Future Waste Scenarios for Sweden based on a CGE-model[Ψ]

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Summary in Swedish

Under de senaste decennierna har avfallsmängderna i stort sett ökat i takt med den ekonomiska utvecklingen. För att möta denna utveckling utgör avfallsprevention en av fyra huvudsakliga prioriteringar inom EU:s sjätte handlingsprogram för miljö, med ambitionen att frikoppla avfall från den ekonomiska utvecklingen. I Sverige har regeringen formulerat 16 miljökvalitetsmål som närmare specificeras i 72 delmål. Avfall ryms under miljökvalitetsmålet En god bebyggd miljö där det framgår att den totala mängden genererat avfall inte ska öka.

SCENARIER FÖR FRAMTIDA AVFALLSMÄNGDER

I denna uppsats används en allmän jämviktsmodell för Sverige för att simulera framtida avfallsmängder, av både farligt och icke-farligt avfall enligt den avfallsklassificering som Sverige rapporterar till EU (EWC-Stat.). Simuleringarna sträcker sig över perioden 2006 till 2030 och baseras på ett basscenario och 4 alternativa scenarier som i huvudsak skiljer sig åt beträffande den ekonomiska tillväxten, avfallsintensiteter (relationen mellan mängd avfall och till exempel insats av en viss produktionsfaktor) och hushållens konsumtion. I modellen kopplas avfallsgenereringen till företagens användning av olika produktionsfaktorer som material, arbete, kapital, bränslen och företagens totala produktion samt hushållens konsumtion.

ALLMÄN JÄMVIKTSMODELL

Det finns ett antal fördelar med att använda en allmän jämviktsmodell för att simulera framtida avfallsmängder gentemot statistiska prognoser som baseras på några få storheter som BNP-utveckling och befolkningsutveckling. För det första innebär detta att modellen kan efterlikna exempelvis den ekonomisk utveckling sådan som den presenteras i Långtidsutredningen 2008. För det andra fångar en allmän jämviktsmodell upp konsekvenser av relativprisförändringar och det ömsesidiga beroendet mellan ekonomins sektorer.

Det finns förhållandevis lite statistik över den historiska utvecklingen inom avfallsområdet vilket begränsar möjligheten att genomföra statistiska analyser. Denna studie baseras dock på ett datamaterial från 2006 med en tämligen hög upplösning. Vi studerar framtida avfallsmängder för 18 typer av icke-farligt avfall och 16 typer av farligt avfall, för ekonomins olika sektorer.

EKONOMISK TILLVÄXT DRIVER AVFALLSMÄNGDEN

Den ekonomiska tillväxtens starka betydelse för avfallsgenereringen framgår tydligt av utfallen i de olika scenarierna. Scenariet med stark ekonomisk tillväxt kännetecknas av förhållandevis kraftfull utveckling av avfallsmängderna. Det omvända gäller för scenarierna som kännetecknas av en svagare ekonomisk tillväxt. Detta gäller både för farligt och icke-farligt avfall men generellt växer mängden farligt avfall snabbare än mängden icke-farligt avfall. Effekten av teknisk utveckling som påverkar avfallsintensiteten i produktionen samt effekten av beteendeförändring hos konsumenter illustreras också tydligt i scenarierna. Simuleringarna visar att dessa effekter har mycket stor inverkan på avfallsgenereringen. En annan slutsats som kan dras av simuleringarna är att avfall som genereras av hushållen växer snabbare än det avfall som genereras av företagens användning av olika produktionsfaktorer (arbete, kapital, material och bränslen).

Både genereringen av farligt och icke-farligt avfall är koncentrerad till ett mindre antal sektorer. För icke-farligt avfall var det fem sektorer (massa- och pappersindustri, jordbruk, byggnadsverksamhet, järn- och stålverk och övrig industri) som under 2006 stod för generering av 82 procent av avfallet medan 81 procent av det farliga avfallet genererades i fyra sektorer (byggnadsverksamhet, järn- och stålverk, handel och tjänster och fjärrvärmeverk). I det basscenario som vi simulerat sker en förskjutning i andelen icke-farligt avfall som genereras i dessa fem sektorer. Vid simuleringsperiodens slut, 2030, står dessa sektorer för 75 procent av det genererade avfallet. En motsvarade andelsförskjutning sker för det farliga avfallet men denna är avsevärt mycket svagare. Enligt simuleringarna uppstår inte så kallade absolut frikoppling av avfall från ekonomisk tillväxt, dvs. att avfallet minskar fast ekonomin växer, för något avfallsslag eller inom någon sektor. Däremot sker så kallad relativ frikoppling för vissa avfallsslag, genom att de ökar i långsammare takt än den ekonomiska tillväxten.

FORSKNINGSPROGRAMMET HÅLLBAR AVFALLSHANTERING

Projektet har genomförts inom ramen för forskningsprogrammet Hållbar avfallshantering med anslag från Naturvårdsverket. Inom programmet verkar ca 25 forskare med olika ämnes- och institutionstillhörighet. Mer information om forskningsprogrammet finns på: http://www.hallbaravfallshantering.se/

ABSTRACT

Over the last decades, waste quantities have grown steadily in close relation to economic growth. To tackle the problem of continuing waste growth within the EU, waste prevention was listed among four top priorities in the EU Sixth Environment Action Programme. A Computable General Equilibrium (CGE) model is here used for projecting future quantities of hazardous and non-hazardous waste in Sweden to 2030. The effects of driving forces behind waste generation are illustrated by comparing the results of waste projections for a Baseline scenario and four alternative scenarios. The scenarios differ mainly in GDP growth rates and in the assumptions about future waste intensities of the economic activities of firms and households. We use a high-resolution data set on waste flows of 18 various types of non-hazardous waste and 16 various types of hazardous waste attributed to six waste-generating sources for the base year 2006. Waste generated in the scenarios, thus, relate to firms' material input, output, employees, capital scrapping and fuel combustion as well as households' consumption. The impact of economic growth in increasing the generation of non-hazardous and hazardous waste is apparent when comparing the growth of waste from 2006 to 2030 in the five scenarios. On the contrary, technological change resulting in less waste intensive production processes and changed behaviour among households, making their activities less waste intensive, have a strong reducing effect, especially on generation of non-hazardous waste relating to firms' material input.

JEL Classification Numbers: C68, D20, H23, R48

Key words: general equilibrium model, waste generation, decoupling, waste intensities, waste scenarios.

1. Introduction

Waste quantities have grown steadily along with Gross Domestic Products (GDPs) over the last decades. The total quantity of municipal waste per capita increased by 29 per cent in North America, 35 per cent in OECD, and 54 per cent in the EU15 from 1980 to 2005. This development holds also for Sweden, where the per capita municipal waste quantity increased by 60 per cent over the same period.[3] Moreover, waste generation in Swedish manufacturing industries increased by 66 per cent from 1993 to 2006.[4] In the EU, waste quantities are expected to increase in the future but decouple from GDP by 2020 (European Environmental Agency, 2005). In the EU15, industrial waste (including paper and cardboard) will increase by about 64 per cent by 2020, while packaging waste will increase by about 50 per cent and municipal waste by about 25 per cent. The expected increase in total waste quantities for the EU10 is, in general, more modest at about 10 per cent by 2020.[5]

According to the EU Sixth Environment Action Programme, waste prevention is one of four top priorities. The objective of the EU is therefore to achieve a significant and overall reduction of waste quantities (absolute decoupling of waste from GDP). However, no quantitative reduction has been specified at the EU level, and it is therefore unlikely that this objective will be achieved within the next few decades. Some projections of future waste quantities nevertheless do indicate relative decoupling of waste from GDP and household consumption (Mazzanti, 2008; Mazzanti and Zoboli, 2008; Skovgaard et al, 2005; and Skovgaard et al., 2008).

In Sweden, the parliament has enacted 16 cross-sectoral environmental quality objectives to guide Sweden towards becoming a sustainable society.[6] The objectives are benchmarks for the national environmental policy, which ultimately seeks to solve the major environmental problems within one generation (i.e. before 2020). To help operationalise the objectives and to determine a timeframe for their fulfilment, the parliament also promulgated 72 interim targets. According to the objective 'A good built environment': 'The total quantity of waste must not increase, and maximum possible use must be made of the resource that waste represents, while at the same time minimising the impact on, and risk to, health and the environment.' The related interim targets focus mainly on treatment of waste.[7] However, according to the last evaluation performed by the Swedish Environmental Objectives Council (2008), it will be very difficult to attain the target of non-increasing waste quantities.

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[3] See http://www.oecd.org/dataoecd/60/46/38106824.xls

[4] This figure was calculated using the data reported by the Swedish EPA (2007), (2008) and Statistics Sweden (2001) on waste generated in Swedish manufacturing.

[5] Refers to the new EU Member States: Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia.

[6] The first 15 environmental quality objectives were enacted by the Swedish parliament in 1999 and a 16th objective was added in 2005. The objectives currently in force are: 1. Reduced climate impact, 2. Clean Air, 3. Natural acidification only, 4. A non-toxic environment, 5. A protective ozone layer, 6. A safe radiation environment, 7. Zero eutrophication, 8. Flourishing lakes and watercourses, 9. High quality groundwater, 10. A balanced marine environment, 11. Thriving wetlands, 12. Healthy forests, 13. A varied agricultural landscape, 14. A magnificent mountain landscape, 15. A good built environment and 16. A rich diversity of plant and animal life.

[7] The quantity of waste deposited in landfills, excluding mining waste, will be reduced by at least 50% by 2005 compared to in 1994. By 2010 at least 50% of all household waste will be recycled through materials recovery, including biological treatment. At least 35% of all food waste from households, restaurants, caterers and retail premises will be recovered by means of biological treatment. This target relates to food waste separated at the source for both home composting and centralised treatment. Food waste and comparable waste from food processing plants etc. will be recovered by means of biological treatment. This target relates to waste that is not mixed with other waste and that is of such quality that makes it suitable, following treatment, for recycling into crop production. By 2015 at least 60% of the phosphorus compounds present in wastewater will be recovered for use on productive land. At least half of this amount should be returned to arable land.

The generation of waste has been projected by the use of CGE models, econometric models and macroeconomic data. Bruvoll and Ibenholt (1997) use a CGE model to calculate future waste quantities for Norwegian manufacturing. Waste generation is linked to material input and/or production level, which are forecasted with the CGE model. During the period 1993-2010, waste generation will increase by 45-110 per cent depending on the type of waste. Notably, waste growth is larger than production growth, despite technical progress. This result is driven by substitution from labour to material input.

Ibenholt (2003) uses the same CGE model as Bruvoll and Ibenholt (1997) but extends the analysis by using the fact that physical mass cannot be destroyed, and hence the mass going into a certain sector must equal the mass coming out from the same sector. From this material-balance perspective, detailed statistics (in tonnes) on production, intermediate inputs, raw materials and emissions to air are used to calculate a possible residual of the balance. Solid waste is assumed to make up a constant share of this residual and hence the waste quantities are given from the mass flows generated by the CGE model. According to Ibenholt (2003), the residual, and hence waste quantities, will increase by 74 per cent in the Norwegian manufacturing industry from 1993 to 2010.

Skovgaard et al. (2005) employ an econometric model to estimate future quantities of eight waste flows (municipal waste, biodegradable municipal waste, industrial waste, waste from the construction and demolition sector, paper and cardboard, glass, packaging, and tyres and waste oil), which are basically related to population growth, economic activity and a time trend. Country-specific parameters are estimated for EU15, and the growth in waste quantities is projected to be 60-65 per cent from 2000 to 2020. For Sweden, industrial waste is projected to grow by about 50 per cent from 2000 to 2020. Skovgaard et al. (2007) use the same data and the same model but make projections to 2030 for municipal waste. For the case of Sweden, their results indicate that the municipal waste will increase by 32.2 per cent from 2005 to 2030. For the EU15 the corresponding growth is 33 per cent with a significant variation among countries from 10.5 per cent for Austria to 118.9 per cent for Luxemburg.

Johnstone and Labonne (2004) estimate the correlation between income, population density and waste quantities on panel data covering the period 1980-2000 for the 30 OECD members. Their results concerning the effect of income (approximated by the level of final consumption) are in line with previous research, suggesting an inelastic income effect on waste generation. In addition, they find that population density has the effect of increasing waste generation and that household size has a negative effect on waste generation. Johnstone and Labonne (2004) also review the literature on the impact of socio-economic factors on waste generation and find that the income elasticity of waste at the household and community levels varies from 0.05 to 0.55.

In the present paper, we use a CGE model of the Swedish economy to project future quantities of hazardous as well as non-hazardous waste, for a baseline and four alternative economic scenarios. The idea behind this approach is that waste generation and waste flows are largely related to the economic activities of firms and households. The future waste quantities will thus reflect economic growth and the relative use of production factors. By using a CGE model and by mapping various types of waste to different sources of waste generation (firms' material input, output, employees, capital scrapping and fuel combustion as well as households' consumption), we obtain at least two advantages compared to econometric forecasts based on economic aggregates such as GDP. First, we can let the CGE model mimic structural change in accordance with the Swedish Long Term Survey 2008, which is the official projection for the

Swedish economy until 2030. Secondly, changing relative factor prices will impact the relative use of factors, which affect the waste quantities.

The analysis presented here bears most resemblance to Bruvoll and Ibenholt (1997) by introducing waste intensities into a CGE model for relating future waste generation to the projection of various economic variables. Our analysis, in contrast to their, exploits a number of scenarios that differ in the assumptions of key factors affecting waste generation, in order to examine the driving forces' relative importance in the generation of waste. The projection reported by Skovgaard (2005) for growth of industrial waste in Sweden 2005-2030 and the projection of municipal waste reported by Skovgaard (2007) for Sweden 2005-2030 both fall within the growth range spanned by our scenarios for future waste generation.

The rest of the paper is organised as follows. The next section describes the method, and Section 3 presents the scenario assumptions and the data. Section 4 and Section 5 contain results and concluding remarks, respectively. Appendix A presents waste quantities for the base year as well as for all scenarios, and Appendix B gives the classifications of sectors and commodities in the CGE model.

2. Method

To capture the effects of future economic scenarios on waste generation within a CGE framework, the waste generation of households and firms due to their economic activities must be modelled with the option of adjusting to changes in the costs and use of waste-generating inputs and outputs. The economic model EMEC exhibits such adjustment mechanisms when households and firms choose among a number of waste-generating and non waste-generating inputs and outputs.

EMEC is a static CGE model with 26 industrial subsectors, 33 composite commodities and a public sector producing a single commodity. Produced goods and services are exported and used together with imports to create composite commodities for domestic use. Composite commodities are used as inputs by industries and for capital formation. In addition, households consume composite commodities and there are 26 consumer goods. While Östblom and Berg (2006) give a full description of EMEC, definitions of production sectors and commodities are also given here in Appendix B.

The waste flows in the economy relate to production and consumption of commodities, and thus economic activity generates waste through input use in production and households' use of outputs. Production demands inputs of materials and energy, which are substitutes for the inputs labour and capital in the model. Firms are cost minimising in the choice of labour, capital, energy, materials and transports for producing outputs. Materials, labour, capital and energy are all waste-generating inputs, but to various degrees. Thus, substitution among these inputs as well as productivity changes in the use of the inputs affects firms' waste flows. Households' waste flows are affected by their consumption of goods and services. The firms' production function and the households' demands, as well as the waste-generating procedures of firms and households, are presented in the following sections.

Production, household demand and waste generation

Firms' production requires primary factors as well as inputs of materials, transports and energy.[8] Output Y is produced by means of labour L, capital K, energy carriers E, materials M and transports T. The demand of production factors then becomes a function of the corresponding relative prices PK, PL, PE, PM and PT and factor productivity MP_g, which may differ among production factors, allowing for a biased technical change.

The production function for sector I is:

$$Y_i = f_i\left(K_i, L_i, E_i, M_i, T_i\right) \qquad i = 1,\ldots, n. \qquad \textbf{(1)}$$

The demand for production factors K, L, E, M, T per unit of production is:

$$X_g = MP_g\ \psi_g\left(PK, PL, PE, PM, PT\right) \qquad g = K, L, E, M, T. \qquad \textbf{(2)}$$

[8] The representative firm is assumed to choose an optimal mix of skilled and unskilled labour and an optimal mix of energy in three stages. The firm, then, decides upon the mix of labour and physical capital in the creation of value added as well as the mix of energy and material (including an optimal transport solution) in the creation of energy-material input. An optimal mix of value added and energy-material input is chosen at the highest level to produce the firm's output.

Waste is generated by incomplete absorption of material inputs (*M*) or by the resulting waste products in the production (*Y*) of goods and services. Waste can also be generated by fuel combustion (*E*), the disposal of scrapped capital equipment (*K*) and due to employees' garbage (*L*), whereas transports (*T*) are not, here, a waste generating production factor. All waste intensities *w*, but the intensities for employees-related waste, are subject to technical change and are generally assumed not to increase over time *t*. Thus:

$$w(\mathrm{t}+1) \leq w(\mathrm{t}) \qquad w \neq w^{L}.$$

Generation of waste *W* type *k* by firm *i* at any point of time is:

$$W_{i,k} = \sum_{g} \left(w_{i,k}^{g} \cdot X^{g} \right) + w_{i,k}^{y} \cdot Y_i \qquad g = K, L, E, M. \qquad \textbf{(3)}$$

Total generation of waste type *k* by firms:

$$W_k = \sum_{i} W_{i,k} \qquad k = 1,\ldots,m \ . \qquad \textbf{(4)}$$

The representative consumers maximize the utility of consumption. The households' demand for various goods and services *HC*, then, is a function of relative prices *PHC* and the total expenditures *PKL*.

The demand function for households is:

$$HC_{pr} = \psi_{pr}\left(PHC_{pr}, PKL\right) \qquad pr = 1,\ldots, n. \qquad \textbf{(5)}$$

Households generate waste by disposing of goods and services consumed. We assume the amount of all household garbage to be in proportion to the demand for housing services HC_5. This approach is similar to Johnstone and Labonne (2004) who assume that households derive utility from consumption of a composite good and household waste collection. In our case, waste collection is part of housing services. The wage intensities of households could increase or decrease over time due to changed behaviour.

The generation of waste type *k* by households W_k^H is:

$$W_k^H = w_{k,5} \cdot HC_5 \qquad \textbf{(6)}$$

3. Scenario assumptions and benchmark data

Scenario assumptions

The scenarios were developed within the research programme by an iterative process with programme participants representing a wide range of disciplines. The scenarios differ in assumptions about the development of a number of variables characterising the scenarios, as indicated by their names (see Table 1). Only the key assumptions of economic variables affecting waste generation are presented for the scenarios.

Table 1. The economic key assumptions in the Baseline and alternative scenarios.
Yearly percentage changes, 2006-2030.

	Baseline	Global sustainability	Global markets	Regional markets	European sustainability
GDP	2.2	2.2	3.3	1.8	1.8
World trade	4.4	4.4	4.8	3.8	3.8
Primary product prices	0.1	0.1	1.7	1.3	0.1
Oil prices	0.8	0.8	3.0	0.8	0.8
Employment	0.2	0.2	0.5	0.2	0.3
CO_2 Permit price €/tonne	39	78	29	39	59
Waste intensities[1]					
Firms' input-related	-1	-3	-1	0	-1
Firms' employees-related	0	-1	1	1	-1
Household waste	0	-2	1.5	1	-2.5

Note: Firms' waste intensities are assumed to relate to technological change except for employees-related waste intensities, which like households' waste intensities are assumed to relate to a changed behaviour. The waste intensities relating to output, fuel usage or scrapping of capital are, in contrast to the firms' input-related waste intensities, not assumed to be altered by technological change 2006-2030.

Sources: The long term survey 2008 (SOU 2008:105, Bilaga 1), Dreborg and Tyskeng (2008) and Ekvall (2008)

Dreborg and Tyskeng (2008) present the assumed scenarios regarding future waste generation in further detail. The Baseline scenario relates closely to that of the Long-Term Survey of the Swedish economy 2008.[9] The waste intensities of 2006 are assumed to develop as given by the figures in Table 1 for yearly percentage changes between 2006 and 2030 according to Ekvall (2008). Global markets, assumingly, continue to develop as during the recent decades in the scenario 'Global sustainability, as well as in the Baseline scenario. Climate change and sustainability policies, however, have a higher priority in the scenario 'Global sustainability', and the CO_2 permit price is therefore assumed to be higher than in the Baseline scenario. In addition, a more rapid technical change in the direction of saving primary resources brings about decreases in the waste intensities. The scenario 'Global markets' is characterized by growing global markets and free trade but less concern for climate change and sustainability policies and thus the CO_2 permit price is assumed to be lower than in the Baseline scenario. Expanding world trade leads to higher rates of employment and economic growth in Sweden but also to higher international prices of raw materials and fossil fuels. Here also, technical change goes in the direction of saving primary resources because of the increase in primary product prices and input-related waste

[9] SOU 2008:105, Långtidsutredningen 2008 (The Long-Term Survey 2008).

intensities therefore decrease. Less concern for sustainability policies, however, affect households' behaviour in the direction of increased waste intensities.
The globalisation trend weakens in the scenarios 'Regional markets' and 'European sustainability', where an increased protectionism among world regions holds world trade back and thereby also slows the rate of economic growth in Sweden down. Technical change is assumed to be less rapid in these scenarios than in the other scenarios due to the weaker globalisation trend. Climate change and sustainability policies are emphasised more in the scenario 'European sustainability' than in the scenario 'Regional markets'. In the scenario 'European sustainability', therefore, the CO_2 permit price is assumed to be higher and waste intensities are reduced. The different assumptions about the CO_2 permit price, however, have small effects on waste generation.

Benchmark data

Data on waste generation are from the waste generation survey for 2006 reported by the Swedish EPA (2008). The data set was processed to fit into the framework of the economic model EMEC. The main difference in this improved data set is that products priced on a market, and therefore already accounted for as a common good in the economic data, are not treated as waste products, but classified as wastes according to the European Waste Catalogue (EWC) code. In addition, wastes generated by various industry subsectors were attributed to five different sources of waste generation: material inputs, output, fuel combustion, employees and scrapping of capital.
Sundqvist and Stenmarck (2009) give a more thorough presentation of the processing of waste data.

As shown in Table 2, the generation of non-hazardous waste was about ten times the generation of hazardous waste in 2006. Most of the non-hazardous and hazardous waste is generated through firms' production activities and use of materials for inputs in production. Here, the dominating non-hazardous waste 'Animal and vegetal waste' is followed by 'Combustion waste', 'Paper waste', 'Sludges' and 'Mineral waste'. The 'Combustion waste' and 'Sludges' are solely generated by firms' production activities, whereas 'Mineral waste' is generated through use of material inputs in production. The dominating types of hazardous waste are 'Mineral waste', 'Chemical waste' and 'Combustion waste'. The firms' production activities account for all generation of 'Mineral waste' and 'Chemical waste', whereas material inputs account for most of the generated 'Combustion waste'. Households' generation of non-hazardous waste is dominated by 'Household waste', whereas their generation of hazardous waste consists of 'Discarded vehicles' and 'Discarded equipment'.

All the economic data are taken from the Swedish National Accounts. The waste intensities of 2006 calculated for the different waste sources are assumed to develop as given by the figures in Table 1 for yearly percentage changes between 2006 and 2030 according to Ekvall (2008), who assumes the waste intensities of households to change by 1.5 to -2.5 per cent annually for different scenarios. To captures several aspects such as technology development, real price change, and environmental awareness, he assumes the waste intensities to differ in accordance with the scenario assumptions regarding these aspects. The corresponding change in waste intensity of firms' input-related waste generation, he assumes to vary from 0 to -3 per cent annually, which reflects different levels of technological development and different developments of real prices. A business as usual assumption of -1 per cent for input-related waste intensities in the Baseline scenario could also be justified when examining data for waste generation in Swedish manufacturing 1993-2006. [10]

Table 2. Non-hazardous and hazardous wastes distributed among generating sources in 2006

Waste label	Non-hazardous wastes				Hazardous wastes			
	Total Kton nes	Pro-duc-tion[1] %	Ma-teri-als %	Hou-se-hold %	Total Kton nes	Pro-duc-tion[1] %	Ma-teri-als %	Hou-se-hold %
Animal and vegetal wastes	4 704	72	20	8	0	0	0	0
Combustion wastes	2 533	100	0	0	260	100	0	0
Household wastes	2 665	13	0	87	0	0	0	0
Mineral wastes	2 083	0	100	0	481	100	0	0
Paper wastes	2 328	8	69	23	0	0	0	0
Sludges	2 099	100	0	0	135	100	0	0
Mixed materials	1 689	32	68	0	10	10	60	30
Metal wastes	1 232	2	84	13	0	0	0	0
Chemical wastes	633	0	100	0	372	11	85	4
Discarded vehicles	0	0	0	0	471	35	0	65
Wood wastes	377	1	99	0	24	4	33	63
Glass wastes	195	4	24	73	0	0	0	0
Plastic wastes	159	7	69	25	0	0	0	0
Discarded equipment	6	67	33	0	153	7	3	91
Used oils	0	0	0	0	125	8	90	2
Sorting residues	93	100	0	0	0	0	0	0
Rubber wastes	44	0	30	70	0	0	0	0
Spent solvents	0	0	0	0	40	0	98	3
Batteries and accumulators	1	0	0	100	36	61	19	19
Textile wastes	20	0	100	0	0	0	0	0
Contaminated soils	0	0	0	0	11	100	0	0
Total	20 861	44	38	17	2 118	54	23	23

Note. 1 Production includes wastes generated by output, fuel combustion, employees and scrapping of capital.

Source: Sundqvist and Stenmarck (2009).

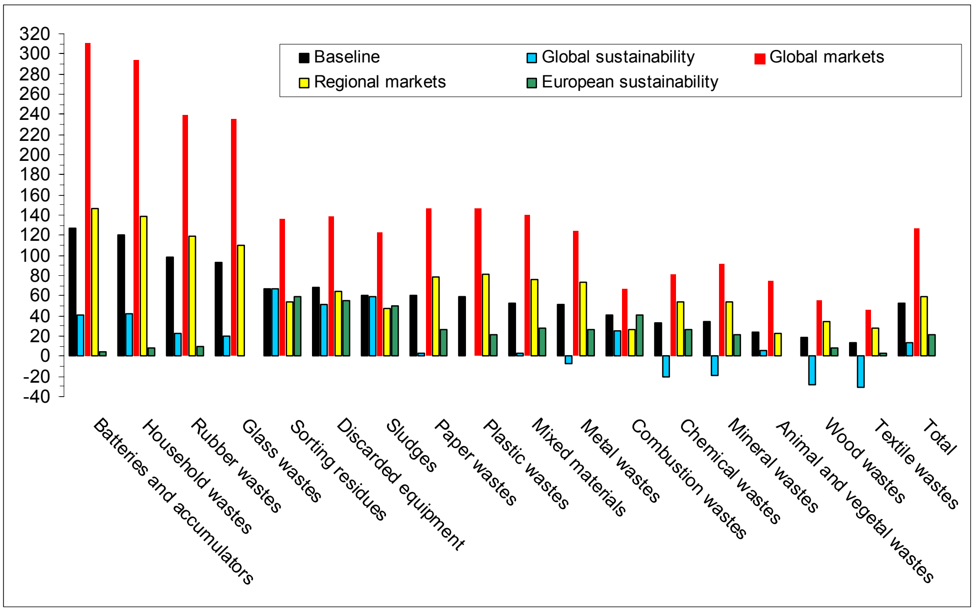
[10] By using data reported by the Swedish EPA (2007), (2008) and Statistics Sweden (2001), a yearly increase of 4 per cent the could be calculated for the waste generated in Swedish manufacturing 1993-2006. For the same period, the Swedish National Accounts report (see Statistical Report NR 10 SM 0801) a yearly 5 per cent increase in the intermediate consumption of Swedish manufacturing(in constant prices).

4. Future waste generation

The future amounts of waste are closely coupled to economic growth given unchanged waste intensities in economic and human activities. However, economic growth might be unequally distributed between waste-intensive products and non-waste-intensive products. Thus, not only the magnitude but also the direction of economic growth will affect future waste generation. The different types of waste, however, are not equally affected by this fact as some types might mainly relate to declining economic activities while others might mostly relate to growing economic activities.

For future waste generation to decouple from economic growth its direction must change in favour of less waste intensive products and/or the waste intensities in economic and human activities must decrease. The waste intensities in economic activities decrease when the technological change develops in the direction of saving on waste generating inputs, when using less waste generating production processes or when installing less waste generating capital equipment. These effects on waste generation are best represented in the scenarios 'Global sustainability' and 'European sustainability'. In addition, rising prices on raw materials will reduce wastes due to an increased recycling of fabricated materials as modelled in the scenarios 'Global markets' and 'Regional markets'. An increased recycling is also assumed for the sustainability scenarios 'Global sustainability' and 'European sustainability'. The waste intensity of human activities decreases due to the changed household behaviour as modelled in the sustainability scenarios.

Figure 1. Generation of non-hazardous wastes in alternative scenarios.
Percentage changes 2006-2030

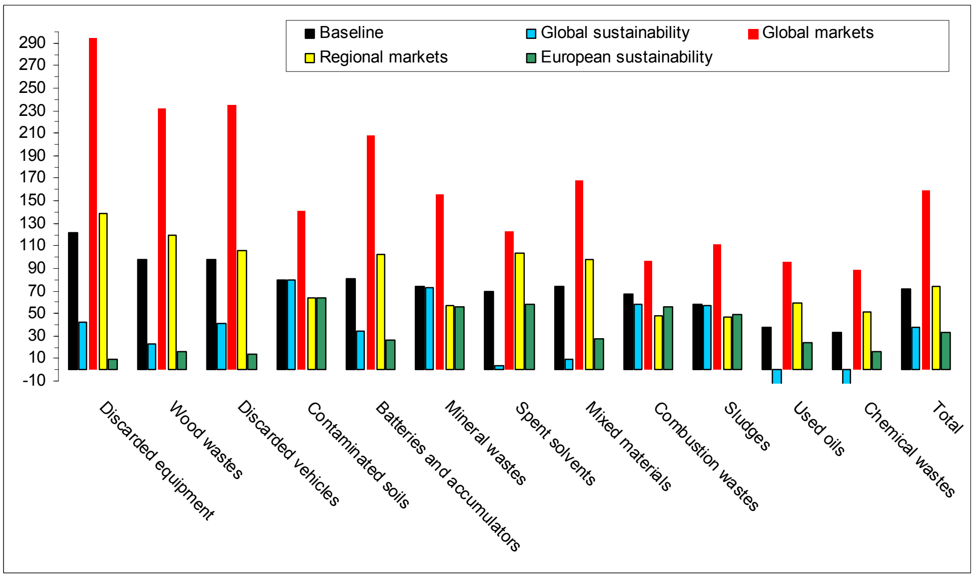


The waste bars depicted for alternative scenarios in Figure 1 reveal characteristic patterns in the generation of non-hazardous wastes. The impact of economic growth on the waste generation is conspicuous when comparing the waste bars of the scenario 'Global markets' with those of other scenarios. This scenario, with a yearly rate of economic growth, that is at least 1½ times that of any other scenarios, results in bars exceeding those of other scenarios when it comes to both total waste and all different types of waste. Technological changes resulting in less waste-intensive production processes and behavioural changes making household activities less waste intensive, as assumed in the scenario 'Global sustainability', obviously have a strong waste-reducing effect as can be concluded by comparing the waste bars of this scenario with those of other scenarios in Figure 1.

Total non-hazardous waste increases the most in the scenario 'Global markets', (by 127 per cent until 2030). This scenario has high economic growth and modest assumed decreases in waste intensities. Total non-hazardous waste will increase least for the scenario 'Global sustainability' (by 18 per cent until 2030), which has the same economic growth as the Baseline scenario but the most rapid assumed decrease in waste intensities. The types of wastes affected the most by economic growth are Batteries and accumulators, Household wastes, Rubber wastes and Glass wastes, whereas Textile wastes, Wood wastes, Mineral wastes, Chemical wastes and Metal wastes are the waste types affected the most by reduced waste intensities of firms' production and households' activities.

Figure 2. Generation of hazardous wastes in alternative scenarios.

Percentage changes, 2006-2030

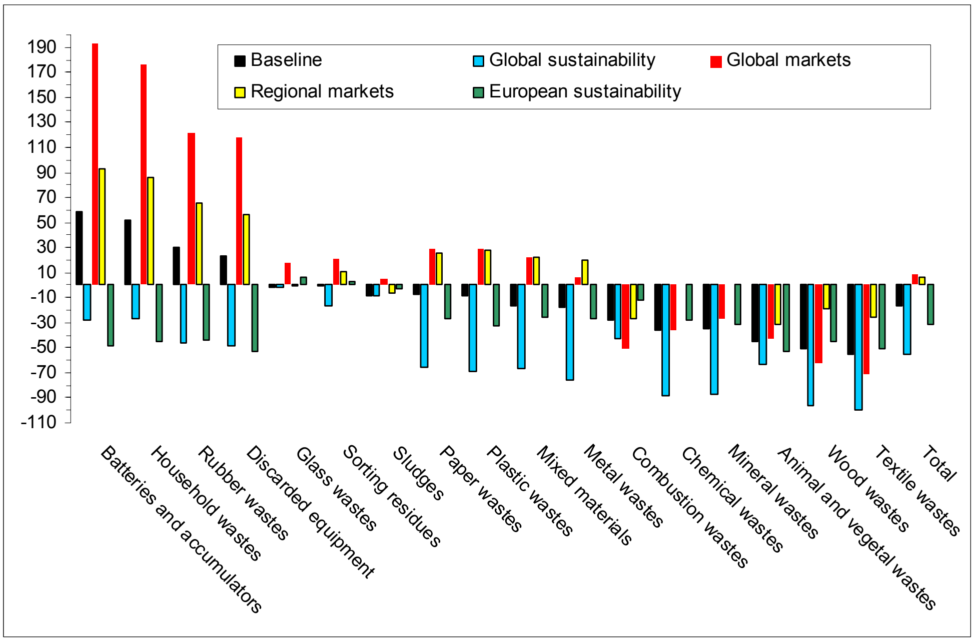


The development of hazardous wastes illustrated in Figure 2 by waste bars for the various scenarios differs somewhat from the development of non-hazardous wastes described above. Total hazardous waste grows at a higher percentage rate than do non-hazardous waste in all scenarios. It grows by 159 per cent in the scenario 'Global markets' compared to 127 per cent for non-hazardous waste and by 33 per cent in the scenario 'European sustainability' compared to 18 per cent in the scenario 'Global sustainability' for non-hazardous waste. The fact that the rate of growth is lower in the former scenario than in the later scenario for hazardous waste but not for non-hazardous waste indicates that the assumed reduction in waste intensities affects the generation of hazardous waste less than it affects the generation of non-hazardous waste. This hypothesis is also underpinned by the observation that only four types of hazardous waste (Used oils, Chemical wastes, Mixed materials and Spent solvents), but nine types of non-hazardous waste show lower waste bars in the scenario 'Global sustainability' than in the scenario 'European sustainability'.

The development of waste intensities in the economy, in the terms of waste/GDP ratios, can be illustrated by relating the growth in various types of waste to economic growth. By neutralising the impact of economic growth on waste generation in this way, the influence of assumed waste savings due to technological change or a changed household behaviour could be compared better among the different scenarios. The picture may, however, still be somewhat blurred by differences in structural changes among the scenarios.

Figure 3. Non-hazardous wastes/GDP ratios for alternative scenarios.

Percentage changes, 2006-2030

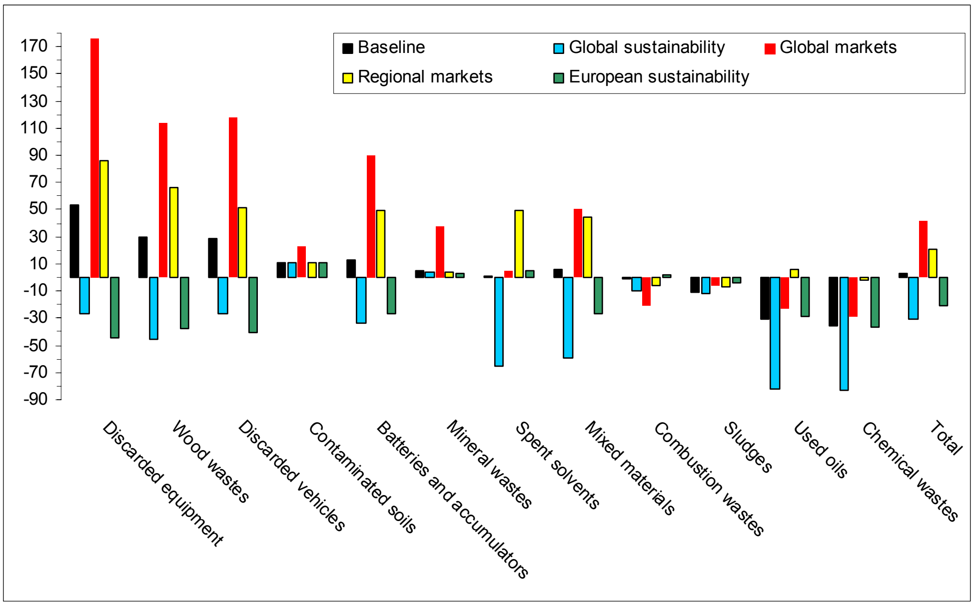


The ratio between total non-hazardous waste and GDP will decline from 2006 to 2030 in all scenarios (by -14, -32 and -55 per cent for the Baseline scenario, the scenario 'European sustainability' and the scenario 'Global sustainability', respectively) except in the scenarios 'Global markets' and 'Regional markets' where it increases by 9 and 6 per cent, respectively (see Figure 3). These two scenarios have the least favourable assumptions about the savings of non-hazardous waste in production and in household activities. Actually, the waste intensities of household activities are assumed to increase in the scenarios 'Global markets' and 'Regional markets', whereas they are assumed to decline in the scenarios 'European sustainability' and 'Global sustainability' but remain unchanged in the Baseline scenario. In the scenarios 'Global sustainability' and 'European sustainability', the wastes/GDP ratios will decline for almost every type of waste and the declines are most pronounced in the scenario 'Global sustainability', which has the most favourable assumptions about the savings of non-hazardous waste in production and in household activities. Only a few waste types (Batteries, Household wastes, Rubber wastes and Discarded equipment) are noted for significant increases in the wastes/GDP ratios in the scenarios 'Global markets' and 'Regional markets', which have the least favourable assumptions about the savings of non-hazardous waste in production and in household activities.

The picture of changes in the hazardous waste/GDP ratios 2006-2030 given by the bars of Figure 4 looks like what was noted for the non-hazardous waste/GDP ratios when examining the waste bars of Figure 3. However, the rate of decline in the economy's intensity of total hazardous waste is however somewhat lower than that noted for total non-hazardous waste in the scenarios 'Global sustainability' and 'European sustainability' (-30 and -21 per cent, respectively). In contrast to the decline observed for the total non-hazardous waste intensity in the Baseline scenario, there is a small increase in the intensity of total hazardous waste. In addition, the total hazardous waste/GDP ratio increases more than does the total non-hazardous waste/GDP ratio in the scenarios 'Global markets' and 'Regional markets'. Significant increases in the waste/GDP ratios are noted for 'Discarded equipment', 'Wood wastes', 'Discarded vehicles' and 'Batteries and accumulators' in the Baseline scenario and in the scenarios 'Global markets' and 'Regional markets'. Almost every waste type has declining waste/GDP ratios in the sustainability scenarios.

Figure 4. Hazardous wastes/GDP ratios for alternative scenarios.

Percentage changes 2006-2030

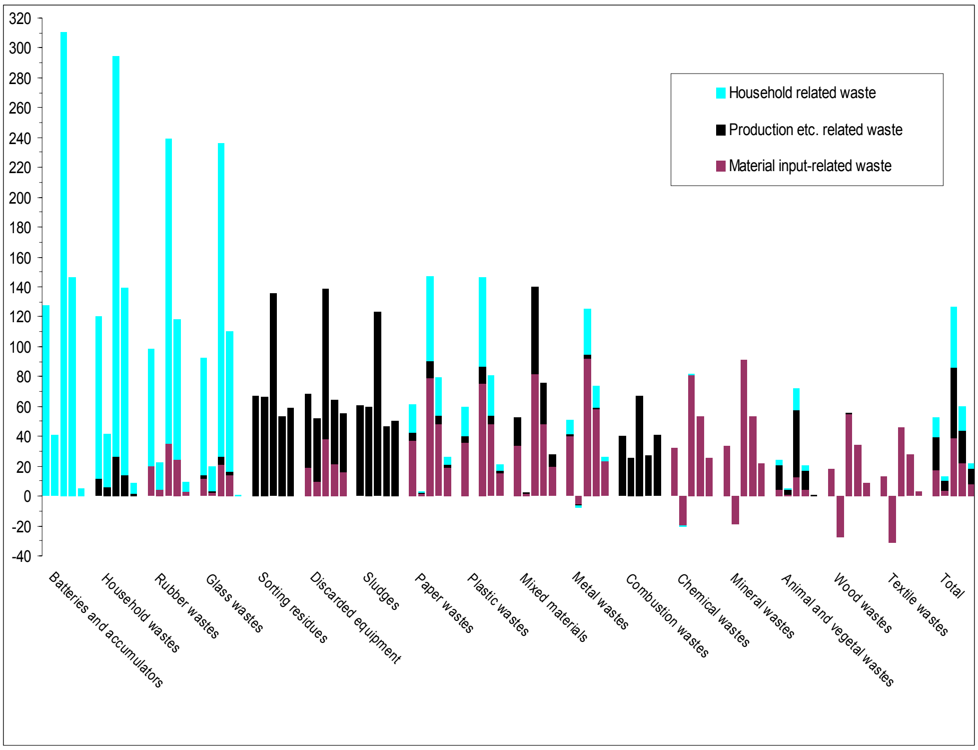


Both non-hazardous and hazardous wastes can be related to various waste generating sources as discussed in preceding sections (equations 3 and 6). The growth of non-hazardous wastes and hazardous wastes distributed among generating sources is shown in Figures 5 and 6, respectively. We distribute the wastes between the generating sources firms' material input, firms' production (including output-related, employees-related, capital-related and fuel-related wastes) and household consumption. Our assumptions about changes in the waste intensities in various scenarios strongly affect waste generation due to firms' material input and the households' consumption, whereas waste generation due to firms' production is hardly affected at all by these assumptions (only employees-related wastes which is only a small part of the wastes generated through firms' production, is affected).

Growth in total non-hazardous wastes is almost uniformly distributed across the three waste generating sources in all scenarios, whereas growth in the different non-hazardous waste types is found to be very unequally distributed across waste generating sources. In terms of growth, households' waste generation is dominating among the waste types with the highest growth rates 2006-2030, i.e. 'Batteries and accumulators', 'Household wastes', 'Rubber wastes', 'Glass wastes' and 'Sorting residuals'. Waste types with low or negative growth rates are typically generated through firms' material input, see 'Chemical wastes', 'Mineral wastes', 'Wood wastes' and 'Textile wastes'.

Figure 5. Non-hazardous wastes distribution among generating sources in alternative scenarios.

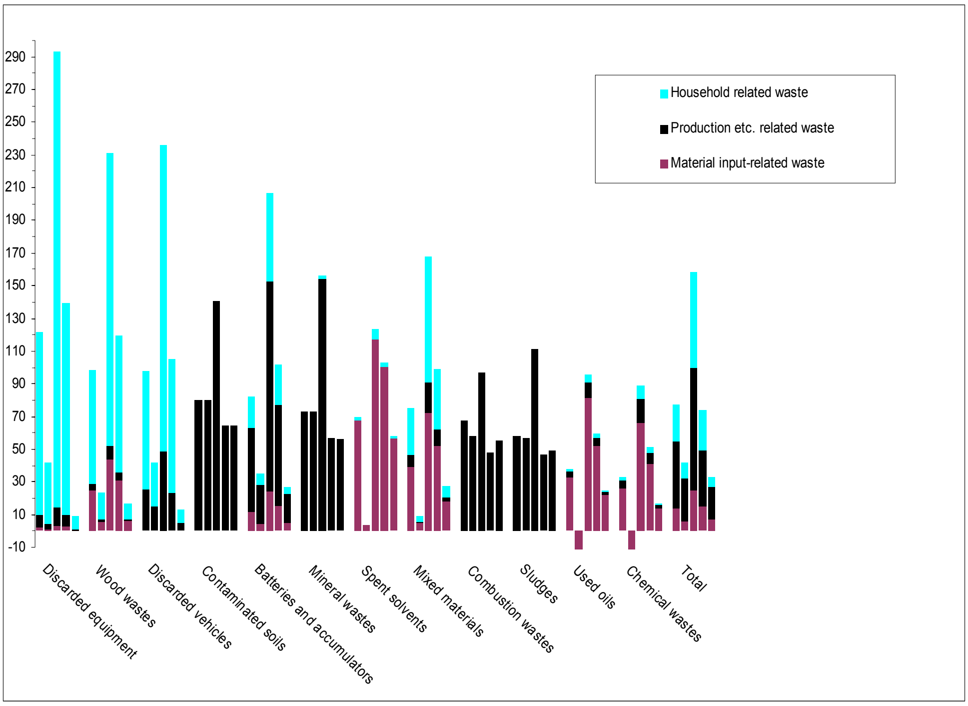
Percentage changes, 2006-2030



In terms of growth in the amount of hazardous waste, both overall and when looking at the individual waste types, firms' production is a more significant source compared to what was shown for growth in non-hazardous waste (Figure 5).

Figure 6. Hazardous wastes distribution aming generating sources in alternative scenarios.

Percentage changes, 2006-2030



However, households' waste generation is also here dominating among the waste types with the highest growth rates 2006-2030, i.e. 'Discarded equipment', 'Wood waste' and 'Discarded vehicles'.

The non-hazardous and hazardous waste generated through firms' production or material inputs could be further broken down by waste generating subsectors of the production system as shown in Table 3, which identifies a few dominating waste-generating subsectors. We find that 'Pulp and Paper', 'Agriculture', 'Construction', 'Iron and steel' and 'Other industries' accounted for more than 80 per cent of the total non-hazardous waste generated in 2006. A few subsectors also account for more than 80 per cent of the total hazardous waste: 'Construction', 'Iron and steel', 'Services' and 'Hot water supply'. The subsectors 'Construction' and 'Iron and steel', thus, are especially dominant when it comes to the generation of waste through production.

Table 3. Subsectors with 1 per cent or more of the non-hazardous/hazardous wastes generated through industrial production in alternative scenarios for 2030.

Subsectoral waste shares in per cent and total production waste in Ktonnes for 2006.

Sector	Non-hazardous wastes						Hazardous wastes					
	2006	Base line	Global sustainability	Global markets	Regional markets	European sustainability	2006	Base line	Global sustainability	Global markets	Regional markets	European sustainability
Pulp and paper	22	25	24	25	25	27	1	1	1	1	1	1
Agriculture	19	15	19	14	13	14	1	1	1	1	1	1
Construction	17	18	15	20	19	17	30	34	38	36	32	33
Iron & steel ind.	14	10	11	9	10	11	20	13	12	12	14	14
Other industries	10	8	8	8	8	8	0	0	0	0	0	0
Services	7	8	8	9	8	7	20	19	19	21	20	19
Engineering	4	6	5	7	7	6	4	5	4	6	6	6
Hot water supply	3	4	5	3	3	4	11	14	15	12	13	14
Other transports	2	2	2	2	2	2	2	2	2	2	3	2
Chemical industry	2	2	2	2	2	2	7	6	7	7	8	8
Mineral products	1	1	1	1	1	1	0	0	0	0	0	0
Refineries	0	0	0	0	0	0	2	1	1	1	1	1
Water and sewage	0	0	0	0	0	0	1	1	1	1	1	1
Total Ktonnes	17 162	23 377	18 392	32 262	24 237	21 503	1 629	2 523	2 223	3 485	2 473	2 301

Sources: Sundqvist (2009) and EMEC.

This picture of the dominant waste generating sub sectors changes somewhat in the scenarios for 2030. The 'Iron and steel industry' and 'Agriculture' reduces their shares of wastes by 2030, whereas 'Pulp and Paper', 'Construction' and 'Hot water supply' are noted for increased waste shares by 2030. The developments displayed in Table 3 are due to structural changes that are advantageous to subsectors with increasing waste shares and disadvantageous to subsectors with decreasing waste shares.

5. Concluding remarks

The scope of future waste generation is here analysed by using five potential scenarios of the Swedish economy 2006-2030: Baseline, Global sustainability, Global markets, Regional markets and European sustainability. Waste generation is from a historical point of view closely related to economic growth and to illustrate this aspect, the economic scenarios differ in the growth rates of GDP. For a decoupling to take place between economic growth and waste generation, the waste generation by firms and households in relation to their economic activities must decrease in the future. This aspect is addressed by letting firms' technology and households' behaviour with respect to the waste intensities of their activities differ among the scenarios. Also, by assuming raw material prices to differ among scenarios, the effects from material savings and structural changes on future waste generation are studied.

The generation of wastes by households and firms is related, here, to their respective economic activities by using a CGE-model and exploiting a data set of waste types generated by various subsectors of production as well as by the household sector. By using this approach, non-hazardous wastes and hazardous wastes can be attributed to different sources of waste generation in the five scenarios. We attribute the various waste types to the following generating sources: firms' material input, firms' production (including output-related, employees-related, capital-related and fuel-related wastes) and households' consumption. Differences in waste intensity among the scenarios strongly affect the amount of waste generated due to firms' material input and household consumption, whereas the amount of waste generated due to firms' production is hardly affected at all with the exception of employees-related waste, which is a small part of the waste generated due to firms' production.

The importance of economic growth as a driving force for generating non-hazardous wastes is apparent when comparing the waste growth from 2006 to 2030 in the five scenarios. The scenario 'Global markets', with a yearly rate of economic growth being at least 1½ times that in any of the other scenarios, demonstrates growth rates exceeding those of the other scenarios for total waste as well as for every waste type. On the contrary, technological changes resulting in less waste intensive production processes and behavioural changes making household activities less waste intensive have a strong reducing effect on the generation of non-hazardous wastes. This is what takes place in the scenario 'Global sustainability', as revealed by its low waste growth compared to the scenarios 'Regional markets' and 'European sustainability', both demonstrating lower yearly rates of economic growth. The developments of hazardous wastes differ somewhat from those of non-hazardous wastes. Hazardous wastes grow faster than non-hazardous wastes in all scenarios. The growth in hazardous wastes (but not that in non-hazardous wastes) is lower in the scenario 'European sustainability' than in the scenario 'Global sustainability', which exhibits the highest rate of reduction in waste intensities due to technological change. Thus, generation of hazardous wastes is less affected than generation of non-hazardous wastes by reduced waste intensities due to technological change. This hypothesis is underpinned by the observation that only four types of hazardous waste but nine types of non-hazardous waste show lower growth rates of wastes in the scenario 'Global sustainability' than in the scenario 'European sustainability'.

The growth in total non-hazardous wastes is almost uniformly distributed across the three waste generating sources in all scenarios, whereas the growth in the different types of non-hazardous waste are found to be very unequally distributed across the sources. Households' waste generation is dominating among the waste types with the highest growth rates 2006-2030, whereas the waste types with low or negative growth rates are typically generated through firms' material input. When it comes to growth in hazardous wastes, firms' production is a more significant generating source compared to growth of non-hazardous wastes. Households' waste generation is, however, also here dominating among the waste types whith the highest growth rates 2006-2030.

The non-hazardous and hazardous wastes generated through firms' production or material inputs could be further broken down by waste generating subsectors of the production system. We find five subsectors to account for more than 80 per cent of total non-hazardous wastes and four subsectors to account for more than 80 per cent of total hazardous wastes generated in 2006. This picture of the dominant waste generating sub sectors changes somewhat in the scenarios for 2030. Structural changes, in favour of the subsectors with increasing waste shares and to the disadvantage of sub sectors with decreasing waste shares 2006-2030, are behind the observed development of waste shares.

The development of the waste intensity in the economy, measured as the waste/GDP ratio, is illustrated by relating the rates of growth in various types of waste to the rate of economic growth. By neutralising the impact of economic growth on waste generation in this way, the influence of assumed waste savings due to technological change or a changed household behaviour could be compared among the different scenarios.

The ratio between total non-hazardous waste and GDP declines from 2006 to 2030 in the Baseline scenario, the scenario 'European sustainability' and the scenario 'Global sustainability', but increases in the scenarios 'Global markets' and 'Regional markets', which have the least favourable assumptions regarding the savings of non-hazardous waste in production as well as in household activities. For the scenarios 'Global sustainability' and 'European sustainability', the waste/GDP ratio declines for almost every type of waste, and the declines are most pronounced in the scenario 'Global sustainability', which has the most favourable assumptions regarding the savings of non-hazardous waste in production and household activities. Only a few waste types show significant increases in the waste/GDP ratio for the scenarios 'Global markets' and 'Regional markets', which have the least favourable assumptions regarding the savings of non-hazardous waste in production and household activities.

The picture of changes in the hazardous waste/GDP ratio from 2006 to 2030 is similar to what was noted for the non-hazardous wastes/GDP ratio. The decline in the total hazardous waste/GDP ratio, however, is somewhat lower than that for total non-hazardous waste in the scenarios 'Global sustainability' and 'European sustainability'. Additionally, the total hazardous waste/GDP ratio increases more than does the total non-hazardous waste/GDP ratio in the scenarios 'Global markets' and 'Regional markets'.

Future waste generation will be closely related to economic growth, according to the present analysis of five potential scenarios differing in GDP-growth rates 2006-2030. Waste amounts generated in the scenario 'Global markets', which has the highest GDP-growth rates, supersedes the waste amounts generated in the other scenarios by 50-100 per cent. Although a 1 per cent yearly decrease is assumed for the firms' input-related waste intensities, this is not enough to offset the impact of a yearly economic growth of 3.3 per cent on waste generation, i.e. to note a decoupling, in the scenario 'Global markets'. The generation of waste, however, decouples from economic growth in the Baseline scenario, in the scenarios 'Global sustainability' and in 'European sustainability', where the assumed yearly decreases in firms' input-related waste intensities are 1, 3 and 1 per cent and the yearly GDP growth rates are 2.3, 2.3 and 1.8 per cent, respectively. Apparently, for a decoupling to be registered, the yearly rate of increase in firms' input-related waste intensities should be one-third or more of the yearly GDP growth rate.

Appendix A

Table A1. Total wastes in 2006 and in economic scenarios for 2030. Ktonnes.

EWC code	Waste label	2006	Basline	Global sustain-ability	Global markets	Regional markets	European sustain-ability
Non-hazardous wastes							
1.2, 1.4, 2, 3.1	Chemical wastes	633	838	506	1149	972	797
3.2, 11, 11.3	Sludges	2 099	3 364	3 348	4 692	3 086	3 156
6	Metal wastes	1 232	1 859	1 138	2 768	2 139	1 558
7.1	Glass wastes	195	375	234	656	410	197
7.2	Paper wastes	2 328	3 749	2 402	5 750	4 175	2 946
7.3	Rubber wastes	44	87	54	149	96	48
7.4	Plastic wastes	159	254	159	392	288	193
7.5	Wood wastes	377	446	272	586	507	409
7.6	Textile wastes	20	23	14	29	26	21
8	Discarded equipment	6	10	9	14	10	9
8.1	Discarded vehicles	0	0	0	0	0	0
8.41	Batteries and accumulators	1	2	1	4	2	1
9	Animal and vegetal wastes	4 704	5 837	4 948	8 085	5 656	4 732
10.1	Household wastes	2 665	5 868	3 773	10 515	6 373	2 892
10.2	Mixed materials	1 689	2 573	1 729	4 052	2 973	2 164
10.3	Sorting residues	93	156	155	219	143	148
12	Mineral wastes	2 083	2 788	1 690	3 986	3 199	2 535
12.4	Combustion wastes	2 533	3 559	3 175	4 237	3 220	3 571
	Total	20 861	31 788	23 608	47 283	33 275	25 378
Hazardous wastes							
1.1	Spent solvents	40	68	41	89	81	63
1.3	Used oils	125	172	108	244	198	155
1.2, 1.4, 2, 3.1	Chemical wastes	372	493	317	704	565	433
3.2	Sludges	135	213	211	286	199	202
6	Metal wastes	0	0	0	0	0	0
7.1	Glass wastes	0	0	0	0	0	0
7.5	Wood wastes	24	48	30	80	53	28
7.7	PCB wastes	0	0	0	0	0	0
8	Discarded equipment	153	339	217	603	366	167
8.1	Discarded vehicles	471	930	667	1 580	967	533
8.41	Batteries and accumulators	36	65	49	112	74	46
10.2	Mixed materials	10	17	11	27	20	13
10.3	Sorting residues	0	0	0	0	0	0
12	Mineral wastes	481	835	832	1 230	756	752
12.4	Combustion wastes	260	435	412	513	384	405
12.6	Contaminated soils	11	20	20	26	18	18
	Total	2 118	3 636	2 913	5 494	3 680	2 814

Source: Sundqvist and Stenmarck (2009) and calculations with the EMEC model.

Table A2. Total wastes generated by the industry sector in 2006 and in economic scenarios for 2030. Ktonnes.

EWC code	Waste label	2006	Basline	Global sustain-ability	Global markets	Regional markets	European sustain-ability
Non-hazardous wastes							
1.2, 1.4, 2, 3.1	Chemical wastes	632	836	505	1 145	969	796
3.2, 11, 11.3	Sludges	2 099	3 364	3 348	4 692	3 086	3 156
6	Metal wastes	1 067	1 484	905	2 091	1 732	1 385
7.1	Glass wastes	53	52	34	73	60	48
7.2	Paper wastes	1 791	2 528	1 645	3 545	2 850	2 383
7.3	Rubber wastes	13	17	10	22	20	15
7.4	Plastic wastes	120	165	104	232	192	152
7.5	Wood wastes	377	446	272	586	507	409
7.6	Textile wastes	20	23	14	29	26	21
8	Discarded equipment	6	10	9	14	10	9
8.1	Discarded vehicles	0	0	0	0	0	0
8.41	Batteries and accumulators	0	0	0	0	0	0
9	Animal and vegetal wastes	4 248	4 800	4 305	6 213	4 531	4 254
10.1	Household wastes	338	577	492	960	632	452
10.2	Mixed materials	1 689	2 573	1 729	4 052	2 973	2 164
10.3	Sorting residues	93	156	155	219	143	148
12	Mineral wastes	2 083	2 788	1 690	3 986	3 199	2 535
12.4	Combustion wastes	2 533	3 559	3 175	4 237	3 220	3 571
	Total	17 342	23 378	18 392	32 095	24 150	21 498
Hazardous wastes							
1.1	Spent solvents	39	66	40	85	79	62
1.3	Used oils	122	165	104	231	190	152
1.2, 1.4, 2, 3.1	Chemical wastes	357	459	296	644	529	418
3.2	Sludges	135	213	211	286	199	202
6	Metal wastes	0	0	0	0	0	0
7.1	Glass wastes	0	0	0	0	0	0
7.5	Wood wastes	9	14	9	20	17	13
7.7	PCB wastes	0	0	0	0	0	0
8	Discarded equipment	14	23	21	32	23	21
8.1	Discarded vehicles	166	236	237	327	214	213
8.41	Batteries and accumulators	29	49	39	84	57	39
10.2	Mixed materials	7	10	7	14	13	10
10.3	Sorting residues	0	0	0	0	0	0
12	Mineral wastes	479	830	829	1 223	752	750
12.4	Combustion wastes	260	435	412	513	384	405
12.6	Contaminated soils	11	20	20	26	18	18
	Total	1 629	2 520	2 225	3 486	2 475	2 303

Source: Sundqvist and Stenmarck (2009) and calculations with the EMEC model.

Table A3. Wastes generated by material input in the industry sector in 2006 and in economic scenarios for 2030. Ktonnes.

EWC code	Waste label	2006	Basline	Global sustain-ability	Global markets	Regional markets	European sustain-ability
Non-hazardous wastes							
1.2, 1.4, 2, 3.1	Chemical wastes	632	836	505	1 145	969	796
3.2, 11, 11.3	Sludges	0	0	0	0	0	0
6	Metal wastes	1 041	1 455	878	2 048	1 702	1 359
7.1	Glass wastes	46	44	27	59	51	41
7.2	Paper wastes	1 601	2 210	1 337	3 082	2 546	2 101
7.3	Rubber wastes	13	17	10	22	20	16
7.4	Plastic wastes	109	148	90	202	172	139
7.5	Wood wastes	375	443	269	582	504	406
7.6	Textile wastes	20	23	14	29	26	21
8	Discarded equipment	2	3	2	4	3	3
8.1	Discarded vehicles	0	0	0	0	0	0
8.41	Batteries and accumulators	0	0	0	0	0	0
9	Animal and vegetal wastes	922	1 065	648	1 400	1 204	966
10.1	Household wastes	0	0	0	0	0	0
10.2	Mixed materials	1 154	1 647	999	2 359	1 898	1 498
10.3	Sorting residues	0	0	0	0	0	0
12	Mineral wastes	2 083	2 788	1 690	3 986	3 199	2 535
12.4	Combustion wastes	0	0	0	0	0	0
	Total	7 998	10 679	6 468	14 917	12 293	9 880
Hazardous wastes							
1.1	Spent solvents	39	66	40	85	79	62
1.3	Used oils	112	149	90	207	175	140
1.2, 1.4, 2, 3.1	Chemical wastes	317	387	234	524	450	361
3.2	Sludges	0	0	0	0	0	0
6	Metal wastes	0	0	0	0	0	0
7.1	Glass wastes	0	0	0	0	0	0
7.5	Wood wastes	8	12	7	15	14	11
7.7	PCB wastes	0	0	0	0	0	0
8	Discarded equipment	4	5	3	7	6	5
8.1	Discarded vehicles	0	0	0	0	0	0
8.41	Batteries and accumulators	7	9	6	13	11	8
10.2	Mixed materials	6	9	5	12	10	8
10.3	Sorting residues	0	0	0	0	0	0
12	Mineral wastes	0	0	0	0	0	0
12.4	Combustion wastes	0	0	0	0	0	0
12.6	Contaminated soils	0	0	0	0	0	0
	Total	493	637	385	863	744	595

Source: Sundqvist and Stenmarck (2009) and calculations with the EMEC model.

Table A4. Wastes generated by the household sector in 2006 and in economic scenarios for 2030. Ktonnes.

EWC code	Waste label	2006	Basline	Global sustain-ability	Global markets	Regional markets	European sustain-ability
Non-hazardous wastes							
1.2, 1.4, 2, 3.1	Chemical wastes	1	2	1	4	2	1
3.2, 11, 11.3	Sludges	0	0	0	0	0	0
6	Metal wastes	165	375	233	678	407	173
7.1	Glass wastes	142	323	200	583	350	149
7.2	Paper wastes	537	1 221	757	2 205	1 325	563
7.3	Rubber wastes	31	70	44	127	76	33
7.4	Plastic wastes	39	89	55	160	96	41
7.5	Wood wastes	0	0	0	0	0	0
7.6	Textile wastes	0	0	0	0	0	0
8	Discarded equipment	0	0	0	0	0	0
8.1	Discarded vehicles	0	0	0	0	0	0
8.41	Batteries and accumulators	1	2	1	4	2	1
9	Animal and vegetal wastes	456	1 037	643	1 872	1 125	478
10.1	Household wastes	2 327	5 291	3 281	9 555	5 742	2 440
10.2	Mixed materials	0	0	0	0	0	0
10.3	Sorting residues	0	0	0	0	0	0
12	Mineral wastes	0	0	0	0	0	0
12.4	Combustion wastes	0	0	0	0	0	0
	Total	3 699	8 411	5 216	15 189	9 127	3 879
Hazardous wastes							
1.1	Spent solvents	1	2	1	4	2	1
1.3	Used oils	3	7	4	13	8	3
1.2, 1.4, 2, 3.1	Chemical wastes	15	34	21	60	36	15
3.2	Sludges	0	0	0	0	0	0
6	Metal wastes	0	0	0	0	0	0
7.1	Glass wastes	0	0	0	0	0	0
7.5	Wood wastes	15	34	21	60	36	15
7.7	PCB wastes	0	0	0	0	0	0
8	Discarded equipment	139	316	196	571	343	146
8.1	Discarded vehicles	305	694	430	1 253	753	320
8.41	Batteries and accumulators	7	16	10	28	17	7
10.2	Mixed materials	3	7	4	12	7	3
10.3	Sorting residues	0	0	0	0	0	0
12	Mineral wastes	2	5	3	7	4	2
12.4	Combustion wastes	0	0	0	0	0	0
12.6	Contaminated soils	0	0	0	0	0	0
	Total	489	1 114	691	2 008	1 207	513

Source: Sundqvist and Stenmarck (2009) and calculations with the EMEC model.

Appendix B

Classification of private production sectors

Production sector in EMEC	NACE Rev.1*	Sector label in the Swedish National Accounts
1. Agriculture	01	Agriculture and hunting
2. Fishery	05	Fishing
3. Forestry	02	Forestry and logging
4. Mining	13	Metal ore mining
	10-11,14	Other mining and quarrying
	37	Recycling
5. Other industries	15,16	Manufacture of food, beverage and tobacco
	17-19	Textile industries
	20	Manufacture of wood and wood products
6. Mineral products	26	Manufacture of non-metallic mineral products
7. Pulp and paper mills	21	Manufacture of pulp, paper and paper products
	22	Printing and publishing
8. Drug industries	244	Manufacture of pharmaceutical products
	245	Manufacture of soap and detergents
9. Other chemical industries	24 excl 244,245	Manufacture of chemicals and chemical products
	25	Manufacture of rubber and plastic products
10. Iron & steel industries	271-273	Iron steel basic industries
11. Non-iron metal industries	274-275	Non-ferrous metal basic industries
12. Engineering	28	Manufacture of metal products
	29	Manufacture of mechanical machinery
	30,31	Manufacture of electrical machinery and computers
	32	Manufacture of communication equipment
	33	Manufacture of measuring equipment, etc.
	34,35	Manufacture of transport equipment
	36,	Other manufacturing industries
13. Petroleum refineries	23	Petroleum refining
14. Electricity supply	401	Electricity
15. Hot water supply	403	Steam and hot water supply
16. Gas distribution	402	Gas manufacture and distribution
17. Water and sewage	41	Water supply and sewage disposal
18. Construction	45	Construction
19. Railroad transports	601	Railway road transports
20. Road goods transports	6024	Road goods transports
21. Road passenger transports	6021-6023	Road passenger transports
22. Sea transports	61	Water transports
23. Air transports	62	Air transports
24. Other transports	63	Other transport activities
	64	Communications
25. Services	50-52	Wholesale and retail trade
	55	Restaurants and hotels
	65	Financial institutions
	66	Insurance
	71-74	Business services
	75,80-85,90-95	Other private services
26. Real estate	70	Letting of dwellings and other real estate

*Nomenclature Général des Activités Economiques dans les Communautés Européennes. The statistical classification of economic activities in the European Community amended in March 1993.

Definition of commodities

Commodity in EMEC	CPA code*	Commodity label in the Swedish National Accounts
1. Agricultural products	01	Products of agriculture and hunting
2. Fish	05	Fish and fishing products
3. Timber	02	Products of forestry and logging
4. Bio fuels	02 pt	Wastes from logging
5. Metal ores	13	Metal ores
	11,14	Other mining and quarrying products
	37	Recycled products
6. Coal	10	Coal
7. Products n.e.c.	15,16	Food products, beverages and tobacco products
	17-19	Textiles and textile products
	20	Wood and wood products
8. Mineral products	26	Non-metallic mineral products
9. Pulp and paper	21	Pulp, paper and paper products
	22	Printed matter
10. Pharmacy products	244	Pharmaceuticals and medical chemicals
	245	Soap,detergents and cosmetics
11 Other chemical products	24 excl 244,245	Chemicals and chemical products
	25	Rubber and plastic products
12. Iron and steel	271-273	Basic iron and steel , tubes and wires
13. Other metals	274,275	Basic non-ferrous metals
14. Engineering products	28	Metal products
	29	Mechanical machines
	30,31	Electric machines and computers
	32	Communication equipment
	33	Measuring equipment
	34,35	Transport equipment
	36,37	Other manufactured products
15. Fuels	23200 pt	Heating oils
16. Motor fuels	23200 pt	Motor gasoline,diesel and jet fuels
17. Other petroleum products	23200 pt	Other refined petroleum products
18. Crude petroleum	11	Crude petroleum
19. Electricity	401	Electricity
20. Steam and hot water	403	Steam and hot water
21. Gas	402	Manufactured and distributed gas
22. Fresh water	41	Collected, purified and distributed water
23. Buildings	45	Construction works
24. Rail transports	601	Rail transports
25. Passenger transports	6021 pt,6023	Passenger transports by bus
	6022	Passenger transports by taxi
26. Large truck transports	6024 pt	Goods transports by trucks > 32 tonnes
27. Medium truck transports	6024 pt	Goods transports by trucks 3.5 - 32 tonnes
28. Small truck transports	6024 pt	Goods transports by trucks < 3.5 tonnes
29. Sea transports	61	Sea transports
30. Air transports	620	Air transports
31. Other transports	63	Other transport products
	64	Communication products
32. Services	50-52	Wholesale and retail trade products
	55	Restaurant and hotel services
	65	Financial services
	66	Insurance services
	71-74	Business services
	75,80-85,90-95	Other private services
33. Dwellings	70	Real estate services

*EU Classification of Products by Activity (CPA).

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