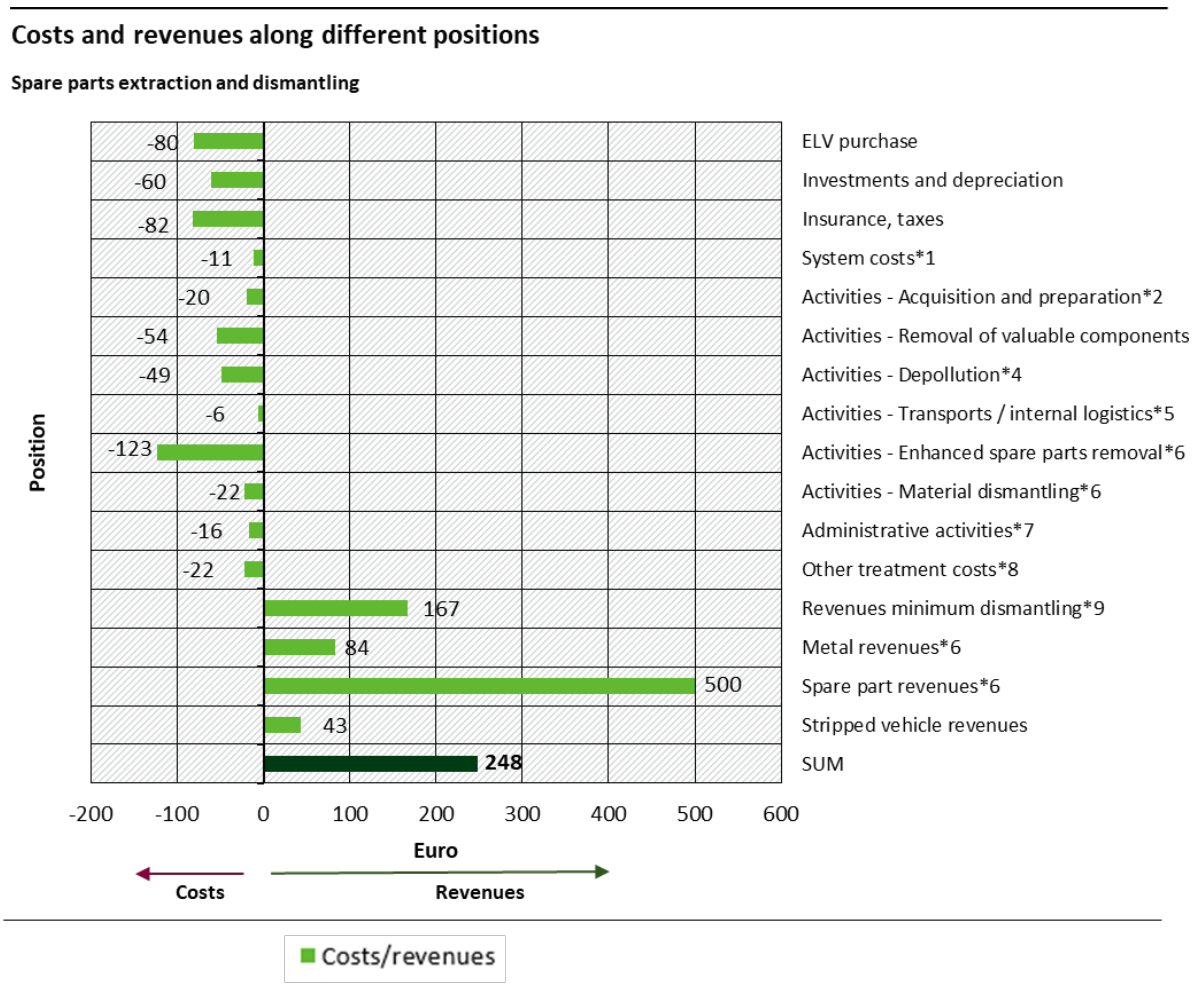
The "Spare parts extraction and metal dismantling" scenario includes the extraction of 200 kg of spare parts and the extensive removal of metals in addition to meeting the minimum requirements of the "Baseline Scenario". Surveys conducted by RETEK in 2014 and 2020 serve as the basis for determining the costs and revenues from the dismantling and distribution of spare parts. The survey conducted in 2020 showed that, while 29 % of the ATFs surveyed are

material-oriented (focus on revenues from catalysts, stripped vehicles etc., see Table 8), the larger share of 71 % work in a spare parts-oriented manner.

The biggest additional costs in this scenario compared with the "Baseline Scenario" are the increased labour costs (+112 minutes for spare parts + 15 minutes for metal parts, resulting in costs of +136 €/ELV, see Table 9), the increase in insurances and taxes and acquisition costs of the ELV (80 € instead of 30 € per ELV). The dismantled spare parts and metals generate additional revenues of 500 € + 84 € per ELV, however reduce the weight of the stripped ELV and thereby the revenues from its sale by 58 €, see Table 10.

It can be seen that, in contrast to the other scenarios, spare parts extraction means that a profit can be made with a throughput of 500 ELVs per year. The "Spare parts extraction + metal dismantling" scenario returns an average total profit of 248 € per ELV (see Figure 14).

Figure 14: Costs and revenues for the Scenario „Spare parts extraction and metal dismantling"



Source: RETEK / Ökopol

*1 System costs: Compulsory membership, duties for operating an end-of-life vehicle and waste treatment plant, functional and leak tests

*2 Vehicle acquisition, classification, assessment and labelling, organisation and set-up time, oil filter removal

*3 Depollution: Extraction of fluids

*4 Removal of battery, removal of wheels, wheel logistics, removal of catalytic converter, fuel removal

*5 Transport to the stripped vehicle storage area, loading to the shredder, other logistics

*6 No enhanced spare parts removal and no material dismantling in baseline scenario.

*7 Administrative activities: Statistics etc., external accounting, advertising costs

*8 Other treatment costs: Disposal, operating materials, cleaning, etc.

*9 Lead-acid battery, tyres, steel rims, aluminium rims, catalytic converter
Source: RETEK / Ökopol

2.1.4.4 Electric vehicles

In the "electric vehicle" scenario, it is assumed that all ELVs treated are electric vehicles.

This takes into account that, in contrast to the other scenarios, no acquisition costs are paid for the ELV (otherwise 30 €/ELV). The scenario is characterised by the increased labour costs determined by the removal of the traction battery (90 minutes per ELV) (see the overview of treatment times in Table 11 and Table 9). Furthermore, the revenue from the sale of the catalytic converters (138 €/ELV) is omitted. At the same time, increased treatment and system costs are incurred because additional training has to be carried out and specific tools have to be purchased. With a throughput of 500 electric ELVs per year, the additional system costs and investments per ELV are comparatively low (12 €/ELV compared to the baseline scenario). The standard throughput of 500 ELV/year applied in the scenarios results in costs that exceed the revenues by 234 €/ELV.

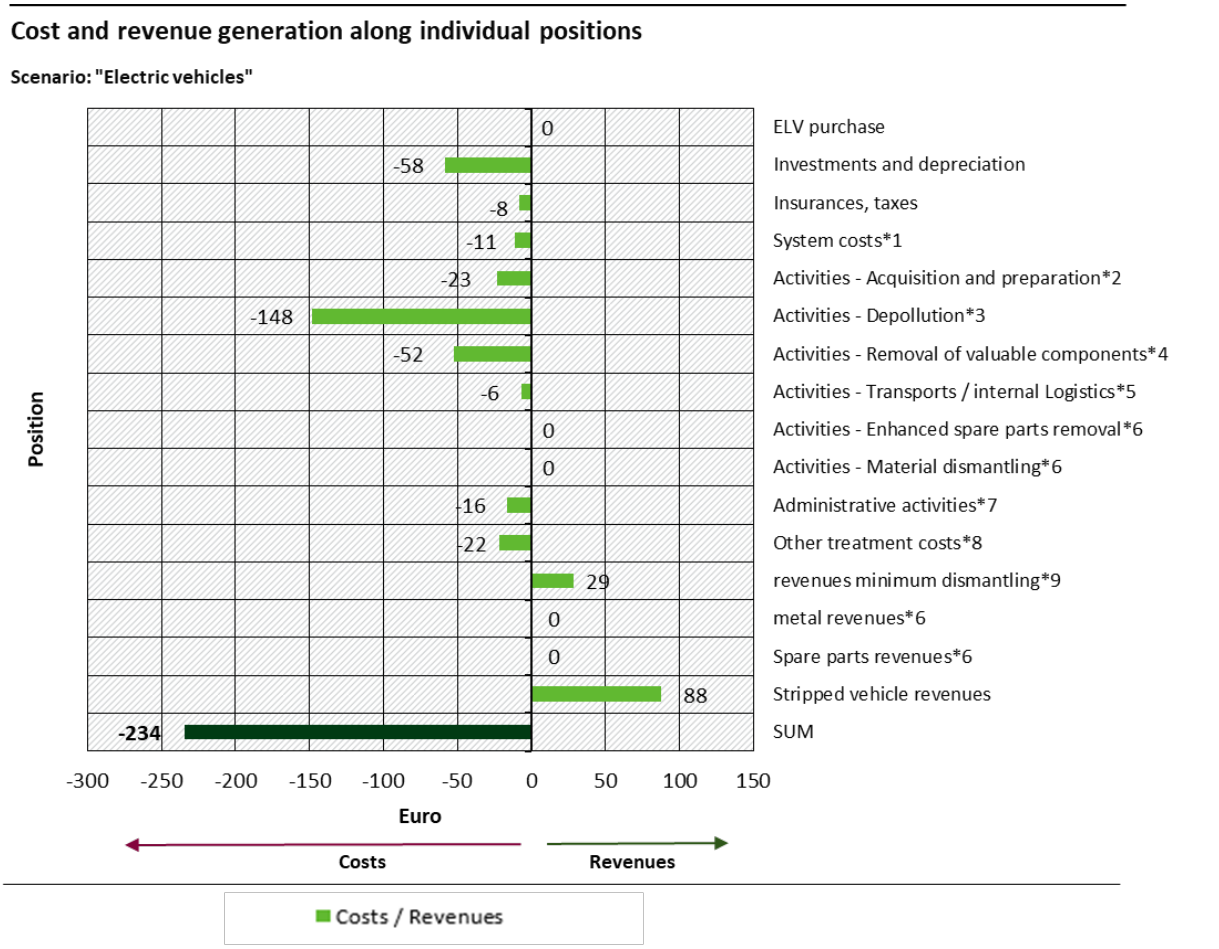
Realistically, however, the number of electric ELVs entering ATF will still be low in the first years resulting in significantly higher specific training and investment costs per electric ELV. Modelling this situation showed that the total costs in this scenario were -631 €/ELV for a throughput of 5 electric ELVs per year and -405 €/ELV for a throughput of 10 electric ELVs per year.

Table 11: Specific treatment times for the "Electric Vehicle" scenario compared with the "Baseline Scenario"

Treatment step	Treatment time in "Electric vehicle scenario" in minutes	Reference: Treatment time in "Baseline Scenario", in minutes	Difference "Electric vehicle" – "Baseline Scenario", in minutes
Classification of the HV vehicle & batteries	5	0	+ 5
Removal of HV battery and re-check	90	0	+ 90
Oil filter removal	0	2	- 2
Removal of gear oil (reduced time compared to combustion engine)	10	18	- 8
Removal radiator coolant (reduced, as time parallel to removal of battery)	5	6	- 1
Removal of fuel	0	6	- 6
Catalytic converter: removal and proceeds on delivery to recycler	0	8	- 8
Sum			**+ 70**

Source: Data based on RETEK AG's practical experience

Figure 15: Costs and revenues for the scenario „electric vehicles“



Source: RETEK / Ökopol

*1 System costs: Compulsory membership, duties for operating an end-of-life vehicle and waste treatment plant, functional and leak tests
*2 Vehicle acquisition, classification, assessment and labelling, organisation and set-up time, oil filter removal
*3 Depollution: Extraction of fluids
*4 Removal of battery, removal of wheels, wheel logistics, removal of catalytic converter, fuel removal
*5 Transport to the stripped vehicle storage area, loading to the shredder, other logistics
*6 No enhanced spare parts removal and no material dismantling in baseline scenario.
*7 Administrative activities: Statistics etc., external accounting, advertising costs
*8 Other treatment costs: Disposal, operating materials, cleaning, etc.
*9 Lead-acid battery, tyres, steel rims, aluminium rims, catalytic converter
Source: RETEK / Ökopol

2.1.4.5 Gas vehicles

The modelling in this scenario assumes that only gas-powered ELVs are treated. A requirement for the treatment of gas-powered cars is the professional qualification of the employees. This is the main reason for the system costs being 10 % higher than in the “Baseline Scenario”. Additional investments (specific tools and a plant for recovering or flaring the gas) result in 5 % higher depreciation costs compared to the “Baseline Scenario”. For treatment times and costs see Table 9. Revenues are in the same order of magnitude (+1 %) as in the baseline scenario. Overall, the operating result in the "Gas vehicle” scenario shows costs that are 40 €/ELV higher than in the “Baseline Scenario”.

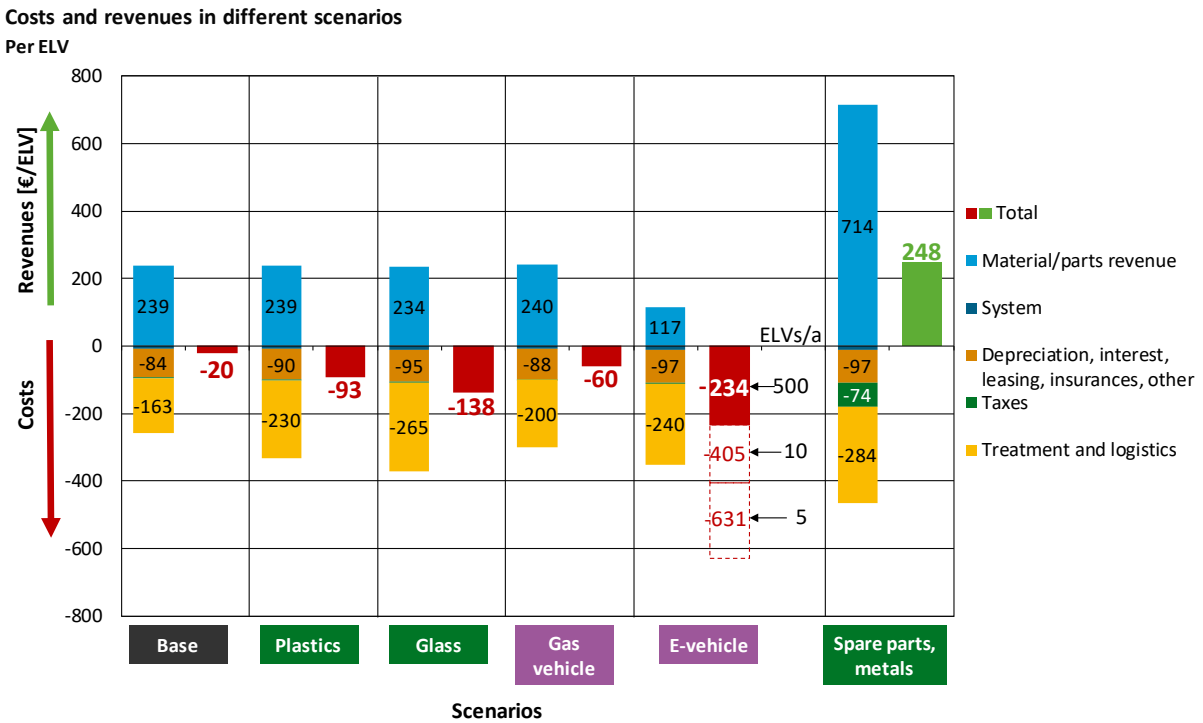
2.1.5 Costs and revenues in the scenarios

The overview of costs and revenues of the ELV treatment in German ATFs in the scenarios in Figure 16 shows that the scenarios differ from the baseline scenario (Figure 12) regarding costs and revenues. With a throughput of 500 ELV/a, a positive operating result is only achieved in the scenario with spare parts extraction, while ELV dismantling in the baseline scenario (i.e. without spare parts extraction) turned out not to be profitable. The average costs amount to around 20 €/ELV on average. In the high-quality recycling scenarios with separation and recycling of glass and plastics, the costs increase even further by additional 70 or 100 €, mainly due to the labour costs.

Table 12: Overview of costs and revenues in the different scenarios [€/AFZ]

Position	Baseline	Metall dismantling	Plastics dismantling	Glas dismantling	Spare parts	Spare parts and metal dismantling	Electric vehicle	Gas vehicles
Systemcosts	-9	-9	-10	-11	-11	-11	-11	-10
Investments, depreciation	-48	-50	-52	-56	-56	-58	-58	-51
Leasing	-2	-2	-2	-2	-2	-2	-2	-2
Insurance	-7	-8	-8	-8	-8	-8	-8	-8
Taxes	-2	-2	-2	-2	-66	-74	-2	-2
Other	-28	-28	-28	-29	-30	-30	-29	-28
Treatment	-162	-184	-219	-262	-261	-283	-239	-199
Transport/ internal logistics	-1	-1	-11	-3	-1	-1	-1	-1
Material/ spare parts revenues	239	272	239	234	656	714	117	240
Sum	**-20**	**-11**	**-93**	**-138**	**222**	**248**	**-234**	**-60**

Figure 16: Cost and revenue of ELV treatment in German authorised treatment facilities per ELV, throughput of 500 ELV/a, average prices of 2019/2020



Scenarios see Table 5, detailed results of baseline scenario see Figure 12.
Source: Calculations by Ökopol and RETEK

When it comes to electric vehicles or gas vehicles, additional costs arise for investments and staff training. The treatment of e-vehicles is economically determined primarily by the treatment costs, the lack of revenue from the catalytic converter, the increased system costs due to the additional training, and increased depreciation for investments in specific tools and investment. In the case of low ELV throughputs, revenues from the sale of traction batteries (e.g. for a second use) could only compensate for the losses if, for example, in the case of 10 electric ELVs per year, more than 405€ would be earned per second-hand traction battery (corresponding to 900€/t). No information was available on whether this is currently realistic for used batteries from end-of-life vehicles.

The disposal of e-cars is economically determined mainly by the treatment costs - by the lack of revenues from the catalytic converter, the increased system costs due to the additional advanced training, and increased depreciation.

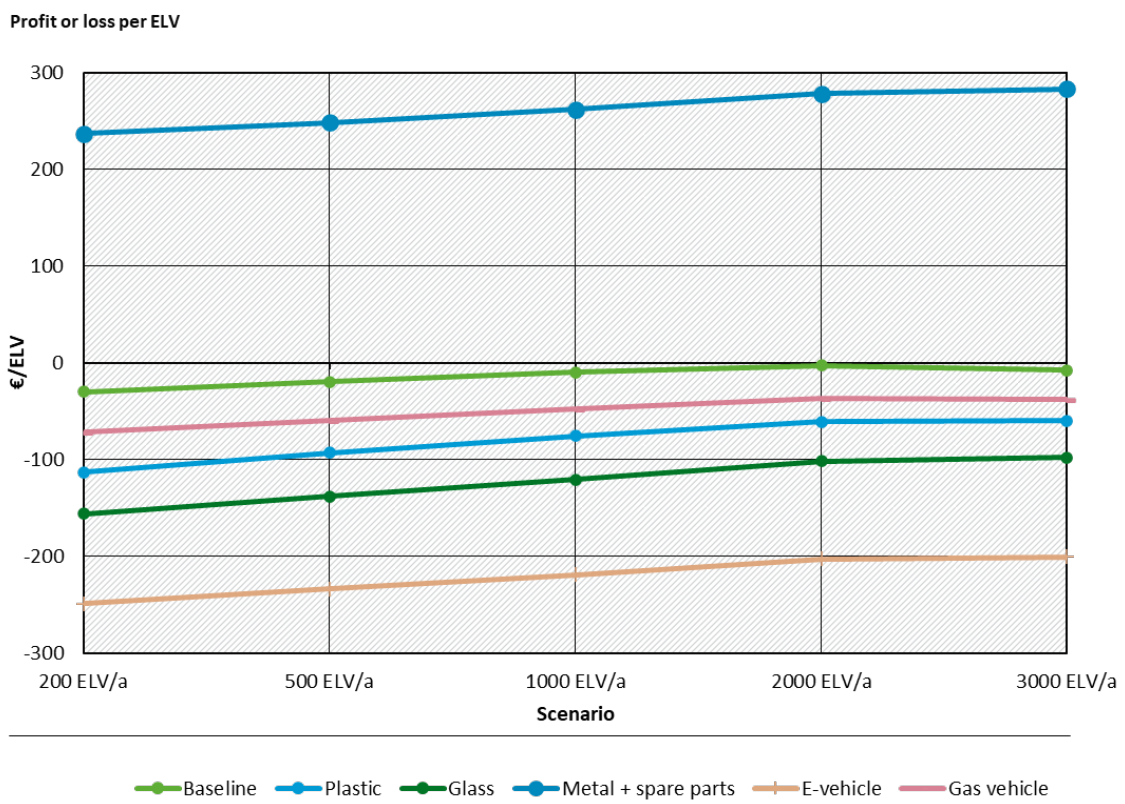
The "gas cars" scenario shows higher costs in treatment times (mainly due to the removal of the gas tank) and in system costs due to the need for additional advanced training.

In all scenarios, logistics costs show the smallest share of total costs per module. This is mainly because the most mass-relevant parts of the vehicles are picked up free station.

2.1.6 Throughput variation

The operating results also depend on the size of the ATF or the ELV throughput. In accordance with the results of the survey of 71 ATFs, conducted by RETEK AG in 2020, the calculation of the throughput variations of the scenarios takes into account that the efficiency of the work increases with increased vehicle throughput. For common ELV throughputs from 200 to 3000 ELV/a, the determined operating results for the various scenarios are shown in Figure 17.

Figure 17: Balance of costs or revenues according to scenarios and ELV throughput in €/ELV (for negative values, the costs exceed the revenues).



For results for 500 ELV/a see also Figure 16
Source: data from RETEK and evaluation by Ökopol

The partly gradual development of the economic situation is due to the discrete increase of the number of devices (e.g. depollution equipment, lifting platforms) and, in the case of small businesses, also to the type of permit (for smaller businesses with a capacity of up to 5 ELV per week, a permit according to the Federal Building Code was taken into account, for larger businesses according to the Federal Immission Control Act (BImSchG)). Furthermore, personnel was taken into account in the calculations in intervals of 0.5 jobs (full time equivalents) per person.

Neither in the "Baseline Scenario" nor in the "Plastics", "Glass", "E-Vehicle" and "Gas vehicle" scenarios, a positive operating result is achieved in any of the throughput variations considered. The only scenario achieving positive operating results, even at low throughputs of 200 ELV/a, is the "Extraction of spare parts and metal dismantling" scenario. It can be seen that the particularly high-quality recycling with disassembly of glass and plastic does not produce economically positive results in any throughput variation.

The considerations must take into account that dismantling times and costs as well as material revenues vary over time. Reduced revenues, e.g. for catalytic converters, or increased purchase prices for end-of-life vehicles (e.g. due to illegal competition) can lead to losses even in the scenarios presented here as economically positive.

2.2 Shredding plants

2.2.1 Approach

Using the example of the situation at TSR, all relevant process steps from acceptance to disposal and recycling of the individual materials, which also includes post-shredder treatment, were considered in order to determine the cost and revenue situation for shredder plants. This analysis also includes a proportional cost share for energy, personnel, certification and auditing, insurance costs and any costs for documentation.

A shredding test from 2016, presented in Sander et al. (2020), serves as the main data basis for the volume flows. The contents taken from the study with regard to the material output flows are supplemented, respectively replaced or corrected by current data. A primary survey was conducted at the four shredding plants of TSR Recycling GmbH & Co. KG.

The process is differentiated into general costs, incoming goods, appraisal, shredder and shredder light fraction and shredder heavy fraction.

The general costs consist of general costs for auditing and certifying the entire site, as well as the facilities and the quota assessments that have to be reported. Also included are costs for insurance (including public liability, fire protection or environmental damage insurance) and other proportional costs, such as for monitoring the disposal facilities.

In the cost pool of incoming goods or acceptance, the individual processes such as weighing, measurement of radioactivity and also documentation are taken into account. The highest cost factor is the purchase of the stripped vehicle. The average costs per stripped vehicle were determined on the basis of the average weights of the shredding campaign mentioned (Sander et al. 2020) and the average prices in the period from January to September 2020 in the amount of just under 110 €/t. It should be noted that the price for the stripped vehicles is influenced by various factors, such as regional price differences, the condition of the stripped vehicles and also the different transport costs.

The following process step is the diagnosis. Here, the general costs for the assessment and also the storage of the materials are considered. This also involves fundamental cost factors, such as personnel and documentation.

The costs and revenues of the shredding process are divided into general processing (for example, for personnel, energy and depreciation), revenues for metals and costs for the disposal of residues.

Post-shredder treatment includes the processing of shredder light and shredder heavy fractions. Due to integrated plant components, among other things with regard to exhaust air purification and waste water treatment, no differentiated statements can be made about the individual costs of the SLF; the costs of processing the SLF are included in the other processing costs for the shredder.

Here, for example, the costs for disposal and recycling of low-calorific and high-calorific residual fractions are examined against the revenues for metals (non-ferrous and ferrous).

The calculation of the general costs as well as the costs for the process steps was based on the total costs (euros/year) divided by the throughput (tonnes per year) and then standardised according to the weight of the stripped vehicle.

The geographically good distribution of the plants considered is a very important factor for the representativeness of the data. The revenues of a shredding plant are determined by the prices for steel scrap and the most important non-ferrous metals, in particular Cu and Al. All these

fractions are based on world market prices, i.e. they are the same for all plants (excluding transport costs).

In terms of costs, the usual operating costs and depreciation were taken into account. These are strongly dependent on the size of the plant. However, since the project partner TSR has plants in almost all performance classes, a good range could be taken into account.

The disposal costs of the residual fractions as the second major cost factor are subject to certain regional fluctuations. However, they do not vary to a great extent, as otherwise transports within Germany would occur on a larger scale if one region were to clearly stand out from the rest.

In contrast, there are significant differences in the third cost pool, the purchase costs for stripped vehicles. Here, prices are usually significantly higher in areas close to the border, since stripped vehicles can simply be exported as green-listed waste and the competition abroad can often use significantly cheaper disposal methods. A geographically good distribution of the plants under consideration balances out this effect.

2.2.2 Cost and revenue situation of shredding plants

Table 13 shows the cost and revenue situation for four TSR shredding plants for 2020. The average of all plants was calculated for the respective cost and revenue types. The total costs and revenues of the listed cost types are determined and calculated pro rata to one tonne of material throughput. This value is multiplied by the individual weight per stripped vehicle.

Table 13: Cost and revenue grid of shredding plants

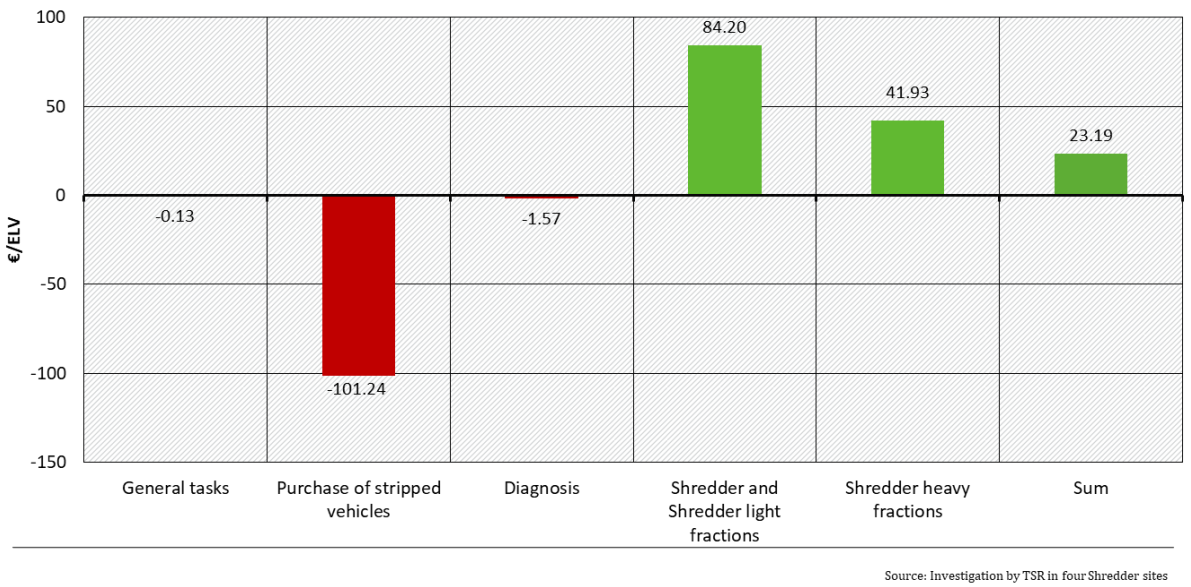
Cost type	Revenue / Cost factors	Menge kg/ Stripped Vehicle	Revenue / Cost €/t	Revenue / Cost €/Stripped Vehicle
General tasks	Auditing/Certification			-0,02 €
	Quota assessment			0,00 €
	Insurances			-0,09 €
	Other			-0,02 €
Incoming goods	Weighing / documentation / radioactivity measurement			-0,09 €
	Purchase costs for stripped vehicles	927	-109,12 €	-101,15 €
Diagnosis	Diagnosis			-0,11 €
	Storage			-1,46 €
Shredder and shredder light fraction	Processing			-36,67 €
	Revenue Type 4	646	222,23 €	143,47 €
	Revenue Cu-Fe anchor	3	893,53 €	3,04 €
	Costs disposal filter dust / wet scrubbing residues	0	-220,00 €	-0,02 €

Cost type	Revenue / Cost factors	Menge kg/ Stripped Vehicle	Revenue / Cost €/t	Revenue / Cost €/Stripped Vehicle
	Revenue metals	2	429,33 €	0,64 €
	Mineral recycling	61	-106,21 €	-6,50 €
	Utilisation of high calorific value	112	-176,59 €	-19,76 €
Shredder heavy fraction	Further processing			-7,72 €
	Metals	50	1.138,45 €	57,17 €
	Recycling of plastics	37	-180,00 €	-6,62 €
	Mineral recycling	9	-95,05 €	-0,90 €
Balance				**23,18 €**

Source: Survey by TSR at four shredder plant locations.

The input weight of the stripped vehicles in this cost and revenue modelling for the shredder corresponds to the weight of the stripped vehicles in the baseline scenario for the modelling at the dismantling facilities. If the weights of the stripped vehicles differ, as it is the case e.g. in the metal and spare parts dismantling scenarios, approx. 10 % of the costs presented in the shredding process can be regarded as fixed costs that are independent of the weight of the stripped vehicle (costs of auditing/certification, quota assessments, insurance, other costs, weighing, documentation, radioactivity measurement, reporting, storage).

Figure 18: Costs and revenues of shredding plants per cost type



2.3 Outlook on future developments

The described cost and revenue situation in German ATFs is a momentary reflection. With a view to future developments, changes may result in particular from:

- Possible changes in the material composition of the future ELVs,
- Possible price fluctuations on spare parts and (secondary) raw material markets.
- New recycling requirements and ambitions to implement a circular economy.

Material composition

Changes in the material composition of the ELVs result from a change in the degree of equipment with various components (see Figure 19) as well as the use of new and alternative materials (see Figure 20), and the spread of alternative drive technologies.

Figure 19: Distribution of selected equipment components of new cars in Germany

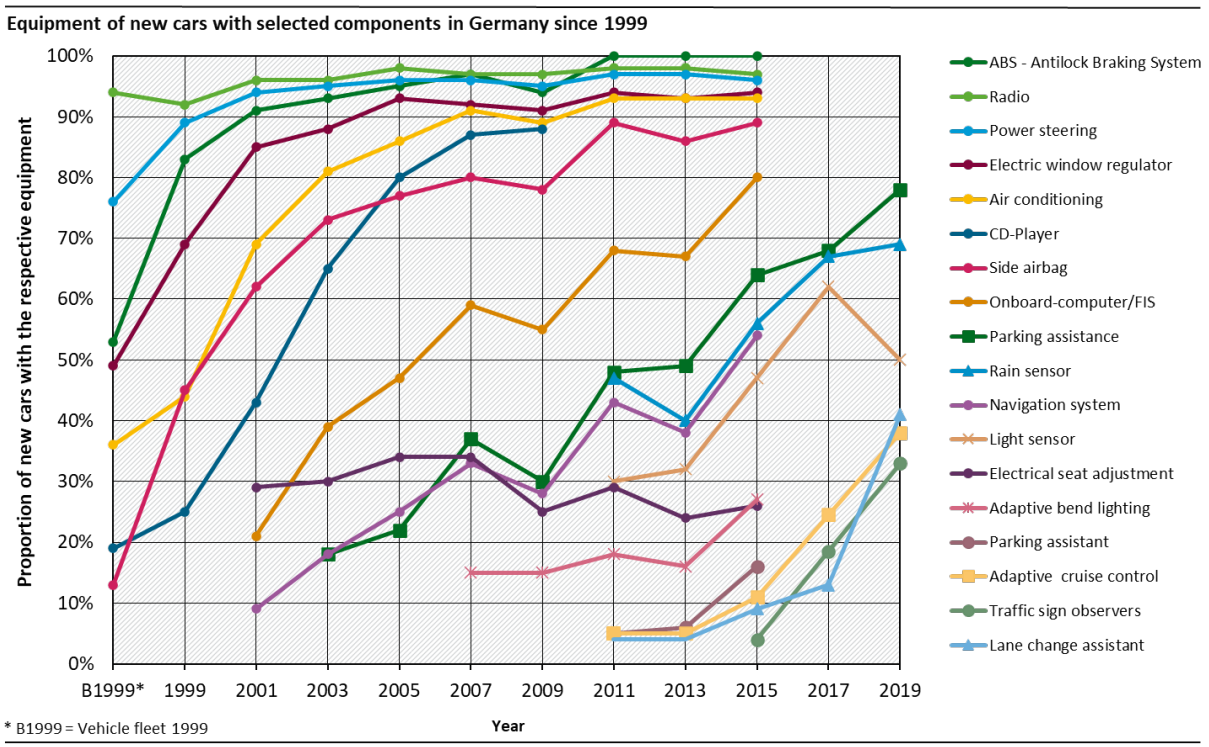


Figure created by Ökopol based on (Kohlmeyer et al. 2015), updated with data from: (DAT 2014, 2016, 2018, 2020)

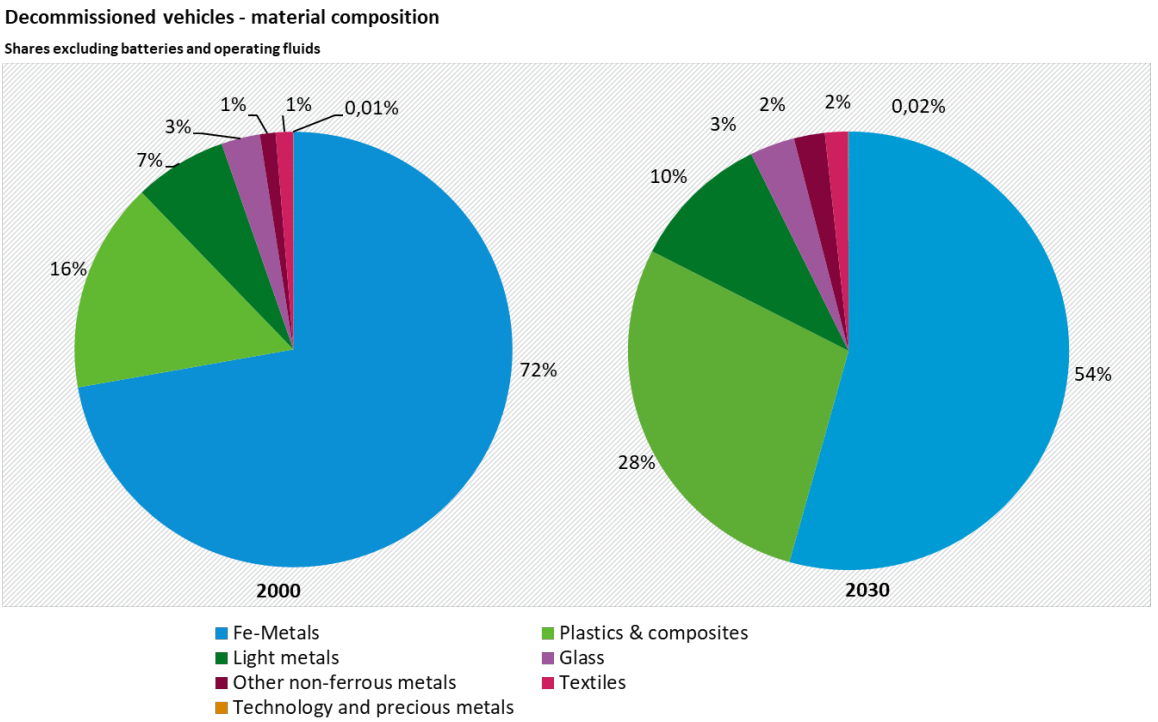
New and alternative materials include, amongst others, increasing amounts of plastics, composites and ultra-high strength steels (see Figure 20) and new refrigerants. These changes in material composition are likely to increase recycling and dismantling costs:

- Diversification of refrigerants (R1234yf in addition to R134a): additional costs of 0.5 to 1 €/ELV.
- Increasing number of ELVs with AdBlue: additional depollution costs of about 2.30 € per ELV with AdBlue.
- Increasing number of onboard batteries: Additional dismantling time 15 to 60 minutes, resulting in dismantling costs of 17 to 68 € per battery.
- According to Figure 20, the amount of technology and precious metals in deregistered vehicles will double by 2030. Against the background of their criticality and increasing

ambitions for circularity, dismantling will have to be increased and/or new effective post-shredder separation techniques will have to be developed and installed to enable recovery.

- The decreasing share of ferrous metals will decrease the potential revenues from metal scrap, while the increasing amount of aluminium and other non-ferrous metals will allow for higher revenues. The complementary increase in plastics, composite materials and high-strength steel will require investments in the development and installation of new treatment technologies.
- The costs for the treatment of electric ELVs were discussed in section 2.1.4.4. According to Figure 16, the treatment of electric ELVs results in costs of 234 €/ELV, or, in the first years, even 631 €/electric ELV for a throughput of 5 electric ELVs per year and 405 €/electric ELV for a throughput of 10 electric ELVs per year.

Figure 20: Average material composition of decommissioned vehicles 2000/2030



Quelle: Faulstich und Kienzler (2018)

Figure created by Ökopol on the basis of data from: Faulstich and Kienzler (2018)

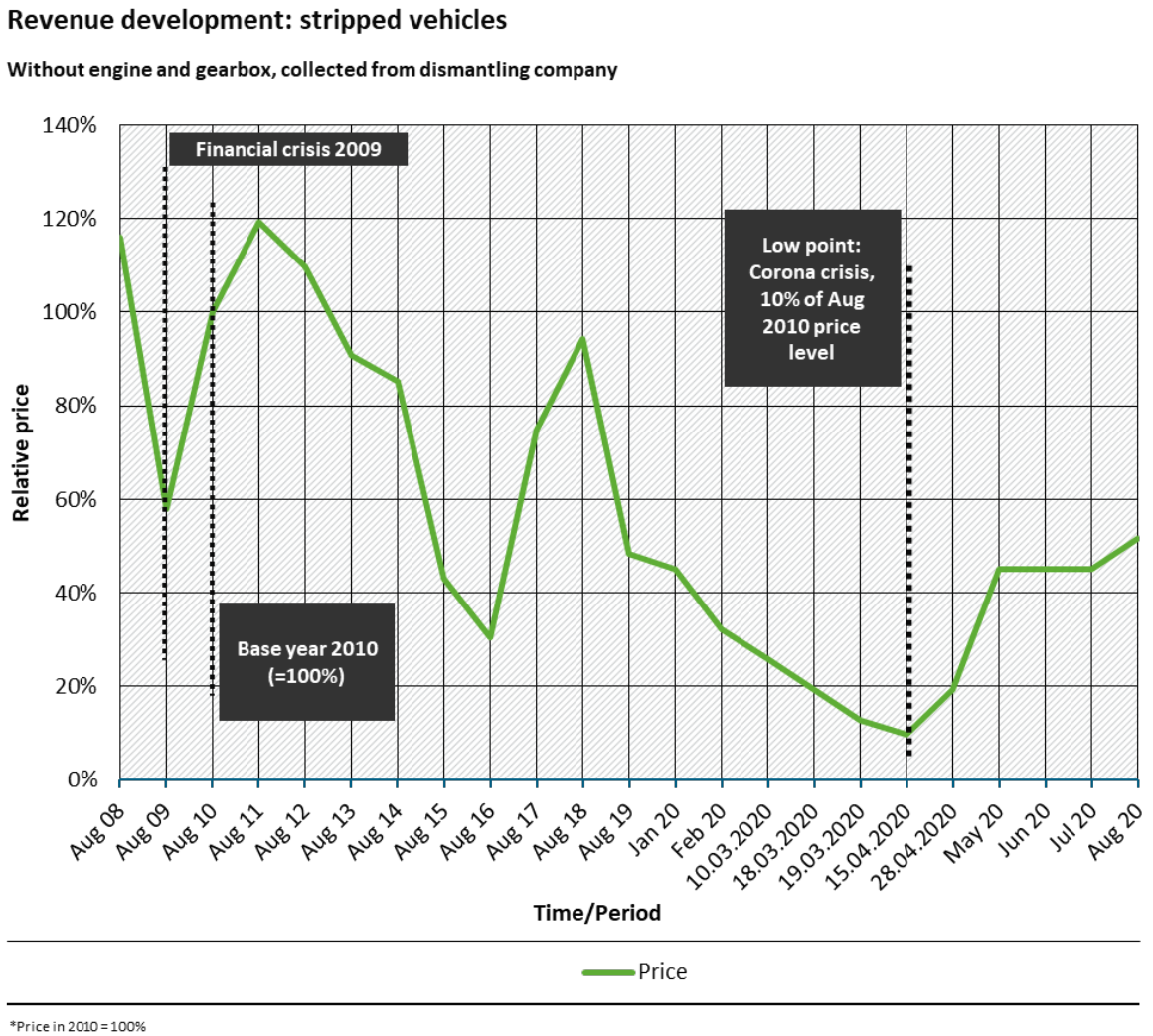
When looking at the development of vehicle types placed on the market, an increase of SUVs and terrain vehicles can be observed: from 8 % in 2008 to 29 % in 2021 (KBA (2019)). This can potentially result in increased revenues from material recovery and spare parts for ATF, if the share of these vehicle types within ELV treated by ATF increases correspondingly.

Price fluctuations and demand for spare parts

Price fluctuations on the commodity markets are closely related to the revenues that can be achieved for components and materials. A retrospective analysis of various components has shown that in many cases prices have fluctuated by +- 50 % over the last 10 years. Figure 21 shows an example of the development of revenues for stripped vehicles relative to 2010. If, in a theoretical worst-case, the profit of a stripped vehicle (101 €) would be reduced by 90 %, the

overall balance per ELV in the "Baseline Scenario" would drop from -20 € to -111 € per ELV. Similar effects and price volatilities may occur for the catalytic converter, copper components and even for recovery costs for shredder residues.

Figure 21: Development of the price for stripped vehicles



Source: Figure: Ökopol; Data collection by RETEK

Spare parts revenues have significantly contributed to the profitability of ELV dismantling, see 2.1.4.3. However, in the long term, a decreasing demand for spare parts can be expected, due to longer service lives and less faults of vehicle components, and because the vehicle systems are becoming more complex and more diverse and therefore self-repair is complicated (Stiftung Auto Recycling Schweiz 2021).

Circular economy

The European Green Deal of 2019 (European Commission 2019) and the Circular Economy Action Plan (European Commission 2020b) have increased the pace towards a Circular Economy in Europe. In the medium term, high-quality recycling of plastics, glass, and electronic components have to be enhanced, which will likely increase ELV treatment costs. At the same time, the European Chemicals Strategy for Sustainability of 2020 "Towards a Toxic-Free Environment" (European Commission 2020a) aims at reducing harmful chemicals in consumer products and at using chemicals that are safe and sustainable by design. This will require

additional efforts (and costs) to eliminate (legacy) substances of concern from the material cycle during ELV treatment.

In conclusion, it can be stated that the future developments in ELV composition in conjunction with enhanced requirement to close material cycles will require new technical developments and intensified ELV treatment and recycling efforts, while market price fluctuations can significantly reduce potential revenues from dismantling activities or, in extreme cases, it appears possible that dismantling activities (even with spare parts extraction) cannot be carried out in a way that can cover costs.

3 Types and business models of unauthorized dismantling

This work package aims to describe the existing types of business models of non-authorized dismantling of end-of-life vehicles and to make an assessment of the quantiative relevance of the different type models.

The common business practices and types of illegal dismantling actors were investigated using different methodological approaches. Their findings were finally compiled and consolidated. The central methodological approaches were:

- an evaluation of relevant previous studies,
- an evaluation of relevant court decisions,
- a practical survey, divided into three steps,
  - identification of 65 suspected cases via knowledge of market participants and competent authorities, satellite image evaluation, on-site knowledge,
  - comparison of information with information on the location of authorised treatment facilities as well as the register of German ATFs, hosted by GESA[7] (www.altfahrzeugstelle.de) and internet-based information such as individual websites and Ebay,
  - on-site inspections of 33 cases, conversations with site operators if possible,
- conducting stakeholder interviews (enforcement authorities, police/customs, dismantling companies, logistics companies).

Based on these different methodological approaches, it was possible to gain a comprehensive picture of the various common types and business models of illegal dismantling and export of ELV.

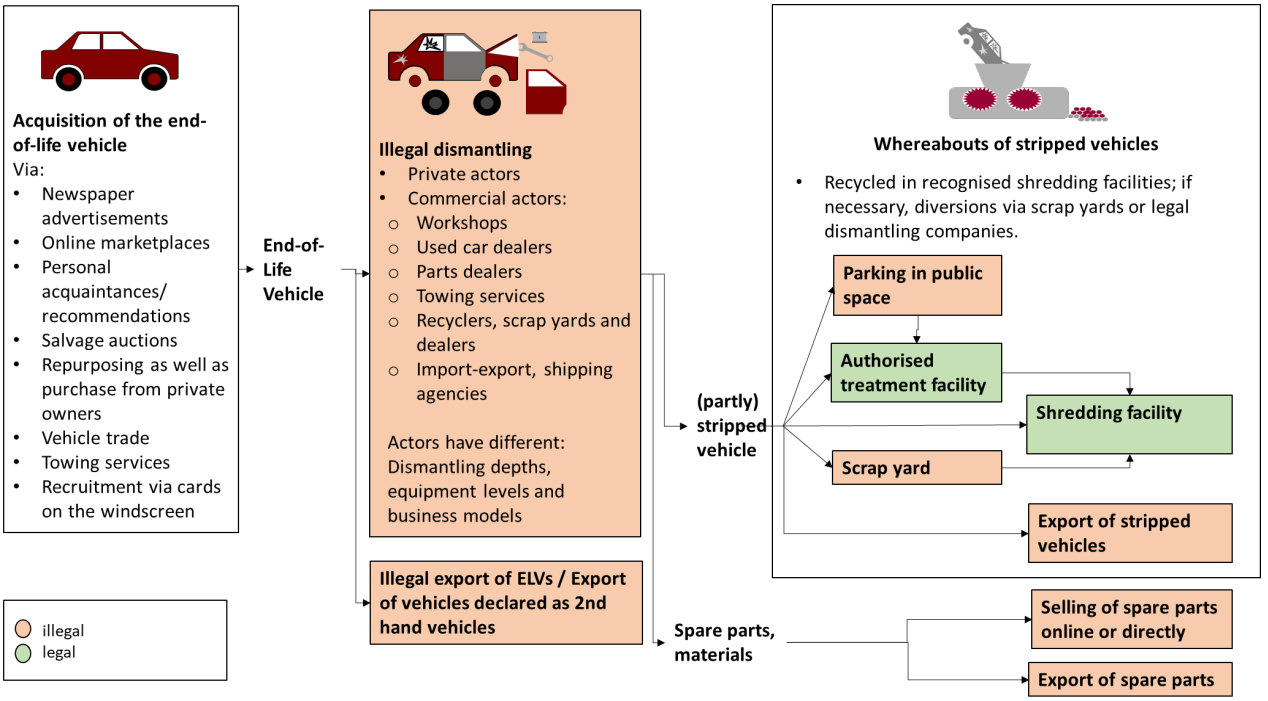
3.1 Acquisition of end-of-life vehicles and whereabouts of partially dismantled vehicles or stripped vehicles

Acquisition of vehicles can take place in various ways across all types of non-authorised actors, via newspaper advertisements, online marketplaces, salvage auctions, purchases from private individuals, personal acquaintances or recommendations, (second-hand) vehicle trade, towing services, the "repurposing" of second-hand vehicles into ELV at garages or second-hand car dealers or via advertising business card distributors (pinning "advertising" cards on the windscreen for the purpose of vehicle purchase).

The acquisition step is followed by illegal dismantling (or export). In general, the stripped vehicle is then, directly or via a scrap yard, forwarded to an authorised shredding plant. Or the partially dismantled ELV may be brought to authorised treatment facilities. The route via ATFs, which complete the depollution and dismantling of the ELVs , was named in the stakeholder survey as a relevant route in addition to direct or indirect (via scrap yards) transfer to shredding plants. Some illegal dismantling actors abandon the scavenged ELVs by "parking" them in public spaces. After one month, the public waste management organisation has to ensure a proper recovery of these abandoned ELVs, delivering them to ATFs and, subsequently, shredding plants.

[7] GESA = Gemeinsame Stelle Altfahrzeuge = joint agency for ELVs (see Article 7 (2a) German ELV Ordinance)

Figure 22: Simplified representation of the basic procedure of illegal dismantling



Source: Author

3.2 Actors involved in illegal dismantling and export

Among the actors involved in illegal dismantling, a basic distinction can be made between purely private actors and those with a registered business.

Among the **private actors**, there are individuals (hobbyists/tinkerers, collectors, individuals with access to large areas where vehicles can be permanently stored) as well as associations of persons (DIY auto repair communities and similar groups/interest groups). For the individuals as well as for the associations of persons, the observed activities include, on the one hand, the pure storage of vehicles and tinkering on a small scale (especially cases identified via the evaluation of court decisions) as well as the dismantling of vehicles with the aim of obtaining spare parts with subsequent sale (mostly via internet marketplaces).

With regard to the equipment, it can be observed from the evaluation of the court rulings that in most cases the storage area and the working area are unsealed. In most cases, there are no installations for removing environmentally hazardous substances, at least not in accordance with the requirements of the End-of-Life Vehicles Ordinance (AltfahrzeugV).

Among the **actors with a registered business**, there is a wide range in terms of their business activities. The "official" (either in the sense of a registered business or according to the self-description or the company name) activities of companies that (also) carry out illegal dismantling include used car trade and export, automobile workshops, spare parts trade and vehicle recycling. Within these main activities, the dismantling of ELV takes place - to a varying extent. This can range from sporadic dismantling activities that arise from opportunities (e.g. at automobile workshops when a vehicle proves to be no longer economically repairable or at used car dealers when a vehicle proves to be unsaleable over a longer period of time) to systematic dismantling activities on a larger scale.

The size of the business is similarly varying. The practical survey showed that about half of the identified businesses have between 3 and 5 employees and an area of between 2,000 and 5,000

square metres. In terms of the number of vehicles identified (end-of-life vehicles and non-end-of-life vehicles), around half of the businesses have more than 50 vehicles parked on the premises. However, the practical survey did not show a clear correlation between the size of the business and the technical equipment.

Instead, within the totality of actors involved in illegal dismantling activities, a distinction can be made between those **with good equipment** (here, in particular, automobile workshops and, in some cases, businesses with a strong focus on regular and continuous dismantling activities) and those **with inadequate equipment** (i.e. businesses largely without suitable equipment for vehicle dismantling). From these two types, a distinction must still be made between actors **with partly inadequate equipment**.

Table 14: Differentiation of equipment types among illegal dismantling actors

Equipment type	Description
Good equipment	Equipment complies at least to a large extent with the requirements of the End-of-Life Vehicles Ordinance (AltfahrzeugV).
Partly inadequate equipment	No devices for removing refrigerant. Devices for removing operating fluids are available, even if they do not (fully) comply with the requirements of the End-of-Life Vehicles Ordinance. Systematic depollution does not take place. Work areas are generally sealed, but some are in the open air. Vehicles are partly stored on unsealed ground.
Inadequate equipment	No devices for removing refrigerant. Devices for removing operating fluids are sometimes available, but usually do not meet the requirements of the End-of-Life Vehicles Ordinance. Removal of pollutants does not take place. Work areas are at least partially unsealed or insufficiently sealed; some are in the open air. Vehicles are stored mainly on unsealed ground and regularly in the open air.

Exports: According to the findings of the investigations, field research and interviews, it is estimated that only about 20 % of the German vehicles of unknown whereabouts were exported illegally. There are

- marginal illegal ELV exports by sea (the export of non-repairable vehicles hasn't been profitable in most cases, since the export of vehicles with additional cargo was restricted);
- to a minor extent, illegal exports of ELVs to Eastern Europe and to the Balkan States (via road by imports and exports companies on car carrier trailers);
- a lot of used vehicle exports, from very good to poor conditions, among them
  - exports of vehicles by sea declared as used vehicles which might be defined as waste vehicles in Germany, but (after repair) are subsequently used on the roads of the countries of destination;

In cases of vehicles in poor condition, it is challenging to distinguish between the export of a used vehicle or an ELV.

3.3 Derivation of common types

Further differentiation can be made within the types of illegal dismantling actors with registered businesses with regard to aspects such as depth of spare parts extraction or target region of spare parts marketing (domestic, foreign EU, non-EU). For the derivation of common types, however, a focus on the equipment appears to be purposeful, as this is decisive regarding the ecological evaluation of the types.

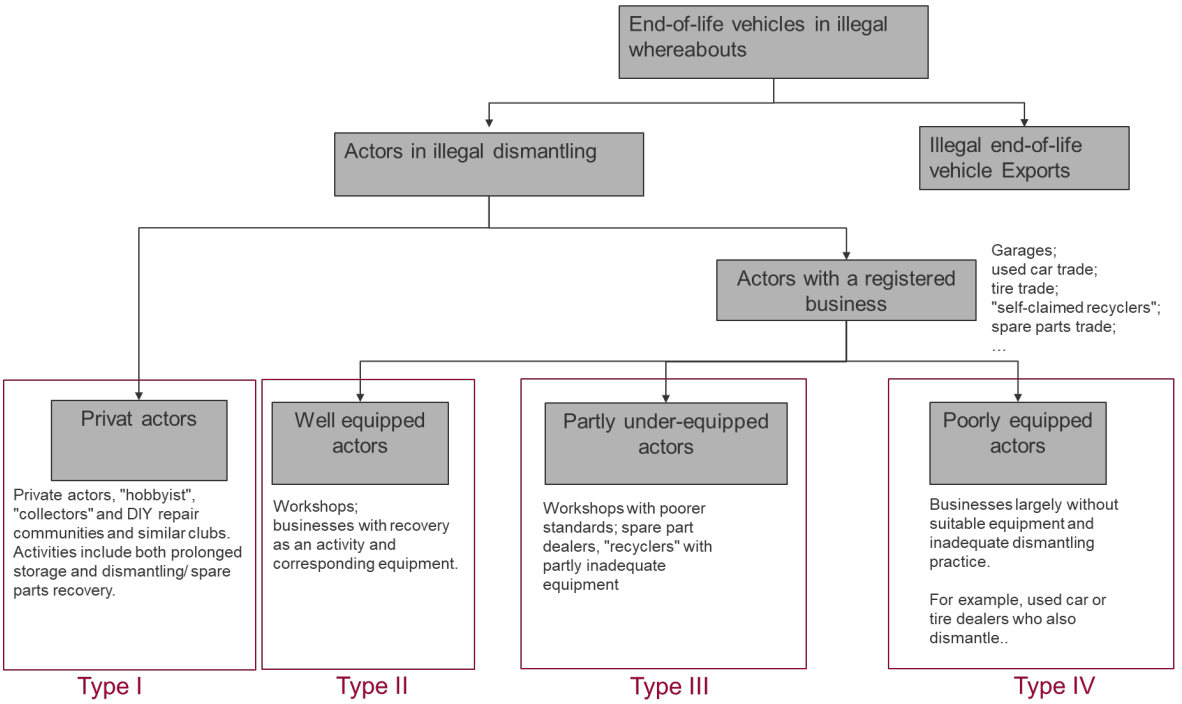
All in all, we can distinguish between these 3 types, which refer to actors with registered businesses, and - as a further common type - the private actors. A large proportion of the latter have inadequate equipment, although there are also cases that could be assigned to the partially inadequate or good equipment. Here, however, it seems appropriate to cover the differences that occur in the ecological aspects in the further consideration by ranges and to consider these clearly separately from the commercial actors due to the relevant economic differences.

Against this background, the following common types for illegal dismantling actors are defined:

- Type 1: Private actors such as private person, hobbyists, collectors and DIY auto repair communities and similar clubs.
- Type 2: Actors with registered businesses and good equipment such as workshops/garages which occasionally dismantle vehicles.
- Type 3: Actors with registered businesses and partly under-equipped such as workshops/garages with poorer standards, spare parts dealers etc.
- Type 4: Actors with registered businesses and largely without suitable equipment and inadequate dismantling practice such as used car or tire dealers.

These different types are also shown in Figure 23.

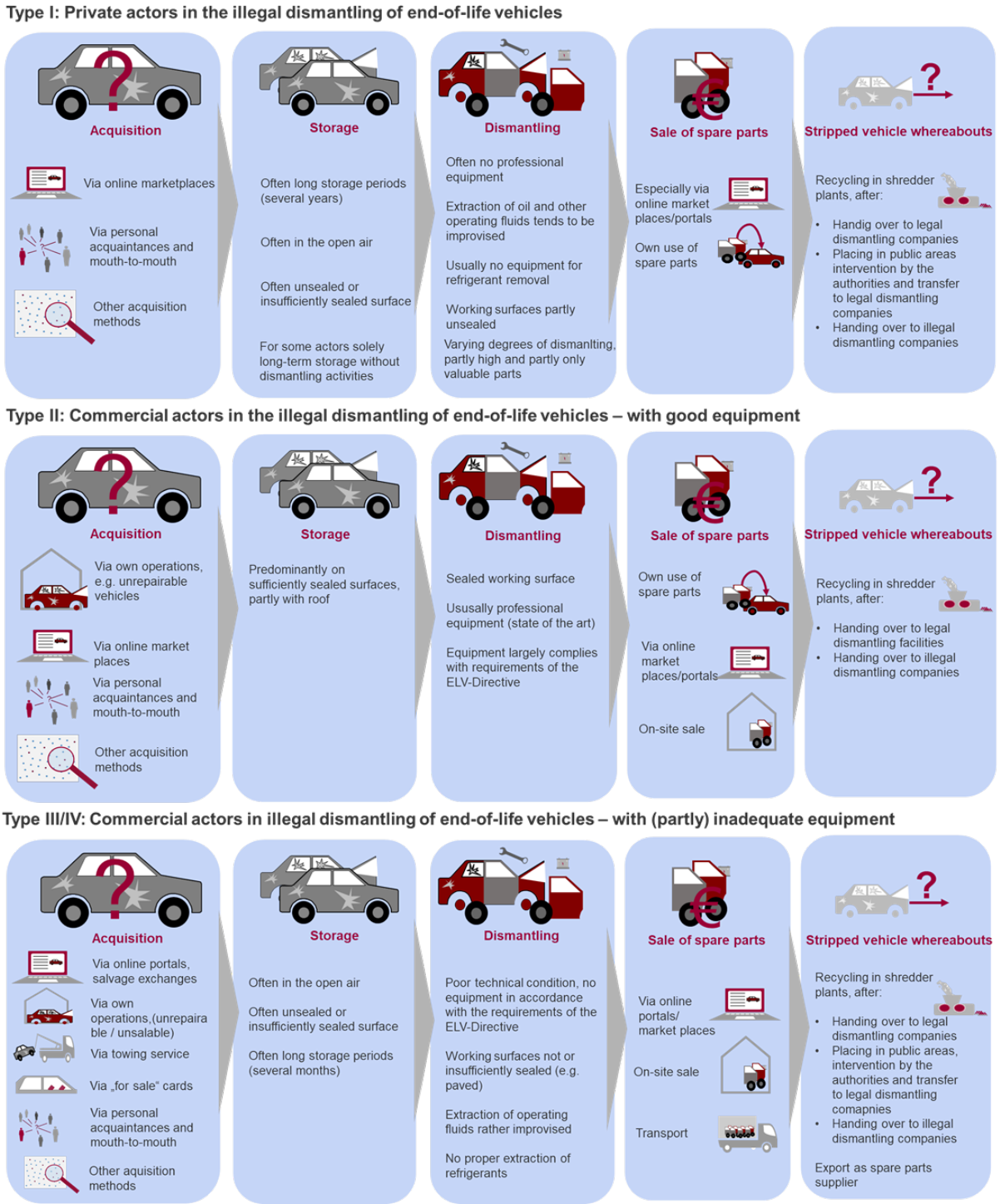
Figure 23: Common types of illegal ELV dismantling



Source: Author

For the four types, Figure 24 illustrates the steps of acquisition, storage, dismantling, spare parts marketing up to the whereabouts of the ELV.

Figure 24: Illustration of the ELV-pathways for the four common types of unauthorized dismantling

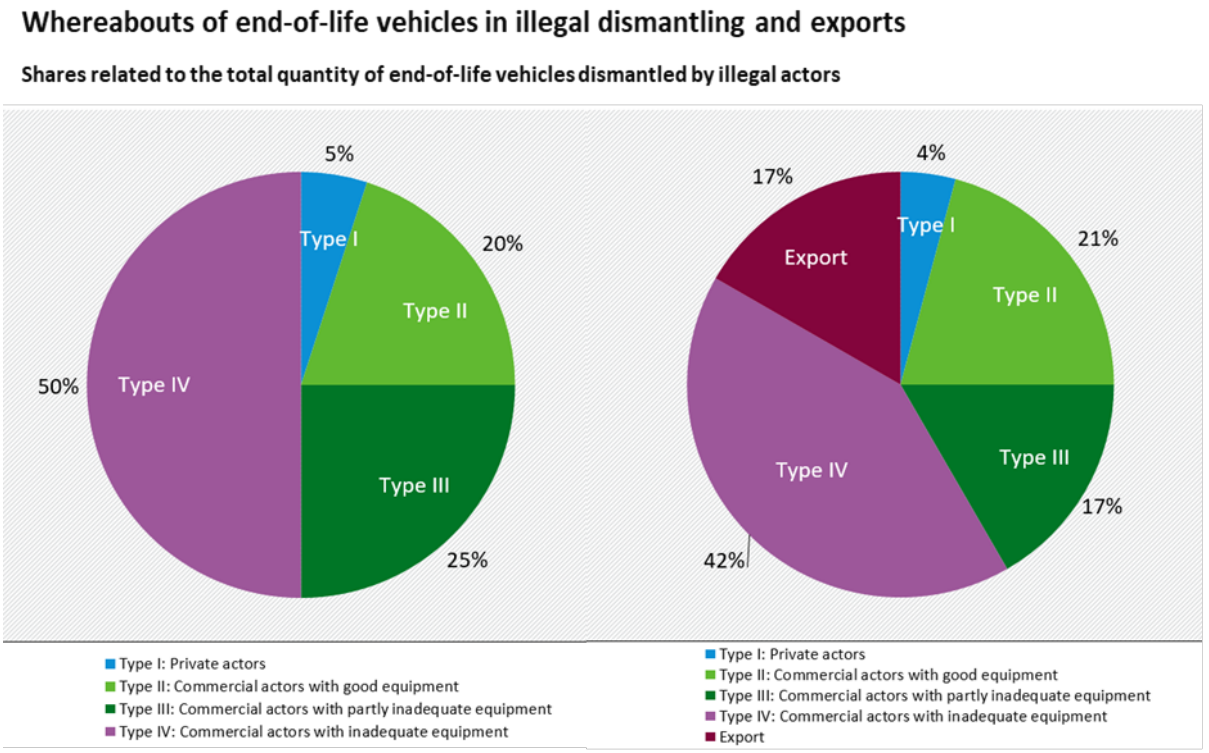


Source: Author

3.4 Relevance of the 4 types

The distribution of illegal dismantling to the four types was estimated on the basis of the practical survey, the stakeholder interviews conducted and the evaluation of the court rulings (Figure 25).

Figure 25: Distribution of illegally treated ELVs to the common types of illegal treatment and export

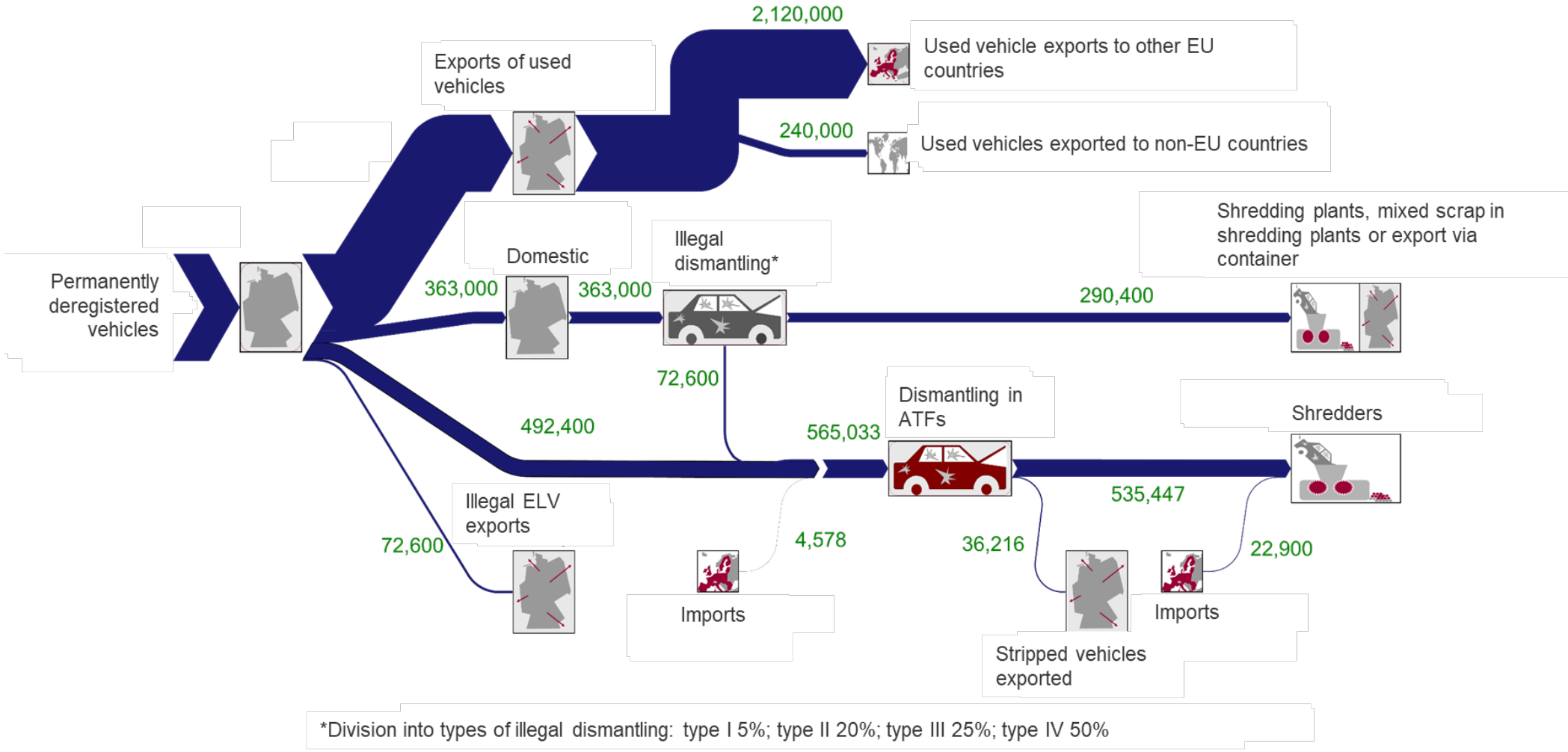


Left: Representation of the distribution of quantities in illegal dismantling.
Right: Distribution of quantities in illegal dismantling and illegal exports
Source: Authors' assessment based on practical investigations, evaluations of court rulings and interviews with stakeholders

4 Situation of the whereabouts of end-of-life vehicles

Based on the annual reporting by BMU and UBA (2020) and the conducted analyses of the fate of end-of-life vehicles (see section 3.4 in particular) with consideration of the findings by Sander et al. (2017), the whereabouts of permanently decommissioned vehicles in Germany have been investigated for the year 2018 (see Figure 26). According to this, the statistical gap amounts to 363,000 vehicles. On the basis of the observations made, it is estimated that 20% of these, i.e. around 72,600 ELVs, are exported illegally. Furthermore, it is estimated that around 363,000 ELVs end up in illegal dismantling. This includes 72,600 vehicles that are subsequently treated in legal dismantling facilities. Accordingly, these 72,600 vehicles are not part of the statistical gap if included in the reporting of authorised dismantling facilities to Destatis. For the majority of ELVs from illegal dismantling, it can be assumed that these are ultimately recycled in shredder plants (possibly as mixed scrap). In addition, to a lesser extent, (partially) dismantled ELVs are also exported in containers along with spare parts, waste electronic equipment, etc.

Figure 26: Whereabouts of permanently decommissioned vehicles in Germany in 2018



5 Comparison of the cost and revenue situation of authorised and illegal dismantling

5.1 ATF as a reference

Based on the results of the assessment of the revenue and cost structure of legal end-of-life vehicle treatment in Germany and the investigations on the types and business models of illegal dismantling, a comparison of the cost and revenue structure of legal and illegal end-of-life vehicle treatment is made.

The model of an ATF with the following parameters serves as the reference:

- Treatment of 500 ELVs per year.
- Depollution and dismantling, complying with the legal minimum requirements.
- No dismantling of glass and large plastics parts.
- Dismantling and recovery of metal components.
- Reclamation of spare parts.

This model ATF aims to maximise revenues from dismantling activities, which can also be assumed to be the goal in most cases for the players in illegal dismantling.

5.2 Differences in cost and revenues

Based on the cost and revenue situation in the ATF reference, the cost and revenue items for the four common types of illegal dismantling are examined and adjusted, taking into account the findings from the practical survey on the actors of illegal dismantling and the interviews conducted with the actors. In addition, the vehicle throughput per operation is varied for the four common types.

The following basic assumptions were made for the considerations:

- The treatment times were adopted unchanged for most activities, even if not all activities are carried out in every case. Personnel costs and the share of productive working time were varied.
- Material and spare parts revenues were adopted unchanged. Although it can be argued that individual non-authorised dismantling companies tend to focus on vehicles that enable higher spare parts revenues, this also applies to individual authorised companies and an adjustment would reduce the comparability of the observations of legal and illegal dismantling. For catalytic converters, it can be assumed that the same revenues are generated regardless of whether they were removed by an illegal actor or an ATF. For other spare parts, it can be assumed that ATFs can achieve higher revenues while illegal actors often remove a wider range of spare parts from ELVs from ELVs.
- Average ELV throughput per dismantling type, see Table 15.

Table 15: Assumed average ELV throughput of illegal dismantling actors

Type of illegal dismantling	Average annual ELV throughput
Type I (private)	2
Type II (good equipment)	50
Type III (partly under-equipped)	200
Type IV (under-equipped)	300

Source: Author

Type 1: Private actors of illegal dismantling

System costs (compulsory memberships in chambers of commerce, authorisation according to the End-of-Life Vehicles Ordinance, training courses and expertise, inspections, etc.) are not incurred by type 1/ private actors. The same applies to insurance costs, taxes - with the exception of property tax.

Investment costs for land and premises (land, hall, outdoor facilities) are not applied here. Investments in equipment are significantly reduced compared to legal dismantling. Handling excavators, forklift trucks, refrigerant extraction equipment and other drainage technology are not included here. A motorised crane, a compressor and a lifting platform are assumed.

Personnel costs are not incurred by type 1/ private actors, even if comparable treatment times are assumed. For comparison purposes, imputed costs analogous to authorised dismantling can nevertheless be applied here.

Type 2: Commercial actors with good equipment

Type 2 actors are, for example, workshops that occasionally dismantle end-of-life vehicles (e.g. vehicles that can no longer be repaired). The dismantling of ELV is not the primary commercial activity here. Accordingly, system costs, administrative costs (incl. external accounting), investments, property expenses and insurance are not allocated to the dismantling activity. Energy and water costs are included at half the amount due to synergy effects. Any existing equipment is also not allocated to the dismantling activity.

The same wage costs (employer's gross) are applied as for authorised dismantling, with certain activities being omitted. This applies to administrative activities in connection with the dismantling of ELV such as the issuing of certificates of destruction (CoD), determination of recycling/recovery rates etc. In addition, less unproductive time is assumed, which reduces the hourly rate. On the other hand, all activities related to spare parts reclamation are carried out.

Typ 3 und Typ 4: Commercial actors, (partly) inadequate equipment

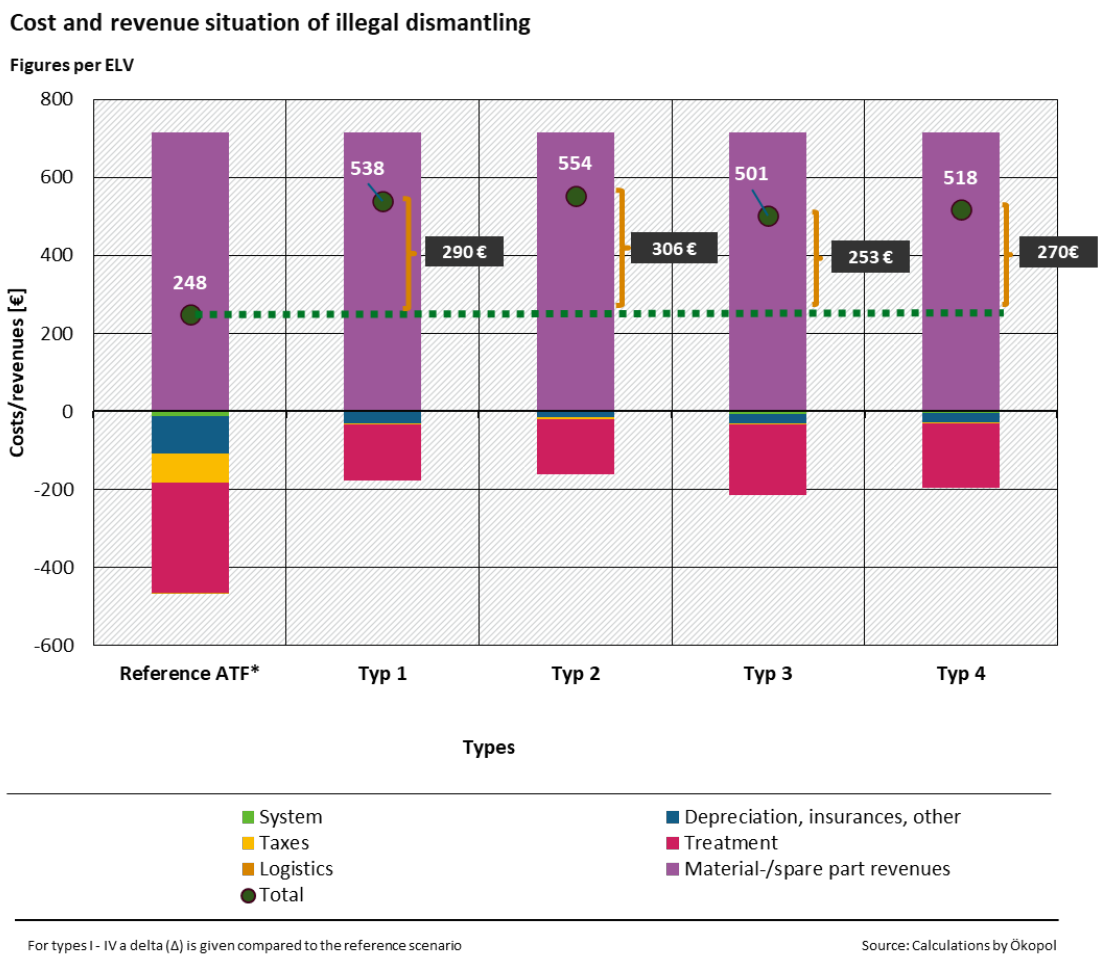
System costs (compulsory membership in the chamber of commerce, authorisation in accordance with the End-of-Life Vehicles Ordinance, training courses and specialist knowledge, inspections, etc.) are not incurred by type 3 and 4 actors or are incurred to a significantly reduced extent compared to authorised dismantling. The investment costs are also significantly reduced compared to authorised dismantling. For treatment costs, the same applies as for type 2 actors.

5.3 Results of the comparison of the cost and revenue structure

Across all cost categories, the four types of illegal dismantling have lower costs than dismantling in an authorised treatment facility. The treatment costs (personnel costs) per end-of-life vehicle

are also significantly lower (between 37% and 50%). As a result, the profit per ELV is – with +252 to +305 €, - significantly higher in the case of unauthorised dismantling (> 500 €/ELV) than in the case of authorised dismantling with the reclamation of spare parts (248 €/ELV) (cf. Figure 27).

Figure 27: Costs and revenues of illegal dismantling compared to legal dismantling in a reference ATF



* Reference ATF: Treatment of 500 ELVs/year, depollution and dismantling according to ELV Directive, no dismantling of glass and large plastics parts, dismantling and recovery of metal components, reclamation of spare parts.
Type I (private) Type II (good equipment) Type III (partly inadequate eq.) Type IV (inadequate equipment eq.)
Source: Calculations by Ökopol and RETEK (Zimmermann et al. 2021)

6 Macroeconomic effects of illegal dismantling

Based on the findings on the cost and revenue structure of unauthorised dismantling compared to authorised dismantling of ELVs and the findings/estimations on the number of ELVs that were not treated or exported in conformity with the legal requirements, the direct effect on added value in Germany can be estimated.

The number of ELVs from Germany, which are illegally treated or exported is unknown. To perform the calculations, estimates were used. The calculations of macroeconomic effects are based on the following figures and estimates for Germany in 2018 (cf. Table 16).

Table 16: Data and estimations for ELV whereabouts in Germany 2018

Whereabouts	Figure	Note
ELVs in ATFs	565,033 ELVs	Accepted by German ATFs: 560,455 ELV from domestic origin + 4,578 ELV from abroad
Statistical gap of finally deregistered vehicles (total)	363,000 vehicles	Findings of this study, which validated and updated the 2018 figures on the whereabouts of ELVs with more reliable data, where possible.
Illegal exports	72,600 ELVs	Estimation: 20 % of the statistical gap
Illegal dismantling	363,000 ELVs	Estimation: 80 % of the statistical gap (290,400) + 72,600 ELVs which are partially dismantled in illegal treatment ("scavenged") and subsequently treated in ATFs (not part of the statistical gap).

Source: Author

Every ELV that is exported (and thus not treated in Germany) or is not treated properly, results in a loss of added value in Germany that would otherwise be generated by the authorised treatment facilities. In addition, the type of treatment matters. A more advanced treatment would also have a greater impact on supplier companies, as more specialised tools or services will have to be purchased.

Two scenarios were compared to determine the macroeconomic impacts:

- The "Status Quo" Scenario is the current situation according to the vehicle flows as shown in Table 16 and according to the ELV distribution to the types of illegal treatment/export.
- In the "Target" Scenario, all 928,000 ELVs (565,000 + 363,000, see Table 16) are treated in authorised treatment facilities.

An estimate of the revenue generated by the different types of dismantling can also be made on the basis of the preliminary work. The revenue per car differs depending on the type of business and the type of treatment (whether valuable parts have already been removed or not). The results can be summarised as follows. The particular estimates of the revenue per car are presented in the footnotes.

Table 17: Number of ELVs and revenue per ELV for the different whereabouts as input data for the macroeconomic calculation.

	ELVs in ATFs	Type I Illegal dismantling, private operator	Illegal dismantling, commercial actors			Illegal export
			Type II good equip.	Type III partly inad-equate equip.	Type IV inadequate equip.	
Number of ELVs (1)	**565,000**	**5 % 18,150**	**20 % 72,600**	**25 % 90,750**	**50 % 181,500**	**72,600**
Thereof: (2) Complete dismantling	492,400	14,520	58,080	72,600	145,200	
Valuable parts only		3,630	14,520	18,150	36,300	
Valuable parts already removed	72,600					
Revenues complete dismantling (3)	€ 713.92	€ 713.92-80 = € 633.92	€ 713.92	€ 713.92	€ 713.92	
Revenues valuable parts only (4)		€ 338.47-80 = € 258.47	€ 338.47	€ 338.47	€ 338.47	
Revenues valuable parts already removed (4)	€ 375.45					
Revenues illegal export						€ 80.00

Footnotes, estimates and sources:

1) ELVs in German ATFs in 2018 (from inside the country and accepted from abroad) (BMU and UBA 2020), estimate on illegal treatment and export.
2) Estimation: In illegal dismantling, only valuable parts are removed from about 20 % of the ELVs, which are subsequently directed to ATFs (in total 72,600 out of 363,000 ELVs). The remaining 80 % are completely dismantled by the illegal operators.
3) a) ATFs: Total revenue per ELV according to reference ATF.
   b) Illegal dismantling types II, III and IV: Revenues identical to ATF.
   c) Type I: Since these are private actors and not commercial owners, not the turnover but only the profit is considered. Since it is estimated that the ELVs were purchased for an average of 80 euros, 633 euros remain.
4) For 20 % of the ELVs in illegal dismantling, the total revenues of € 713.92 are split: The workshop or illegal dismantler removes valuable spare parts worth € 338.47 and then passes the ELV on to an ATF which can realise the remaining revenues of € 375.45. For type I (private actor), € 80 are subtracted for purchasing the ELV

Source: Calculations and estimations by Ökopol and RETEK

Undeclared work: The relevance of undeclared work in illegal ELV dismantling was assessed and estimated by the authors, based on interviews with economic actors and authorities and literature. It depends on the type of activity:

- Type 1: The dismantling activities of private actors are performed in their spare time, without any employment.
- Type 2: This type mainly comprises workshops and garages. No undeclared work is assumed.

- Types 3 and 4: Based on information on inspections and on studies on moonlighting in Germany, the share of undeclared work is estimated to 10 % for type 3 (partly inadequate equipment) and to 30 % for type 4 (inadequate equipment).

Results

The calculation tool used for the analysis (Porsch et al. 2015) was designed to estimate the impact of policy measures. In order to apply the tool in this case, the macroeconomic consequences are considered for the case that all ELV were steered into and treated properly in authorised treatment facilities. This result is the difference between the "Status Quo" Scenario and the "Target" Scenario.

In the first step, the revenue in the individual sectors is calculated from the above figures.

- All revenues in authorised treatment facilities are allocated to the sector **"waste water disposal services; services for the collection, treatment and disposal of waste and for the recovery of recyclable materials; services for the removal of environmental pollution and other waste disposal"**.
- In contrast, all revenues generated in the commercial part of illegal dismantling (types 2, 3 and 4) are allocated to the sector **"car dealership, automobile maintenance and repair services".**

This leads to the following distribution of revenues in the sectors in the "Status Quo" Scenario and the "Target" Scenario, cf. Table 18.

Table 18: Revenue in the different sectors

Dismantling type	Revenue "Status Quo" Scenario	Revenue gain/loss in "Target" Scenario (compared with the "Status Quo" Scenario)
Repair and trade services motor vehicles (illegal dismantling 2, 3 and 4)	180 million euros	- 180 million euros
Treatment and disposal of waste and recovery of recyclable materials (ATFs)	379 million euros	**+ 284 million euros**
Expenditures on undeclared work (No sector - illegal dismantling (Type 1, 10 % of Type 2 and 30 % of Type3)	51 million euros	- 51 million euros
Revenue (negative expenditures) for exported ELVs (No sector)	-6 million euros	+ 6 million euros
Total: additional expenditure to be financed		**+ 59 million euros**

Source: Own calculations (VVA)

A very important assumption for estimating the macroeconomic impact is the question of where additional funds spent in a sector come from in the "Target" scenario.

- In our case, the total revenue in the ATF sector increases by 284 million euros in the "Target" scenario.

- Part of this revenue is financed from the reduced revenue in illegal dismantling (180 million euros).
- In addition, the funds previously spent on undeclared work services are deallocated (51 million euros).
- Finally, in the "Target" Scenario, the additional almost 6 million euros in export revenue are eliminated, as the previously illegally exported ELV now enter domestic ATFs.

In total, **additional expenditure of 59 million euros must therefore be financed**. It is decisive for the overall economic impact as to how this money is made available. There are different policy options available to finance this gap. The costs could be financed by a public subsidy, the costs could be financed by car owners by forcing them to use the ATF for their vehicles or the producer of the cars could be obliged to foot the bill using a producer responsibility scheme. Therefore three possibilities were modelled:

- If **consumers** have to finance this additional sum completely, they will reduce their remaining expenditure, which in turn will lead to sales losses in many sectors.
- Alternatively, if we assume that the **state** provides the money through a subsidy (and does not otherwise reduce its spending), then there would not be such a shift in consumption and the overall economic consequences would be much more positive.
- In the last model, **car manufacturers** would bear the costs of these 59 million euros, which would lead to an increase in production costs in this sector. This would be analogous to new Extended Producer Responsibility (EPR) regulations.

Based on the revenue differences, the following values are calculated for the macroeconomic consequences, see Table 19:

Table 19: Macroeconomic consequences of a complete shift of illegal ELV treatment to authorised dismantling (with and without consumption shifting)

Indicator	Difference of "Target" scenario to "Status Quo" scenario in euros		
Financing	**Consumers bear the extra expenses**	**State bears the extra expenses**	**Car manufacturers bear the extra expenses - EPR**
Additional added value in the German national economy	37 million euros	85 million euros	28 million euros
Additional compensation of employees	19 million euros	46 million euros	15 million euros
Additional employment subject to social security contributions (Full Time Equivalents)	500	1,200	300
Additional social security revenue	6 million euros	14 million euros	4 million euros
Additional product taxes	0.9 million euros	1.4 million euros	0.7 million euros
Additional income taxes[1]	2-3 million euros	5-8 million euros	1.5-2.5 million euros

[1] The tool does not calculate an income tax effect, as the ratio of income tax to revenue varies substantially in the individual sectors. An approximate estimate of the income tax effects has been calculated in this case. For 2017, the income tax revenue was 7.82 % of GDP. For this reason, we used 6-9 % as an approximate interval.
Source: Own calculatrions

From the macroeconomic assessment, based on the illegal treatment of 363,000 ELVs and the illegal export of 72,600 ELVs per year in Germany, the following can be concluded, if all German ELVs were accepted and treated by authorised treatment facilities (ATFs):

- The total revenues of all (legal) German ATFs could increase by 284 million euros. This would, on average, correspond to **additional 250,000 euros of revenues per year for each of the 1,100 or so German ATFs**.
- In total, an **additional expenditure of 59 million euros** must be financed. In case the car manufacturers bore these costs according to the EPR principle, this would amount to additional costs of around **20 euros per new car**, based on annually around 3 million new passenger cars registration (or more) in Germany.
- The complete shift of ELVs into ATFs could create an additional added value in the German national economy of 28 to 85 million euros per year. According to the calculations and estimations, this also leads to additional employee compensation and workplaces of about several 100 jobs and additional social security payments of 4 to 14 million euros.

- Taxes: The expected increase in income taxes and product taxes is rather limited because
- The economic effects of the shift to complete ELV treatment in ATFs are very much dependent on how it is financed. For all three financing options, however, positive economic effects result from the shift to authorised dismantling.

In addition to these positive economic effects, environmental costs would be avoided by avoiding illegal dismantling activities, see following section 7.

7 Ecological impacts and environmental costs of illegal dismantling

As (direct) environmental impacts of the unauthorised dismantling of ELVs, soil and water contamination due to the release of waste oil can be expected or observed. In addition, in unauthorised dismantling, refrigerants are often not separated properly. The release of refrigerants from air-conditioning systems from ELVs contributes to the global warming potential.

The environmental costs of the illegal ELV treatment in Germany add up to about 40 million euros per year.

7.1 The climate impact of released refrigerants

Air conditioning systems in motor vehicles contain R134a and (in younger cars) R1234yf. The current proportion in ELVs is estimated to 98 % R134a and, respectively, 2 % R1234yf.

Two refrigerant scenarios with different ELV air conditioning equipment rates[8] are calculated. Scenario "Status Quo" assumes an ELV air conditioning equipment rate of 75 %, while scenario "New cars" assumes 92.6 % as equipment rate.

An estimation for the annual refrigerant loss due to improper handling in the illegal ELV treatment in Germany is provided in Table 20. It is based on the estimation of 363,000 ELVs treated in unauthorised dismantling. For type II operators, a refrigerant loss of 10 % of the average content of 600 g per ELV is assumed, for types I and III 70 % and for type 4 100 %.

Table 20: Estimation of refrigerant emissions due to improper depollution of ELVs in unauthorised dismantling in Germany (2018)

Scenario	Refrigerant	Estimated refrigerant emissions from improper depollution	Specific Global Warming Potential (GWP) [kg CO_2-eq/kg]	Contribution of the emissions to GWP	Total	Environmental costs
Scenario „Status Quo": 75 % of ELVs with A/C	R134a	117 t	1,43	167,000 t CO_2-eq	167,000 t CO_2-eq	€ 32.6 million
	R1234yf	2.4 t	1 to 4	6 t CO_2-eq		
Scenario „New cars": 92,6 % of ELVs with A/C	R134a	144 t	1,43	206,000 t CO_2-eq	206,000 t CO_2-eq	€ 40.2 million
	R1234yf	2.9 t	1 to 4	7 t CO_2-eq		

Source: Calculation based on data from RETEK and (UBA 2020)

[8] Scenario "Status Quo": based on the reference company (RETEK) and currently dismantled vehicles; Scenario "New cars": based on new registrations and a vehicle lifetime of 15 years

The amount of refrigerants, which is estimated to be released in illegal dismantling, is estimated to be 167,000 t of CO_2-equivalents in the scenario "Status Quo" and 206,000 t of CO_2 equivalents in the scenario "New cars".

According to the Methodological convention 3.1 for the Assessment of Environmental Costs of the German Environment Agency (Bünger and Matthey 2019), the emission of one tonne of CO_2 causes environmental costs at €195 . As a result, the monetised value of the environmental effect of the refrigerant release per year is, therefore, **€32.6 million in Scenario "Status Quo"**. This amount is **40.2 million € in Scenario "New cars"**.

7.2 Soil contamination due to waste oil

Precise cost rates per improperly treated ELV or per contaminated area are not yet available. Therefore, other estimation approaches were applied in the following.

Cost rates based on decontamination costs

Since other methods for estimating a cost rate do not have the necessary data basis, average decontamination costs of soils were used as an auxiliary value, in accordance with the German Environment Agency's "Methodological Convention 3.1 for the Assessment of Environmental Costs" (Bünger and Matthey 2019). Here, the cost rates of the Federal Office for Spatial Development from Switzerland are used for the calculation of environmental costs due to soil contamination (Bieler et al. 2018).

The value is based on average decontamination costs of the contaminated soil. The decontamination costs consist of the costs for the disposal (dumping) of contaminated soil material, the replacement with uncontaminated material and the costs for excavation and transport. This calculation was originally made in 2000, but has been continuously updated since then, most recently in 2015.

To calculate decontamination costs, the polluted soil area or volume must be multiplied by a cost rate for excavation, replacement and disposal of the polluted soil volume. These calculations are made for the most important heavy metals, especially lead. However, the damage costs for the individual pollutants are not added up, since a soil is only remediated once, even if it contains different pollutants. In the end, therefore, the substance that pollutes the largest volume of soil annually up to the critical concentration and thus causes the greatest external costs is relevant for the cost calculation.

Volume of contaminated soil and annual damage

It is assumed that during the non-authorised treatment and storage of the estimated 363,000 ELVs in Germany in 2018, in total 36,000 litres of waste oil were spilled. The area concerned and contaminated might amount to 4.5 km^2. The maximum volume that can be polluted by the spilled waste oil by illegal ELV dismantling - in the sense of reaching the precautionary limits of the German Federal Soil Protection and Contaminated Sites Ordinance (BBodSchV) - has been estimated to about 8.000 m^3. Applying the decontamination costs (see above) of 119.60 EUR/ m^3 to decontaminate this volume, the annual damage adds up to a total of about **1 million EUR.**

7.3 Conclusion

The environmental costs of the illegal treatment of estimated 363,000 ELVs caused by oil spillage (cf. 7.2) and refrigerant release (cf. 7.1) sum up to around 40 million euros per year.

8 Assessment of impacts and recommendations for action

The analysis of the cost and revenue structure of authorised dismantling facilities and the comparison with illegal dismantling operators showed that the activities and cost items resulting from the fulfilment of the obligations under the End-of-Life Vehicles Ordinance account for a relevant share of the costs. In the case of dismantling by non-authorised actors, there are significant cost advantages, as a number of cost items are not incurred or are incurred to a lesser extent, see 5. For the four model types of non-authorised dismantling defined on the basis of the investigations carried out, there are lower costs across all differentiated cost categories compared to dismantling in an authorised dismantling facility. The treatment costs (personnel costs) per end-of-life vehicle are also significantly lower. As a result, the positive result per end-of-life vehicle is significantly higher in illegal dismantling than in authorised dismantling, namely by up to 250 to 300 euros per end-of-life vehicle, compared to a dismantling company with spare parts sales (cf. Figure 7).

While the activities of the illegal dismantling companies generate higher revenues than those of the authorised dismantling companies, negative environmental impacts result from non-compliance with the obligations of the End-of-Life Vehicles Ordinance. Refrigerant emissions and oil discharges into the environment were identified as particularly relevant. Both together result in environmental costs in Germany of around 34 to around 41 million euros p.a. (base year: 2018).

In addition to the negative environmental impacts caused by illegal dismantling, the authorised companies lose revenue due to dismantling by non-authorised actors. This lost revenue can be estimated at around 284 million euros per year. Furthermore, lost tax revenues (in the amount of 2.2 to 9.4 million euros) and missing social security contributions (in the amount of 4 to 14 million euros) can be determined.

The competitive situation between authorised and unauthorised players in the dismantling of end-of-life vehicles also reduces the scope for additional - ecologically beneficial - activities by the authorised players. For example, glass and plastic dismantling or a more in-depth separation of electronic components would cause additional costs that would not be offset by corresponding revenues.

Moving all end-of-life vehicles with non-authorised whereabouts - for which the additional costly processing steps would then be carried out in accordance with the End-of-Life Vehicles Ordinance - to authorised dismantling would contribute to reducing negative environmental impacts and also result in a positive economic effect (additional value creation in the German economy of 28 to 85 million euros, 300 to 1,200 additional employees subject to compulsory social security contributions, 4 to 14 million additional social security contributions, additional tax revenues of 2 to 9 million euros).

Various measures can contribute to preventing illegal dismantling of end-of-life vehicles and strengthening authorised dismantling.

The proposed measures presented below in sections 8.1 to 8.3 focus on those measures that have direct links to the research and results in this project.

8.1 Avoiding illegal dismantling through improvements in enforcement

A central starting point for avoiding illegal dismantling activities can be improved enforcement by the competent authorities. In the stakeholder interviews conducted, the enforcement of

suspected cases of illegal dismantling activities was described as a complex and time-consuming process. The main challenges in this regard are, among others:

- The constellation of actors involved in unauthorised dismantling is often unclear (e.g. private individuals on commercial or non-commercial premises, subleased parts of premises, automobile workshops with their very different characteristics, dealers, exporters, scrap yards).
- Problems with access to the site and identification of responsible persons: It regularly happens that sites are not accessible (fence, locked gates, guard dogs) and that it remains unclear who owns the vehicles on the site. In the latter case, it happened, for example, that reference was made to relatives who had “only parked" the vehicles
- Determining whether illegal activities are present: Here, the information provided by the actor and the observations of the enforcement authorities or reports are regularly in conflict with each other. The main challenge here is to determine the waste status (see also section 8.1.4).
- High personnel expenditure for enforcement; in addition to carrying out inspections/controls, their preparation and follow-up as well as the coordination with other departments, which is sometimes necessary, are also time-consuming. Basically, “the more is inspected, the more is detected”. The cases identified are only "the tip of the iceberg". On the other hand, human resources are scarce. This corresponds to findings from earlier studies (cf. Sander et al. 2017; Sander et al. 2016).

Against the background of these challenges, the following recommendations aim to prevent illegal dismantling.

8.1.1 Simplified reporting options for suspected cases of illegal dismantling

In the stakeholder discussions and the final workshop on the project, the possible benefits of a simplified option for reporting suspected cases of illegal dismantling were repeatedly suggested. In particular, the request for a central office for such reports was expressed. The advantages mentioned here were a possible simplification and uniformity of reporting suspected cases as well as increased awareness of such a central reporting office. It was assumed that such a simplified reporting possibility would lead to more corresponding reports.

However, reporting via the German Environment Agency – as suggested in the final workshop on the project – does not seem feasible due to the responsibility of the federal states for enforcing the End-of-Life Vehicles Ordinance. However, it would be conceivable for the federal states to cooperate and implement a joint reporting office. Examples of such cooperation would be the “Gemeinsame Stelle Altfahrzeuge“ (GESA)[9] or the “Servicestelle Stoffliche Marktüberwachung“[10].

In the UK, for example, it is already possible to report suspected cases anonymously online, both via the Environment Agency[11] and the Vehicle Recyclers Association[12].

[9] GESA = Gemeinsame Stelle Altfahrzeuge = joint agency for ELVs

[10] Joint Agency for market surveillance of substances

[11] https://environmentagency.blog.gov.uk/2015/08/06/action-against-illegal-scrap-metal-criminals/

[12] https://www.vrauk.org/illegaloperators.aspx

It should be noted, however, that a potential increase in the reporting of suspicious cases only has a positive effect if the personnel capacities are also available to follow up on them accordingly. The next section discusses the strengthening of law enforcement personnel.

8.1.2 Strengthened domestic enforcement in terms of personnel

The follow-up of suspected cases of illegal dismantling is associated with considerable effort and sometimes varies considerably from case to case. Often, the work required per case can stretch over weeks and require the involvement of various authorities (in addition to the environmental/waste management authorities, building authorities, trade supervisory authorities, customs, police/state criminal investigation office, public prosecutor's office).

However, for a stable foundation of action among the authorised actors and implementation of the applicable legal obligations, more effective enforcement is needed. As described in section 8.1, the predominant assessment of the actors in law enforcement is that illegal activities could be identified and prevented through better staffing of law enforcement ("the more is inspected, the more is detected").

Such a reduction in the extent of the treatment of end-of-life vehicles in non-authorised dismantling facilities through improved (more efficient, more comprehensive) enforcement would lead to a shift of dismantling activities to legal, documented disposal channels with corresponding positive ecological and economic effects.

In concrete terms, there was a need for more staff at the authorities responsible for monitoring suspected cases (waste management authorities, environmental authorities), but also at building authorities and trade supervisory authorities. Some actors also considered it necessary to strengthen the staffing of law enforcement agencies (police, public prosecutor's office).

8.1.3 Improved cooperation in enforcement

In addition to strengthening enforcement in terms of personnel, the stakeholder discussions also clearly showed that functioning cooperation between the various authorities within a region (cooperation between environmental/waste authorities, trade supervisory authorities, building authorities, state criminal investigation office/police/customs/ public prosecutor's office) as well as supraregional cooperation (e.g. supraregional cooperation between waste/environmental authorities) can make a significant contribution to efficient and effective enforcement.

The strengthened cooperation of actors within a region can, for example, accelerate the closure/termination of illegal activities, as often there are not only deficiencies under waste law, but also deficiencies under building law or labour law, which can be used for official intervention. In some cases, deficiencies in building law or labour law can lead to a quicker closure than sometimes lengthy procedures regarding proof of the waste status of the vehicles concerned.

Supra-regional cooperation can help to pass on actor-specific knowledge. For example, the phenomenon was described regionally that actors involved in illegal dismantling relocate their activities to surrounding regions after the enforcement authorities have intervened. Through a supra-regional exchange, such a development can be countered more quickly – and more cost-efficiently.

8.1.4 Distinction between end-of-life vehicles and used vehicles in Germany

Previous expert reports (Sander et al. 2017; Sander et al. 2016) have already described the differentiation between end-of-life and used vehicles as a problem. The fact that this difficulty still exists and represents a problem in practice was clearly shown in the stakeholder discussions conducted.

In addition to the stakeholder interviews conducted, court decisions were evaluated and the Correspondents' guidelines No. 9 on the shipment of end-of-life vehicles under the European Waste Shipment Regulation were considered.

In summary, it can be stated that a generally valid development of "simple" criteria - i.e. criteria that can be applied without restriction during inspections – is difficult due to the complexity of the product "motor vehicle". However, with regard to improving enforcement – in the sense of simplifying the determination of the waste status – the aspect of "spare parts removal" in particular, which is regularly a central component of illegal dismantling activities, is seen as a central criterion. Both the vast majority of the evaluated court rulings and the Correspondents' Guidelines see the use of a vehicle as a spare parts source not as a purpose but as an indicator of its waste status ("cannibalisation is not a purpose" or rather "*A used vehicle should normally be classified as waste […] if at least one of the following criteria applies […]: The vehicle is destined for dismantling and reuse of spare parts or for shredding/scrapping*"), although there are individual court decisions that rule differently here. These individual court rulings, which consider the removal of spare parts as a new use, are not comprehensible from the point of view of the experts. However, from the point of view of the experts, vehicles that are not intended for further use, but only as spare parts sources, should be classified as waste.

Here, it is recommended that the removal of spare parts be established as a legally unambiguous indicator of the waste status via a corresponding concretisation of the definition of "end-of-life vehicle" in the End-of-Life Vehicles Ordinance. It is often comparatively easy to determine whether spare parts are being removed from vehicles in concrete cases of suspected illegal dismantling; either by observing corresponding activities and/or by the fact that removed used spare parts are offered for sale.

8.2 Transfer of the Model of Compulsory Verification for Operators of Electronic Marketplaces under the ElektroG[13], VerpackG[14] and BattG[15]

Online marketplaces represent a central marketing channel for spare parts obtained through illegal dismantling activities. An obligation for the operators of online marketplaces to verify whether the second-hand vehicles or vehicle parts offered are waste can help to limit illegal activities.

8.2.1 The model of compulsory verification

Used vehicles are frequently offered on online marketplaces for used vehicles. These may also be end-of-life vehicles within the meaning of § 3 (1) No. 2 of the End-of-Life Vehicles Ordinance (AltfahrzeugV), i.e. those that are waste according to § 3 (1) of the KrWG. If they are waste, the end-of-life vehicles are subject to the obligations of the End-of-Life Vehicles Ordinance, in particular the obligation to hand over the vehicle according to § 4 (1) End-of-Life Vehicle Ordinance. Accordingly, anyone who discards, wishes to discard or must discard a vehicle must

[13] Electrical and Electronic Equipment Act

[14] Packaging Act

[15] Battery Act

only hand it over to an authorised collection point, an authorised take-back point or an authorised dismantling facility. Offering end-of-life vehicles via online marketplaces is contrary to these obligations if - which is likely to be the case regularly - the purchaser is not an authorised collection point, an authorised take-back point or an authorised dismantling facility.

This illegal behaviour could be countered if only those used vehicles were allowed to be offered via online marketplaces that do not fall under the definition of waste and are thus end-of-life vehicles within the meaning of the End-of-Life Vehicles Ordinance. This could be achieved if the operators of the marketplaces were obliged to verify whether the vehicle offered in each case is waste or not.

Such a compulsory verification for operators of online marketplaces and fulfilment service providers with regard to electrical and electronic equipment, packaging and batteries was proposed in an expert opinion for the German Environment Agency on the extended producer responsibility (EPR) of third-party manufacturers in online retail (Hermann et al. 2020).

The model of a compulsory verification pursued in the expert report makes the operators of online marketplaces and fulfilment service providers responsible for the fulfilment of registration obligations by manufacturers. The marketplace operators have to ensure that only those manufacturers offer on their platforms who have fulfilled the notification obligations resulting from the aforementioned laws. The operators are thus given an active role in ensuring compliance with the obligations arising from producer responsibility under waste law, without being considered producers themselves. Since the operators of online marketplaces, and even more so fulfilment service providers, are much more accessible to the authorities than producers in third countries, enforcement of the law is improved. In the meantime, these proposals have been taken up by the legislator.[16]

8.2.2 Transferability to the sale of end-of-life vehicles via online marketplaces

Experience has shown that end-of-life vehicles are also offered on online marketplaces such as ebay etc. without ensuring that this end-of-life vehicle can only be purchased through authorised collection points, take-back centres or dismantling companies. The offering of car parts such as tyres, engine parts etc. is also very common.

However, it is not permitted to dispose of an end-of-life vehicle by offering it via an online marketplace without ensuring that this end-of-life vehicle can only be acquired through authorised collection points, take-back centres or dismantling facilities. As outlined in another section, detailed regulations on the return, transfer and disposal of end-of-life vehicles apply under the End-of-Life Vehicles Ordinance (AltfahrzeugV). This is not only relevant under waste law, but also under criminal law. Therefore, if it is an end-of-life vehicle, it qualifies as waste, with the consequences described. If this waste is offered via electronic marketplaces, this leads to a violation of the transfer obligations from § 4 of the End-of-Life Vehicles Ordinance if the buyer is not an authorised recipient according to the End-of-Life Vehicles Ordinance. Owners may only hand over end-of-life vehicles to an authorised acceptance centre, an authorised take-back centre or an authorised dismantling facility.

To date, however, there is no suitable enforcement mechanism to ensure that no end-of-life vehicles or parts from improper treatment are offered. In particular, it is difficult to monitor the trade in end-of-life vehicles or their parts via online marketplaces.

[16] Electrical and Electronic Equipment Act of 20 October 2015 (BGBl. I p. 1739), as last amended by Article 23 of the Act of 10 August 2021 (BGBl. I p. 3436).

This problem situation is similar to the problem of so-called third-country free riders described above. It is true that the sellers of end-of-life vehicles and parts thereof on online marketplaces are regularly individuals from EU member states. However, the situation is comparable in that similar actors as in the case of electrical and electronic equipment, batteries and packaging are also active here:

- There is a provider who evades the obligations of waste law (in this case: obligation to surrender according to § 4 of the End-of-Life Vehicles Ordinance) by using an online marketplace. As a rule, the providers pay a fee to the operator for providing the marketplace. Even if no fee is paid, as may be the case with ebay classifieds, for example, this does not change the offer via an online marketplace. This is at least partially comparable to a manufacturer from a third country. In the case of salvage exchanges, the insurance companies or appraisers have the residual value determined while the vehicle still belongs to the owner. Here, too, it is ultimately a question of the last owner wanting to get rid of the vehicle, which therefore falls under the waste property and becomes an end-of-life vehicle.
- There is an online marketplace that is not involved in the obligations arising from extended producer responsibility under waste law. This is comparable to the online marketplaces mentioned above.
- There are buyers who purchase the products offered via the online marketplaces from the supplier. With the salvage exchanges, there is no immediate sale, but the potential buyer makes an offer. A sale only follows if the vehicle owner agrees. In the case of a sale, the new owners of the end-of-life vehicles enter into the obligations under waste law, for example according to § 4 of the End-of-Life Vehicles Ordinance (AltfahrzeugV) and may also be criminally liable if they act accordingly. However, this differs from the compulsory verification under the ElektroG, which is primarily aimed at preventing third-country free riders. As a rule, this concerns new electrical appliances, not the trade in old electrical appliances. It is also problematic in this respect that the operator of the marketplace is generally not likely to know whether the vehicle on offer is an end-of-life vehicle. This would be different if there were objective criteria that could be used to determine whether the vehicle is an end-of-life vehicle, e.g. a certain mileage, an economic total loss or similar. In contrast to the ElektroG, the time of placing on the market cannot be used as a starting point for the obligations.
- Similarly, the owners of WEEE (Waste of Electrical and Electronic Equipment) are obliged under § 10 (1) ElektroG to collect them separately from unsorted municipal waste and to separate spent batteries and accumulators that are not enclosed in the WEEE from the latter before handing them in at a collection point.

In the case of end-of-life vehicles or their parts, an obligation on the part of the operators of online marketplaces to carry out verifications could be designed as an independent obligation not linked to ownership. The operators would then have to verify whether the vehicle owners offering vehicles on their marketplaces are actually offering end-of-life vehicles. The marketplace operators would then have to restrict the addressees of corresponding offers on their websites from the outset or subsequently. They would not be classified as owners (comparable to manufacturers in the case of electrical and electronic equipment), but they would be included in the obligations under waste law.

The existing End-of-Life Vehicles Ordinance (AltfahrzeugV) could be used as regulatory material for the implementation of such a compulsory verification for the operators of online marketplaces. The steps required for this would be:

- Definitions of online marketplaces and operators of online marketplaces in § 2 End-of-Life Vehicles Ordinance (based on § 3 No. 11 a and b ElektroG 2022):
  - "*online marketplace: means a website or any other means by which information is made available via the Internet that enables owners of vehicles who are not operators of the online marketplace to offer or provide vehicles within the scope of this Act;*[17]
  - *operator of an online marketplace: any natural or legal person or partnership that maintains an online marketplace and enables third parties to offer or provide vehicles on that marketplace within the scope of this Act".*[18]
- A prohibition norm, e.g. in addition to § 4 End-of-Life Vehicles Ordinance (based on § 6 (2) sentence 2 ElektroG 2022):
  - *"If the product is an end-of-life vehicle within the meaning of § 2 (1) No. 1 and 2, operators of online marketplaces may only allow the offering or making available of these products to collection points, take-back points or dismantling facilities within the meaning of § 2 (1) No. 14 - 16 of the End-of-Life Vehicles Ordinance."*[19]
- A regulation on fines as a sanction option in the event of infringements by the operator of an online marketplace in addition to § 11 End-of-Life Vehicles Ordinance (based on § 45 (1) No. 4a ElektroG 2022):
  - *"Any person who intentionally or negligently (...) enables the offering or making available of an end-of-life vehicle in contravention of § 4 (...) shall be deemed to have committed an administrative offence within the meaning of § 69 (1) No. 8 of the Circular Economy Act."*[20]

Such a compulsory verification constitutes an intervention in the fundamental rights of the operators of online marketplaces, which would have to be examined in detail as to its suitability, necessity and appropriateness

- Such a compulsory verification would serve a legitimate purpose, namely the prevention of illegal disposal of end-of-life vehicles. In view of the approximately 300,000 end-of-life vehicles per year relevant here, which are not treated in accordance with the requirements of the End-of-Life Vehicles Ordinance, approximately 284 million Euros are withheld from the intended disposal channels. It can be assumed that a not inconsiderable proportion of these end-of-life vehicles or their parts are traded over the internet.
- The suitability of an compulsory verification depends above all on whether the platform operators can assess whether a vehicle offered on their website is an end-of-life vehicle and thus waste. It must be possible to assess the vehicles quickly on the basis of simple, easily comprehensible criteria. With a number of vehicles offered on internet portals that can run

[17] Own translation, orig.: "elektronischer Marktplatz: eine Website oder jedes andere Instrument, mit dessen Hilfe Informationen über das Internet zur Verfügung gestellt werden, die es Besitzern von Fahrzeugen, die nicht Betreiber des elektronischen Marktplatzes sind, ermöglicht, Fahrzeuge im Geltungsbereich dieses Gesetzes anzubieten oder bereitzustellen"

[18] Own translation, orig.: "Betreiber eines elektronischen Marktplatzes: jede natürliche oder juristische Person oder Personengesellschaft, die einen elektronischen Marktplatz unterhält und es Dritten ermöglicht, auf diesem Marktplatz Fahrzeuge im Geltungsbereich dieses Gesetzes anzubieten oder bereitzustellen"

[19] Own translation, orig.: "Handelt es sich um ein Altfahrzeug im Sinne von § 2 Abs. 1 Nr. 1 und 2, dürfen Betreiber von elektronischen Marktplätzen das Anbieten oder Bereitstellen von diesen Produkten nur für Annahmestellen, Rücknahmestellen oder Demontagebetrieben im Sinne von § 2 Abs. 1 Nummern. 14 – 16 der Altfahrzeugverordnung ermöglichen"

[20] Own translation, orig.: "„Ordnungswidrig im Sinne des § 69 Absatz 1 Nummer 8 des Kreislaufwirtschaftsgesetzes handelt, wer vorsätzlich oder fahrlässig (…) entgegen § 4 Absatz (…) das Anbieten oder Bereitstellen eines Altfahrzeugs ermöglicht"

into the millions, a test procedure would be required that enables a relatively simple assessment of the waste status, i.e. a distinction between waste and non-waste. For this purpose, criteria that are as easy to apply as possible should be developed. If this is not possible, the suitability is in question. The difficulty of classifying waste/non-waste was discussed in section 8.1.4. In accordance with the remarks made there regarding the removal of spare parts, one conceivable criterion would be that for spare parts it must be proven that the vehicle is intended for further use (i.e. is not an end-of-life vehicle) or that the removal of the spare parts has been carried out by authorised dismantling companies.

- The suitability also depends on whether it is technically possible to make the operators of online marketplaces responsible. If necessary, a comparison with the GESA is conceivable. According to §7 (2a) of the End-of-Life Vehicles Ordinance (AltfahrzeugV), GESA has the task of: "*Collecting data on authorised dismantling facilities, shredding plants and other facilities for the further treatment of end-of-life vehicles centrally for the whole of the Federal Republic of Germany and making it available to both the public and the enforcement authorities. All experts are obliged to report to the End-of-Life Vehicles Clearing House the dismantling facilities, shredding plants and other facilities for the further treatment of end-of-life vehicles authorised by them*"[21].

8.3 Further measures against illegal end-of-life vehicle dismantling

The measures presented above were derived directly from the research on illegal ELV treatment carried out in this study and from the results of the previous chapters.

In addition, there are further approaches to counter illegal ELV treatment that are briefly mentioned here but will not be elaborated on:

- **Strengthening the certificate of destruction:** This request, which has been expressed by various actors for years, cannot be implemented in the sense of an additional environmental benefit or steering effect in the properly functioning treatment infrastructure through singular measures that are solely aimed at the instrument of the certificate of destruction. The certificate of destruction as a steering instrument can only be effective in combination with the vehicle registration and deregistration system, see also Kitazume et al. (2020) und Kohlmeyer et al. (2017).

- **Strengthening extended producer responsibility as an approach to long-term sustainability:** The analysis of the cost and revenue situation of authorised dismantling has shown that it is possible to make a profit in the dismantling of end-of-life vehicles, but that a number of conditions must be met for this to happen (e.g. the amount of revenue that can be generated from the removal of spare parts and the dismantling of materials). Price fluctuations can contribute to relevant changes in the revenue situation. Activities such as glass dismantling and the dismantling of large plastic parts, on the other hand, can cause relevant additional costs. Furthermore, end-of-life vehicle treatment (including the need for training and special tools and equipment) will become more complex in the future, e.g. due to two different refrigerants, the increase in electromobility, composite materials, etc. Strengthening extended producer (EPR) responsibility can be an approach to contribute to

[21] Own translation, orig.: "Daten zu anerkannten Demontagebetrieben, Schredderanlagen und sonstigen Anlagen zur weiteren Behandlung von Altfahrzeugen zentral für die gesamte Bundesrepublik zu sammeln und sowohl der Öffentlichkeit als auch den Vollzugsbehörden zur Verfügung zu stellen. Alle Sachverständigen sind verpflichtet, der Gemeinsamen Stelle Altfahrzeuge die von ihnen anerkannten Demontagebetriebe, Schredderanlagen und sonstigen Anlagen zur weiteren Behandlung von Altfahrzeugen zu melden."

Source: https://hilfe.gadsys.de/fbrwiki/gesa-info.

the financial security of dismantling activities - especially of ecologically beneficial additional dismantling steps such as glass and plastic dismantling. This would transfer the financial responsibility for dismantling to the manufacturers. Up to now, manufacturers have essentially been subject to the take-back obligations under § 4 of the End-of-Life Vehicles Ordinance (AltfahrzeugV), combined with further obligations such as the obligation to hand over end-of-life vehicles under § 4 (3) of the End-of-Life Vehicles Ordinance (AltfahrzeugV). According to this, operators of acceptance points and collection points are obliged to hand over end-of-life vehicles only to an authorised dismantling facility. Transferring the financial responsibility for dismantling to the manufacturers would go beyond these obligations.

► In addition to measures to improve enforcement by the authorities, Mehlhart et al. (2017) recommend the following measures:-

- the improvement of vehicle registration systems,
- economic incentives or penalties for the use of the certificate of destruction, and
- an improvement of whereabouts transparency through improved statistics on vehicle imports and exports. A more detailed description of these recommended measures can be found in the study (Mehlhart et al. 2017).

8.4 Summary of measures

A summary and evaluation of all recommended measures can be found in Table 21.

Table 21: Assessment of measures

Measure	Aim	Addressee	Effort and costs	Implementation horizon	Level of legal implementation	Practical feasibility	Acceptance	Effectivness
(M1) Creation of simplified reporting possibilities for suspected cases of illegal dismantling	Avoidance of illegal dismantling	Federal government/ provinces or economic actors	For the creation of a reporting possibility (without follow-up activities): low	Short to medium term	None	Clarify responsibility and, if necessary, legal issues (data protection).	High	Simplified reporting options (online portal) can significantly simplify the identification of suspected cases. However, an effect only occurs when followed up with enforcement.
(M2) Strengthened enforcement in terms of personnel	Avoidance of illegal dismantling	Public authority actors at regional/ municipal level	High	Short to medium term	None	Rather questionable due to scarce resources among municipal actors	Authorities: limited due to additional effort / costs	Number of "successfully handled cases" roughly proportional to the staff deployed
(M3) Improved cooperation in enforcement	Avoidance of illegal dismantling	Public authority actors at regional/ municipal level	Low-medium	Short to medium term	None	Already practised in part; in part rather questionable due to scarce resources of municipal actors	Authorities: limited due to additional effort / costs	High potential to reduce illegal dismantling
(M4) Concretisation of the definition of end-of-life vehicles in the End-of-Life Vehicles Ordinance, in particular with regard to the removal of spare parts	Avoidance of illegal dismantling	Federal government	Low	Medium term	German End-of-Life Vehicles Ordinance	Feasable	Authorised dismantling facilities: high Other spare parts removing companies: low	Relocation of spare parts removal to authorised dismantling facilities; simplification of enforcement through clear criterion

Measure	Aim	Addressee	Effort and costs	Implementation horizon	Level of legal implementation	Practical feasibility	Acceptance	Effectivness
(M5) Application of the compulsory verficiation model for the waste status in online marketplaces for second-hand vehicle trading	Avoidance of illegal dismantling	Federal government	Additional effort for marketplaces due to new obligations; Inspection effort for authorities	Short to medium term	German End-of-Life Vehicles Ordinance	Difficult, because easily enforceable differentiation criteria are hard to find.	Online marketplaces: low Authorised dismantling facilities: high	Since the marketing of spare parts is largely handled online, a high potential for reducing illegal dismantling is seen here if implemented consequently.
(M6) Strengthening the Certificate of Destruction	Steering into authorised ELV treatment	Federal government / EU	Additional effort to change the vehicle registration system; reduced enforcement effort against illegal dismantlers.	Medium term	German Vehicle Registration Ordinance and others; European End-of-Life Vehicles Directive	Revision of vehicle registration system: not easy on national level, since new processes and proof criteria have to be developed, difficult on EU level due partial lack of competence at EU level	Authorised treatment facilitiers and car manufacturers : high.	Very effective in combination with the vehicle registration and deregistration system. However, hardly effective as a singular measure.
(M7) Strengthening extended producer responsibility	Strengthening the economic sustainability of legal dismantling	Federal government / EU	Only shifting of costs; no additional costs	Rather medium to long term	German End-of-Life Vehicles Ordinance	Feasable	Questionable for manufacturers and dismantlers	Financing security of dismantling activities would be ensured; additional ecologically beneficial dismantling activities could be financed

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