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Waste from private cars in 2030

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This report has been reviewed and approved in accordance with IVL's audited and approved management system.

Foreword

The results presented in this report are a result of research done with support from the Swedish Environmental Protection Agency within the framework of the research programme ”Towards Sustainable Waste Management”. This research is part of the project “Future waste quantities”, which deals with projections of future waste quantities and with waste prevention. The work presented in this report has been carried out at IVL Swedish Environmental Research Institute. Useful input has been providedas by Maria Ljunggren Söderman and Åsa Stenmarck at IVL, by Anna Henstedt and Mats Mattsson at Bil Sweden, Börje Sundberg and Tove Bååth at SJ, Inge Karlsson and Nilserik Sahlén at Statistics Sweden, Andreas Andersson at Volvo Car Corporation, Lars Mårtensson at Volvo Truck Corporation, Kenth Algotsson at Saab, Ralejs Tepfers at Chalmers University of Technology, Jerker Nyblom at Akademiska Hus in Stockholm, Reidar Grundström at Sjöfartsverket, and Therése Lundman at Luftfartsstyrelsen. The final manuscript reflects the views of the authors only, however.

The study was completed in 2011, but final editing of the report was made in 2016.

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Summary

Towards Sustainable Waste Management (TOSUWAMA) is an interdisciplinary research programme on policy instruments and strategic decisions that can contribute to developing waste management in a more sustainable direction. It includes ten different projects. One of these, "Future waste quantities", aims to investigate how the quantity of waste develops in different future scenarios for the year 2030. For this purpose we apply the Environmental Medium term EConomic model (EMEC), a computational general equilibrium model of the Swedish economy. EMEC estimates the waste quantities in the year 2030 based on the projected economic activities (investments, production, etc.) in that year. However, the quantity of waste from long-life products – such as buildings, vehicles, and appliances – might not be linked to the level of investment and production in that year but to the level of investments and production in the decades before that. This report presents a complementary study where the waste quantity is instead estimated based on the technical life-time of long-life products.

An initial screening procedure (Chapter 2) indicates that the waste from old buildings and, to some extent, appliances is related to the economic activity in 2030 and, hence, rather well modelled with EMEC. The quantity of waste from vehicles other than private cars appears to be rather small and does not require a specific investigation. In the end, discarded private cars is the only waste fraction where an analysis based on the technical life-time can contribute significantly to the estimate of waste quantities in 2030.

The analysis of the quantity of private cars that are discarded in 2030 is based on estimates of the life-time of cars, of the number of new cars in Sweden in 2015 and 2020, and of the average weight of these cars. We also investigate the material composition of the cars. Our results indicate that EMEC overestimates the quantity of discarded vehicles by 25-100%. There are sources of errors also in our study, but the difference in results should still be taken into account when conclusions are based on EMEC results and the quantity of discarded vehicles is a significant issue.

Sammanfattning

Hållbar Avfallshantering är ett tvärvetenskapligt forskningsprogram om styrmedel och strategiska beslut som kan bidra till att avfallshanteringen utvecklas i en mer hållbar riktning. Programmet inkluderar tio olika projekt. Ett av dessa, "Framtida avfallsmängder", syftar till att undersöka hur mängden avfall utvecklas fram till år 2030 i olika scenarier. För detta syfte använder vi modellen EMEC (Environmental Medium term EConomic model). Det är en allmän jämviktsmodell av svensk ekonomi. EMEC uppskattar avfallsmängderna år 2030 baserat på den ekonomiska aktiviteten (investeringar, produktion, etc.) i olika sektorer under det året. Hur mycket avfall från långlivade produkter – rivningsavfall från byggnader och konstruktioner, skrot från fordon och apparater – som uppstår under ett bestämt år kan dock inte självklart kopplas till hur mycket som investeras och produceras under samma år. Istället kan den avfallsmängden styras av investeringar och produktion som gjorts årtionden innan dess. Denna rapport presenterar en kompletterande studie där utgångspunkten istället är att beräkna mängden avfall från långlivade produkter baserat på deras tekniska livslängd.

En första screening (kapitel 2) visar att avfallet från gamla byggnader och, i viss mån, apparater har starka samband med den ekonomiska aktiviteten år 2030 och därmed ganska väl modelleras med EMEC. Mängden avfall från fordon verkar domineras av skrotade personbilar. Mängden bussar, lastbilar, tåg, flygplan och fartyg som skrotas i Sverige är i jämförelse sannolikt liten, och avfall från dessa fordon kräver därför inte en särskild utredning. Slutsatsen från vår screening är att skrotade personbilar är den enda avfallsfraktion där en analys baserad på den tekniska livslängden avsevärt bidrar till att förbättra uppskattningen av hur mycket avfall som genereras år 2030.

Analysen av mängden personbilar som skrotas 2030 baseras på uppskattningar av bilarnas livslängd, av antalet nya bilar i Sverige år 2015 och 2020, och av den genomsnittliga vikten av dessa bilar. Vi undersöker också materialsammansättning i bilarna. Våra resultat indikerar att EMEC överskattar mängden skrotade fordon med 25-100%. Det finns naturligtvis felkällor även i vår studie. Skillnaden i resultat mellan EMEC och vår analys bör ändå beaktas när slutsatser dras baserade på EMEC-resultat, särskilt i de fall mängden bilskrot är avgörande för dessa slutsatser.

1 Introduction

1.1 The research program

Towards Sustainable Waste Management (TOSUWAMA) is an interdisciplinary research programme dedicated to investigating policy instruments and strategic decisions that can contribute to developing waste management in a more sustainable direction[1]. The primary target groups for the findings of TOSUWAMA is the Swedish Environmental Protection Agency and other policymakers in the field of waste management at European, national, regional and local levels, recycling companies, waste management companies and R&D organisations in waste management.

The ten research projects in TOSUWAMA are based on close co-operation and exchange of knowledge and results, see Figure 1. Each project adds important information and knowledge to the programme. These will be integrated in the project "Future-oriented synthesis", aiming at identifying decisions that contribute to the development of a more sustainable waste management system. In this way, the results of Towards Sustainable Waste Management will provide useful input to actual decision-making and strategy development in waste management and other related fields.

Figure 1 TOSUWAMA projects and the information flows between projects.

[1] More information about the program is available at http://www.hallbaravfallshantering.se/

1.2 Future Waste Quantities

This report is part of TOSUWAMA Project 7 "Future waste quantities", where we investigate how the quantity of waste develops in different future scenarios. Estimates of the future waste quantities are important for analyses of the long-term consequences of policy instruments in the waste-management sector.

Project 7 also investigates how the trend can be affected by policy measures aiming at waste prevention. Keeping the quantity of waste down is an important step towards sustainability since waste management affects the environment. Even more important, a reduction in waste flows often results in a reduction in material production, which reduces resource depletion as well as emissions to the environment. Analysing the options for waste prevention is therefore an important part of the programme.

This project includes four different activities:

- a top-down analysis of all Swedish waste flows, identifying the main causes of these flows and projecting how they can develop depending on the economic activities in different future scenarios (Sundqvist et al. 2010, Östblom et al. 2010), and a discussion on how they can be affected by different policy instruments (Ekvall et al. 2010);
- a separate analysis of the future scrap quantities from long-life products (this report);
- a bottom-up analysis of the economic cost of waste prevention in specific cases (Profu 2009); and
- the development of a structure of strategies for reducing the waste quantities through increases in the material efficiency of the society (Ekvall 2008).

For the top-down analysis we refine and apply the Environmental Medium term EConomic model (EMEC), a computational general equilibrium model of the Swedish economy (Östblom & Berg 2006, Östblom et al. 2010). The model distinguishes between 48 waste types (hazardous as well as non-hazardous) and 20 sectors (19 industrial sectors plus households) where waste is generated. All in all, this covers, with few exceptions, the total generated waste in Sweden.

Our input data are from the current national waste statistics. They are divided by data on current activities in the various EMEC sectors to calculate current waste intensities in each sector. We estimate how these intensities will develop until the year 2030 in the different external scenarios (Sundqvist et al. 2010). The resulting estimates for future waste intensities are used in EMEC to calculate waste quantities in 2030. The quantities of each waste type will vary between scenarios, because the economic development and the waste intensities (waste coefficients in EMEC) will both vary. The results are refined in other TOSUWAMA projects and used as input to other models (Ekvall et al. 2009, Östblom et al. 2010).

The EMEC estimates of waste quantities in the year 2030 are based on the projected economic activities (investments, production, etc.) in that year. However, long-life products – such as buildings, vehicles, and appliances – becomes waste many years after they have been produced. The quantity of waste from these products in 2030 might not be linked to the level of investment and production in that year but to the level of investments and production in the decades before that. If this is the case, EMEC will produce rather poor estimates of the quantity of waste from long-life products. A separate analysis of waste quantities from long-life products is called for to investigate this matter.

1.3 The report and method

This report presents the analysis of future waste quantities based on the technical life-time of long-life products. It is intended to complement the top-down analysis in EMEC, which is described in the previous section. The long-life products considered in this analysis are buildings, vehicles, and appliances. Infrastructure other than buildings is not included in the analysis.

The first phase of the analysis (presented in Chapter 2) is a screening procedure to identify what long-life products should be given priority in the analysis. As a result of the screening, the second phase (Chapter 3) focus on private cars.

The waste quantity from discarded private cars in the year 2030 is estimated for four different future scenarios:

- Scenario 1: Global sustainability
- Scenario 2: Global markets
- Scenario 3: Regional markets
- Scenario 4: European sustainability

These scenarios contain different assumptions regarding the economic, political and technological development until 2030, which might affects the number, size, and material composition of private cars. The scenarios have been developed specifically for use in this research programme (Dreborg & Tyskeng 2008), and the same scenarios are used in the top-down analysis in the EMEC model.

We calculate the future waste quantity from discarded cars based on estimates of the life-time of cars, of the number of new cars in Sweden in 2015 and 2020, and of the average weight and material composition of these cars. The main source of these estimates is Bil Sweden, the Swedish association for manufacturers and importers of cars, trucks and buses.

2 Screening of long-life products

2.1 Buildings

In 2006, the Swedish construction sector generated 8 Mtonnes of waste. This makes it the third largest sector, together with pulp and paper production, when it comes to generating waste (SEPA 2008).

The lifetime of a building depends on whether or not the required functions are available in the building (Tepfers 2008). As long as it is possible to modernize and adjust a building when new requirements arise, the building frame will serve, providing that the strength is enough for the new functions of the building. An example of this is the million program buildings that were constructed during the 1960s. These buildings were intended for a technical lifetime of 30 years, but they will become much older since they are renovated and insulation is added. The building frames and the apartment functions allow for this (Tepfers 2008).

If, on the other hand, the building cannot be adjusted after new requirements, the building will be demolished. Since demolishing costs money, it is often so, that buildings are not demolished until the land is required for a new building (Nyblom 2008). This, however, also depend on time, what kind of building it is and where the building is located. In the 1970s, many buildings were demolished in order to give place for new buildings, while nowadays many buildings are demolished due to difficulties in letting out apartments (Sahlén 2008).

It is the economy that decides whether the building is demolished or not, since also empty buildings cost money. If the prospects to find a buyer or a tenant to an empty building within the near future are small, so that the costs for the maintenance of the building will exceed the costs for demolishing, it is more likely that the building will be demolished. This case is most likely to occur in locations where the population is decreasing; in big cities and other places where the population increase, there is a large demand for buildings and building sites.

The conclusion from this is that buildings rarely are demolished only due to the fact that they have reached their "maximum technical lifetime". This means that the amount of demolition waste cannot be calculated as a function of the technical lifetime of the building. Instead, the lifetime of a building seem to depend on changes in requirements in different ways. Either buildings are re-built or demolished when new requirements of the functions of the building arise, which implies that re-building and demolishing follows the building process and thereby the business cycle. Or buildings are demolished due to depopulation, which rather implies an inverse relationship between demolishing and the building process in that region.

For the reasons raised above, we have chosen not to include buildings in the further analysis.

2.2 Vehicles

Discarded vehicles are one of the largest flows of hazardous waste in Sweden. SEPA (2008) estimated the quantity of scrapped vehicles in the year to 470 ktonnes. More than half of this originates from households and nearly a third from the service sector according to the SEPA statistics. SEPA (2008) states, however, that the share from the service sector might be overestimated.

2.2.1 Private cars

Private cars are an important part of the vehicles in Sweden. With an average kerb weight of the private cars of about 1400 kg, and about 265 000 cars scrapped per year (see Chapter 3), the total weight of discarded private cars is 371 ktonnes per year.

The domestic market for second hand cars is well established. New cars are often bought by companies for use by their employees, but second-hand cars are typically bought by households. This explains why such a large share of the discarded vehicles originates in households.

Private cars are traded in a cascade: relatively new and expensive cars are bought by households with a strong economy and/or households, for which the car is a priority. When the car becomes older they might sell it to households with a weaker economy and/or that give the car less priority. When the car, finally becomes too expensive to repair and maintain, no one is interested in owning it and it becomes is discarded. This indicates that the quantity of waste from private cars in the year 2030 is governed not by the economic activity in that year but by the quantity of cars that in 2030 gets too old to maintain.

Further analysis of the waste from private cars is called for, because private cars is an important part of the vehicles and because the quantity of this waste flow in 2030 seems to be rather independent of the economy in that year.

2.2.2 Trucks and Buses

Today, the majority of the trucks used in Sweden only stays in Sweden 6-8 years before they are exported (Mårtensson 2009). This has been assumed to be the case also for the buses used in Sweden. Thus, trucks and buses are not included in the further analysis.

2.2.3 Railway vehicles

SJ scrapped 149 passenger wagons during the period 2004-2008, i.e. during a period of 5 years (Sundberg 2008). The average weight of these passenger wagons were 43.3 tons (Bååth 2008). Thus, the weight of the passenger wagons scrapped each year is about 1290 tonnes. Assuming that the total amount of discarded locomotives and goods wagons is equal to the amount of passenger wagons scrapped, the total quantity of discarded railway vehicles is 2.6 ktonnes per year. Thus, the amount of trains (locomotives, passenger wagons and goods wagons) scrapped each year is significantly less than 1% of the amount of vehicles scrapped each year. For this reason, we have chosen to exclude trains from further analysis.

2.2.4 Aircrafts

Used civil aeroplanes are most commonly exported. Military planes, however, are always scrapped in Sweden – even military planes that have been exported to other countries are taken back to Sweden to be scrapped (Algotsson 2009). This is also verified by information about deregistered aircrafts supplied by Luftfartsstyrelsen (Lundman 2009). The same conditions have been assumed to be valid for helicopters, i.e. that the civil helicopters are most commonly exported while military helicopters are assumed to be scrapped in Sweden.

We have chosen to exclude aircrafts since the quantity of scrap from military aeroplanes and helicopters most likely is quite small compared to the total quantity of waste from discarded vehicles.

2.2.5 Ships

Hardly any scrapping of ships takes place in Sweden (Grundström 2008). If any at all, this concerns small ships and boats (i.e., mainly pleasure boats) that not so easily can be transported abroad.

There are about 1.3 million pleasure boats in Sweden (Kustguide 2011). Of these, 15% are larger boats designed to allow for staying overnight (Kustguide 2011). Assuming the lifetime of such boats to be 30 years and an average weight of 2 tonnes, the total scrap weight of these boats is 13 000 tonnes per year. Assuming the lifetime of the remaining, smaller 85% of the pleasure boats (which includes everything from canoes to small sailing or motor boats) to be 10 years and the average weight to be 0.2 tonnes, the weight of the scrapped smaller boats is 22 100 tonnes per year.

Thus, the total quantity of scrap from pleasure boats is about 35 000 tonnes per year if all pleasure boats are scrapped in Sweden. Since this is not the case, the total quantity of scrap from old ships is likely to be less than 35 ktonnes, i.e., significantly less than 10% of the total scrap from discarded vehicles. Although 10% is a noticeable part of the total, it is far less than the quantity of private cars. For this reason, we do not make ships a priority in the further analysis.

2.3 Appliances

The quantity of discarded equipment in Sweden was 200 ktonnes in the year 2006 (SEPA 2008). This is less than half, compared to the discarded vehicles, but it is still a noticeable share of the total hazardous waste. More than half of this waste was generated in households, and large household appliances appear to be an important part of it: in 2008 and 2009 the quantity of discarded large household appliances was approximately 70 ktonnes/year (SEPA 2011).

Appliances have a slightly shorter life-time than vehicles. IVA (2002) estimates the life-time to 10 years for large appliances (refrigerators, dishwashers, etc.), and 5 years for household electronics (computers, TV sets, etc.). These service life-spans might be even shorter now. When the product has not a very long life, an analysis based on the life time of the product adds less to the top-down analysis in EMEC. This is because the difference in economic activity in the model will not be very large between the year the appliance is produced and bought and the year when it is discarded.

The second-hand market for appliances is less well established and developed for appliances, compared to private cars. Appliances often stay in the same household for the whole duration of their use phase. They can be discarded because they break and are too expensive or difficult to repair because they become out of fashion, and/or because new products with better functionality are introduced on the market. The first of these three reasons depend mainly on the life time of the products, which is not accounted for in the EMEC top-down analysis. The two latter reasons, however, depend strongly on the economy of the household at the time when the appliance is discarded. This is modelled in EMEC, but it is difficult to account for in an analysis based on the technical life time.

For the reasons raised above, we have chosen not to include appliances in the further analysis.

3 Waste from private cars

3.1 Average lifetime

The majority of the private cars are scrapped after 10-15 years. This has been observed in the ARTEMIS model that accounts for survival probabilities for different vehicles. In order to estimate the amount of scrapWa produced from private cars in 2030, we have therefore chosen to estimate the number of private cars that are produced for the Swedish market in 2015 respective 2020.

3.2 The number of cars

At Bil Sweden, Mattsson (2009) analysed the statistics of new Swedish registrations of private cars for the years 1960-2008 (see Figure 2). He found a trend defined by the equation:

y = 208788 + 994*x,

where y is the number of new registrations x years after 1960. If this trend is extrapolated into the future, the number of new registrations i Sweden will be 268 000 private cars in 2020.

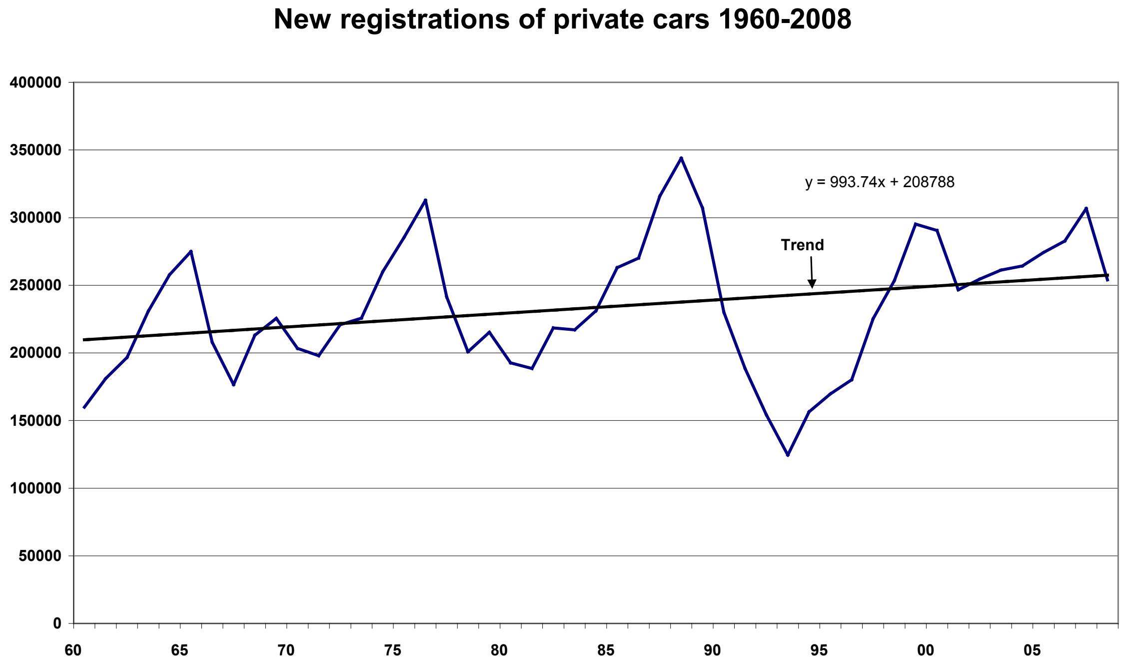

Figure 2 New registrations of private cars in Sweden during the period 1960-2008.

3.3 Average kerb weight

The average kerb weight of private cars in use in Sweden increased from 1292 kg in the late 1990s to 1424 kg a decade later – a 10% increase in ten years (SIKA 2009). The average kerb weight for new cars produced in 2008 for the Swedish market was 1527 kg (Karlsson 2009).

Since the car industry is under change, the opinions about how the kerb weight is developing diverge. In a life cycle assessment of lightweight compact class passenger vehicles performed in 2004, two weight reducing scenarios were studied; the reference weight in the study was 1000 kg, which was compared with two lightweight scenarios for 100 kg and 250 kg less weight based on reference functions (in terms of comfort, safety, etc.; Schmidt et al. 2004). According to Henstedt (2009), however, weight reducing measures in the construction is offset by the increased weight for safety improvements (e.g., strengthening), air conditioning, electronics, etc. This makes the weight of the car rather constant. Looking into the future weight and material composition of private cars, Andersson (2009) argues that it is relevant to distinguish between conventional and electrical cars. This is mainly due to the fact that the electric batteries are quite heavy.

We have chosen to use the average kerb weight for conventional cars produced in 2008 (1527 kg) as the reference weight and, in order to cover the different opinions in how the kerb weight is developing, we have chosen to vary this weight by +/- 10%. The same weight has been assumed for electrical cars. The batteries add significantly to the weight of these cars. On the other hand, we assume the rest of the electrical car to weigh less than a conventional car.

The development of the market for private cars with electrical batteries is difficult to predict. However, IVA (2009) have put forward a vision where we will have 100 000 electrical cars on the Swedish market in 2015, 600 000 in 2020 and that the sale of electrical cars will amount to 100 000 cars per year in 2020. Since we do not have any other information, we have assumed that the average life time for the electrical cars is equal to the average lifetime for the conventional cars.

3.4 Scenarios for 2030

The average lifetime and kerb weight in the year 2030, and also the role of electric cars, is likely to depend on the economic, political, and technological development until then. For this reason it is reasonable to make different estimates and assumptions for the four different scenarios (see Figure 3).

3.4.1 Scenario 1: Global sustainability

The globalisation of the economy continues in this scenario, facilitating trade, enhancing competition and technological development. National authorities and global organisations implement strong policy instruments etc. to govern society in a sustainable direction. The resulting economic growth will be moderate (Dreborg & Tyskeng 2008). The average lifetime of the private cars in this scenario has been assumed to be 12.5 years, which is in the middle of the 10-15 year interval mentioned in Section 3.1. Using the equation of Mattsson (2009), the total amount of cars that is scrapped 2030 (and produced 12.5 years before) is estimated to 266 000.

We assume that political incentives and environmental awareness of consumers result in a fulfilment of the vision concerning the amount of electrical cars: 100 000 electrical cars are added per year to the Swedish market. The share of electrical cars in this scenario is thus 38% (100 000 / 266 000).

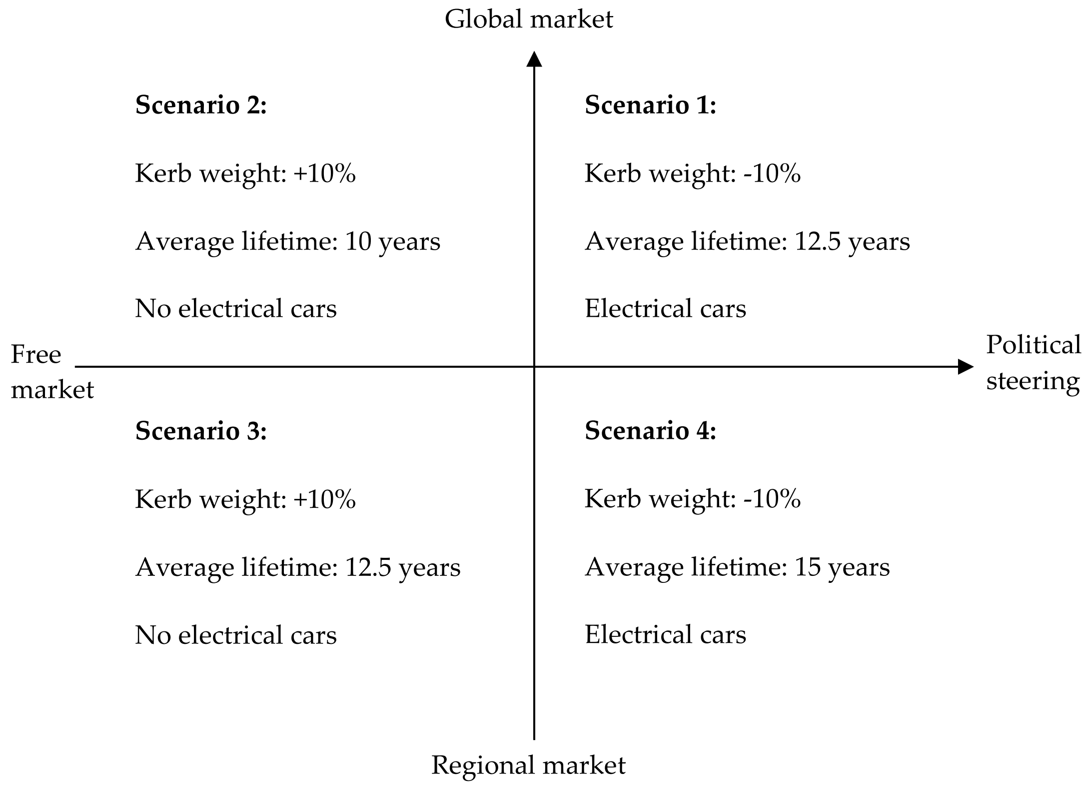

Figure 3 The scenarios included for private cars.

The same forces are assumed to reduce the weight of the cars in this scenario by 10% as compared with the reference weight for conventional cars. Thus, the kerb weight in this scenario is 1374 kg. The electric battery is assumed to constitute 10% of the total weight in the electric cars.

3.4.2 Scenario 2: Global markets

The globalisation of the economy also continues in this scenario, facilitating trade, enhancing competition, and technological development. Few and/or weak political instruments are in place to restrict the market forces. This results in a strong economic growth (Dreborg & Tyskeng 2008). The average lifetime of the private cars in this scenario has been assumed to be 10 years, since the free market will most probably lead to that the households are economically strong and thereby replaces old cars more often. The total amount of cars that is scrapped 2030 (and produced 10 years before) is estimated to 268 000. The weight of the (conventional) cars in this scenario has been assumed to be increased by 10% as compared to the reference weight, as a consequence of the lack of political steering for sustainability. Thus, the kerb weight in this scenario is 1680 kg. The use of electrical cars is very limited and can be neglected for the purpose of our calculations. This assumption has been made since it will probably, at least initially, require powerful measures in order to introduce the electrical cars on the Swedish market, as well as development of infrastructure for charging (IVA 2009).

3.4.3 Scenario 3: Regional markets

In this scenario, the globalisation of the economy is replaced by a pattern dominated by regional trade and cooperation. This results in a weak economic growth, slow technological development, etc. The average lifetime of the private cars in this scenario has been assumed to be 12.5 years, which is in the middle of the 10-15 year interval mentioned in Section 3.1. Using the trend curve in the graph above, the total amount of cars that is scrapped 2030 (and produced 12.5 years before) is estimated to 266 000.

Few and/or weak political instruments are in place that aim at improved environmental performance. For this reason, we assume in this scenario, just as in Scenario 2, that the share of electrical cars is very small (approximately 0 %) and that the average weight of the cars is increased by 10% as compared to the reference weight. Thus, the kerb weight in this scenario is 1680 kg.

3.4.4 Scenario 4: European sustainability

Just like in Scenario 3, the globalisation of the economy is in this scenario replaced by a pattern dominated by regional trade and cooperation. However, here strong political instruments are in place that aims at improved environmental performance in Europe. This results in a slow economic growth, technological development, etc. The average lifetime of the private cars in this scenario has been assumed to be 15 years. Using the trend curve in the graph above, the total amount of cars that is scrapped 2030 (and produced 15 years before) is estimated to 263 000.

In this scenario, we have assumed that the vision concerning the amount of electrical cars is fulfilled, i.e. that 100 000 electrical cars is added per year to the Swedish market. The share of electrical cars in this scenario is thus 38% (100 000 / 263 000). As in Scenario 1, the weight of the conventional cars in this scenario has been assumed to be reduced by 10% as compared with the reference weight, as a consequence of the political steering for sustainability. Thus, the kerb weight in this scenario is 1374 kg. The weight of the electrical cars has been assumed to be the same as for the conventional cars, with an electric battery that constitutes 10% of the total weight.

3.5 Results

The total quantity of waste produced from private cars is 360-450 ktonnes in 2030, according to our calculations (see Table 1).

Table 1. Quantity of waste from old cars in the four scenarios for the year 2030.

	Total amount [units]	Share of electrical cars	Kerb weight [kg]	Total weight [ktonnes]
Scenario 1	266 000	38%	1374	366
Scenario 2	268 000	0%	1680	450
Scenario 3	266 000	0%	1680	447
Scenario 4	263 000	38%	1374	361

For Scenarios 2 and 3, where the kerb weight is assumed to increase by 10%, we estimate that the total increase is in the ferrous fraction and that the weight of all other material fractions remains as in the reference case (see Table 2) .For the scenarios in which the kerb weight is reduced by 10%, the percentage distribution of material fractions have been adopted from the life cycle assessment of lightweight compact class passenger vehicles mentioned above.

Table 2. Distribution of the total weight on different material fractions for the reference case and the scenarios where the kerb weight is increased by 10%.

	Corresponding weight [kg]	Distribution when the weight is increased by 10%
Ferrous	1069	1222
Aluminium	46	46
Non-ferrous	30	30
Fluids	30	30
Glass	46	46
Plastics and Textiles	229	229
Others	76	76
Total:	**1527**	**1680**

For the scenarios in which the kerb weight is reduced by 10%, the percentage distribution of material fractions have been adopted from the life cycle assessment of lightweight compact class passenger vehicles mentioned above (see Table 3). The resulting estimated quantities of the different material fractions for the studied scenarios are presented in Table 4.

Table 3. Distribution of the total weight on different material fractions for the reference case and the scenarios where the kerb weight is reduced by 10% (figures in brackets are the percentages that has been used).

	Distribution for reference weight (1527.2 kg)	Corresponding weight [kg]	Distribution when the weight is reduced by 10%	Corresponding weight [kg]
Ferrous	70%	1069	34-60% (47%)	646
Aluminium	3%	46	11-33% (22%)	302
Non-ferrous	2%	30	2-4% (3%)	41
Fluids	2%	30	1-2% (1.5%)	21
Glass	3%	46	2-4% (3%)	41
Plastics and Textiles	15%	229	13-23% (18%)	247
Others	5%	76	2-9% (5.5%)	76
Total:		**1527**		**1374**

Table 4. Total weight for the four scenarios divided on different material fractions [tonnes]. The precision in the results is much lower than the exactness of the figures indicates.

Material fraction	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Ferrous	165 308	327 432	324 988	163 443
Aluminium	77 378	12 279	12 187	76 505
Non-ferrous	10 552	8 186	8 125	10 433
Fluids	5 276	8 186	8 125	5 216
Glass	10 552	12 279	12 187	10 433
Plastics and Textiles	63 309	61 393	60 935	62 595
Others	19 345	20 464	20 312	19 126
Electric battery	13 893	0	0	13 737
Total	**365 612**	**450 219**	**446 859**	**361 488**

3.6 Comparison to EMEC results

The total quantity of waste produced from private cars is 500-1260 ktonnes in 2030, according to the EMEC calculations (Östblom et al. 2010). Our estimate is 30-60% lower (see Table 5).

Table 5. Quantity of waste from vehicles and privates cars in the four scenarios for the year 2030.

	Discarded vehicles in EMEC [ktonnes]	Discarded private cars in this study [ktonnes]	Difference [%]
Scenario 1	567	366	**-35%**
Scenario 2	1262	450	**-64%**
Scenario 3	892	447	**-50%**
Scenario 4	**503**	**361**	**-28%**

Part of the large difference in results is explained by the fact that our study does not include all types of vehicles. Used trucks, civil aeroplanes, and ships are exported rather than discarded in Sweden, but the waste fraction "Discarded vehicles" in EMEC also includes railway vehicles, pleasure boats, etc. These might constitute perhaps 10% of the EMEC results.

Our calculations do not take into account the fact that the economic growth is likely to affect the number of cars used in Sweden. Instead, we use the extrapolation of the current trend for new cars (Figure 2) in all scenarios. For this reason, our calculations are likely to underestimate the quantity of scrap in Scenario 2, where economic growth is the strongest. This can explain part of the very large difference in the results for Scenario 2.

On the other hand, the same limitation in our calculations should result in an overestimation of the quantity of scrap in Scenarios 3 and 4, where economic growth is weak. This is not consistent with the results in Table 5. The difference between the two calculations is the smallest for Scenario 4, but for Scenario 3 the difference is almost as large as in Scenario 2.

If our results for Scenario 2 are indeed too low and the results for Scenario 4 (at least) are too high, this indicates that accurate results, including all types of vehicles, would have been 20-50% below the EMEC results. In other words, our study indicates that the quantity of discarded vehicles is overestimated by 25-100% in the EMEC calculations.

4 Discussion and recommendations

This investigation of future waste quantities based on the technical life-time of long-life products is intended to complement the top-down analysis in the computational general equilibrium model EMEC. It was based on the hypothesis that EMEC will produce rather poor estimates of the quantity in the year 2030 of waste from long-life products, such as buildings, vehicles, and appliances, because this quantity is not linked to the level of investment and production in 2030, which EMEC calculates, but to the level of investments and production in the decades before that. The initial screening indicated, however, that the waste from old buildings and, to some extent, appliances is related to the economic activity in 2030 and, hence, rather well modelled with EMEC. The quantity of waste from vehicles other than private cars is rather small and does not require a specific investigation. Hence, discarded private cars is the only waste fraction where an analysis based on the technical life-time can contribute significantly to the estimate of waste quantities in 2030.

It should be noted, in this context, that infrastructure such as roads, railways, harbours, etc. is not included in the analysis. The waste from these types of infrastructure occurs mainly during construction and maintenance. This means that the waste quantity any given year is related to the economic activity in the construction sector the same year. This relationship is included in EMEC. Hence, we do not believe an investigation based on the technical life-time of roads, railways, and harbours will add much to the results generated by EMEC.

For private cars, our study indicates that the EMEC results are too high. If our study is correct, the difference is such that EMEC overestimates the quantity of discarded vehicles by 25-100%. This should be taken into account when conclusions are based on EMEC results and the quantity of discarded vehicles is a significant issue. When making such comparisons, it should be remembered that the precision in Table 4 is far less than what is indicated by the exactness of the figures.

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