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Stakeholder analysis of incineration tax, raw material tax, and weight-based waste fee

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Foreword

The results presented in this report is a result of research done with support from the Swedish Environmental Protection Agency within the framework of the research programme ”Towards Sustainable Waste Management”. The results are a part of the project “Institutional aspects and the waste-incineration tax”. The work presented in this report has been carried out at IVL Swedish Environmental Research Institute. The text in the report reflects the perceptions and deliberations of the authors, but constructive input was received from Dr. Mattias Bisaillon at Profu, from Prof. Göran Finnveden ate the Royal Institute of Technology, and from Dr. Thomas Forsfält at the National Institute of Economic Research.

Table of Contents

Summary

This report is a part of the assessments of policy instruments in the research programme Towards Sustainable Waste Management. It presents a stakeholder analysis aiming to describe how the organization of the waste sector can affect the outcome of various policy instruments. This analysis is complementary to the optimizing models used in other projects in the research programme.

The stakeholder analysis focuses on the insight that an effective policy instrument needs to give the right incentives to the right stakeholder, i.e. the aimed stakeholder must have control over the wanted or expected effects. The policy instrument can give such incentives if it is designed to affect the correct stakeholders directly. It can also give incentives indirectly by making a third-party stakeholder give a correct incentive to the stakeholder in control. The effects of such indirect incentives are more difficult to predict and there is a risk that the effect is weakened because more transfer costs etc. will be involved. On the other hand, in cases where the right incentives already exist, a policy instrument can be effective by eliminating barriers to the right actions.

Climate tax on waste incineration:
This tax considers the emissions of fossil carbon dioxide from waste incineration. The tax rate is different for heat production and electricity production.

The climate tax hits the owners and operators of waste incinerator plants. It gives them a direct incentive to co-produce heat and electricity. However, the incentive to increase recycling is only indirect (as the tax is designed in this study), since the owners of waste incinerators are not in direct control of the level of recycling.

In 2030 scenarios, particularly in scenarios with a rapid technological development, it might be possible for waste incinerators to charge companies, municipalities and organisations for each kg of plastic waste they deliver, also plastic in mixed waste. This would give the waste generating companies a clear incentive to increase source separation of their plastic waste. It would also give municipalities and other waste collection enterprises an incentive to invest in collection systems where it is easier for households to deliver source-separated waste. The incentive for households to increase source separation would still be weak, however. In scenarios where the source separation system is displaced by a central post-collection separation, the tax could give a direct incentive to make the post-collection separation more efficient.

All in all, there is a clear risk that the optimizing models used in the study overestimate the effect on plastics recycling because it is assumed that the waste-management system as a whole adapts with economic rationality to the climate tax on incineration. This is particularly true for waste plastics from households. On the other hand, the climate tax may contribute to increase the general gate fees at waste incinerators, which can contribute to an increased recycling of materials other than plastics, to the reduction of total waste quantities, and to an increase in landfilling, incineration and/or recycling in other countries.

Raw material tax:
The raw material tax presented by Bisaillon et al. (2009) is based on the quantity of non-renewable material that enters the Swedish technosphere through raw-materials extraction or through imports. The tax is higher for fossil raw materials and plastics than for other materials (for example ores). It is also larger for materials producers than for importers: importers pay only for amounts of finished materials

imported, while materials producers pay also for mine tailings and other extracted materials that goes to waste or is consumed in the production process.

This raw material tax is likely to reduce the amounts of mine tailings and waste rocks by 3-3.5 percent. The affect on plastic waste could not be calculated with the models available. The total quantity of other Swedish waste flows would be reduced by less than 0.2 percent. It is also likely that the use of renewable and recycled raw materials for Swedish plastics production will be stimulated.

The tax will reduce the competitiveness of Swedish mining industry and of the chemicals industry beyond plastics production. If applied on coal and coke used as reducing agents in steel industry, it might fully eliminate Swedish ore-based steel production and also affect the production of other ore-based metals.

The effect on the competitiveness of the Swedish industry will be much smaller if the tax is not calculated based on the quantity of materials extracted or imported to Sweden but on the estimated quantity of non-renewable raw materials that are extracted to produce products that are used in Sweden. Such an adjusted tax is likely to reduce the quantity of plastic and chemical waste. It would also provide an incentive to channel recycled plastics and renewable substitutes to fossil raw materials to the industry that produces mainly for the Swedish market, creating something of a niche market for these raw materials.

Since this (?) adjusted tax have little impact on the competitiveness of Swedish industry, it might be possible to increase the tax, perhaps in the same order of magnitude as the cost of producing the material without the tax. This would and give the industry a stronger economic incentive for material-efficient production on the Swedish market.

The consumer patterns of households and other end-consumers are likely not to be significantly affected by the raw material tax, because an increase in the cost of material means less to the price of the product the more it is refined, transported and retailed.

Weight-based waste collection fee:
The waste collection fee is paid by house-owners for the amount of residual waste. A weight-based fee gives households in most single-family houses an economic incentive to reduce the quantity of residual waste through waste prevention, increased source separation, or irregular or even illegal waste management. It also raises their attention to waste and waste-management issues, which can contribute to waste prevention and increased source separation at least in a short-term perspective.

It is difficult to affect the households in apartment housesto an economic incentive today. However, the house-owners (housing companies) get an economic incentive to make source separation easier for the tenants and to raise their attention to waste and waste-management issues. This should contribute to increased source separation and, possibly and in a short-term perspective, also to waste prevention. In the future, the weighting of residual waste from individual households might be possible also in apartment houses, particularly in scenarios with rapid technological development and/or a strong political governance towards sustainability.

Experience from implementation of weight-based feeshows that the total effect of introducing a weight-based fee currently is significant, at least in the short term perspective, but the influence of the raised attention and the economic incentive are not certain. The raised attention is more important in future scenarios with a high environmental awareness, and the economic incentive is more important in scenarios where the focus of house-owners is more on economic issues. In the latter, there is a more pronounced risk of illegal waste treatment, and, hence, more important to have an effective control system in place.

Sammanfattning

Denna rapport är en del av utvärderingen av styrmedel inom forskningsprogrammet Hållbar Avfallshantering. Rapporten presenterar en bild av hur avfallssektorn är uppbyggd och hur det påverkar effekten av olika styrmedel. Den gjorda analysen kompletterar de optimerande modeller som är använda och redovisade inom forskningsprogrammet.

Intressentanalysen betonar insikten att styrmedel, för att de ska vara effektiva, behöver ge rätt incitament till rätt intressenter, t.ex. intressenter som har kontroll över det som styrmedlet ska ha tänkt påverkan på. Styrmedel kan ge sådana incitament om de är designade så att de påverkar den tänkta intressenten direkt. Styrmedel kan också skapa påverkan genom att en tredjeparts intressent förmedlar påverkan till den tänkta intressenten. Effekten av sådana indirekta incitament är svårare att förutsäga och det finns en risk att effekten försvagas genom att till exempel större kostnader kan bli följden.

I de fall där rätt incitament redan finns kan ett styrmedel vara effektivt genom att det istället eliminerar hinder som är i vägen för den önskade handlingen.

Klimatskatt på avfallsförbränning:
Klimatskatten påverkar ägare av avfallsförbränningsanläggningar. Den ger dem ett direkt incitament att samproducera värme och el. Dock är incitamentet att påverka återvinningsgraderna endast indirekt. Ägarna till avfallsförbränningsanläggningar har inte direkt kontroll över nivåerna för materialåtervinning.

År 2030, speciellt i scenarier med snabb teknisk utveckling, skulle det kunna vara möjligt för avfallsförbränningsanläggningar att ta betalt från företag, kommuner och organisationer för varje kg av plastavfall som de tar emot för förbränning. Det skulle ge de avfallsalstrarna ett tydligt incitament att källsortera plasten istället för att skicka den till förbränning. Det skulle också ge kommuner och insamlande företag incitament att investera i insamlingssystem som gör det lättare för hushållen att bidra till källsorteringen. Incitamenten för hushållen att faktiskt utföra sorteringen skulle dock fortfarande vara små.

I scenarier där källsorteringssystemet är ersatt av en eftersortering skulle skatten ge incitament till att förbättra eftersorteringen och öka utsorteringsgraden av plast.

Totalt sett är det en uppenbar risk att de optimerande modellerna överskattar effekten skatten skulle ha på plaståtervinningsgraden om de antar att avfallshanteringssystemet totalt sett justeras efter till klimatskatten. Detta gäller speciellt hushållens plastavfall.

Å andra sidan skulle klimatskatten bidra till att öka avgiften för avfallsförbränning generellt vilket skulle kunna bidra till en ökning av materialåtervinning av olika material förutom plast, en minskning av avfall generellt, eller till att öka deponering/ förbränning/ återvinning i andra länder.

Skatt på råvara:
Det förslag på skatt på råvara som presenteras av Bisaillon et al. (2009) baserar sig på kvantiteten av icke-förnybara råvaror som kommer in i Sveriges teknosfär genom utvinning i Sverige eller import av råvara. Den är mycket högre för fossila material och plast än för andra material. Den är också större för materialtillverkare än för importörer, importörer betalar bara för de ton av material som importeras medan material producenter betalar också för de biprodukter och avfall som uppstår.

Råvaruskatten skulle troligen minska gruvavfallsmängderna med 3-3,5 procent, plastavfallet med en okänd men betydande mängd samt totala avfallsflödet i Sverige med mindre än 0,2 procent. Det är också troligt att den skulle stimulera till användningen av förnybar och återanvänd råvara i svensk plastproduktion.

Skatten skulle minska konkurrensförmågan hos svensk gruvindustri och kemikalieindustri (även annan kemikalieindustri än plasttillverkning). Om skatten läggs på kol och koks som används som reducerande material skulle den fullständigt kunna radera svensk malmbaserad stålproduktion och skulle också påverka annan malmbaserad metalltillverkning.

Effekten på konkurrensförmågan för svensk industri skulle vara mycket mindre om skatten inte beräknades baserat på kvantiteten av material utvunna eller importerade till Sverige utan istället på den uppskattade kvantiteten av icke förnybara material som utvinns för att producera produkter som ska användas inom Sverige. En sådan justerad skatt skulle troligen minska mängden av plast- och kemavfall. Den skulle också ge incitament att kanalisera återvunnen plasträvara och återvinningsbara substitut till fossil råvara till den industri som producerar mest för den svenska marknaden och på så sätt skapa en form av nischad marknad för dessa material.

Eftersom den justerade skatten har liten påverkan på konkurrenskraften hos svensk industri skulle det kunna vara möjligt att lägga den på en högre nivå, kanske i samma storleksordning som kostnaden för att producera materialet utan skatten. Det skulle ge industrin ett starkare ekonomiskt incitament att vara materialeffektiv när man producerar för den svenska marknaden.

Konsumtionsmönstren hos hushåll och andra slutkonsumenter skulle troligen inte påverkas av råmaterialskatten eftersom en ökning i materialkostnad betyder mindre för produktens slutpris när den är mer förädlad och distribuerad.

Viktbaserad avfallstaxa:
Avfallstaxan betalas av fastighetsägaren. En viktbaserad taxa ger hushåll i de flesta enfamiljshus ett ekonomiskt incitament att minska mängden restavfall som slängs i den blandade fraktionen. Detta kan göras genom avfallsförebyggande, ökad källsortering eller genom illegal avfallsbehandling. Viktbaserad avfallstaxa skapar också uppmärksamhet kring avfall och frågor kopplade till avfallshantering vilket i sin tur kan bidra till avfallsförebyggande och ökad källsortering i alla fall i ett kortare perspektiv.

Boende i flerfamiljshus får idag inga ekonomiska incitament av en viktbaserad taxa. Dock får fastighetsägaren ett incitament att förenkla för de boende att källsortera och öka deras uppmärksamhet kring avfallsförebyggande och avfallshanteringsfrågor. Detta skulle kunna bidra till en ökad källsortering och möjligtvis på kort sikt också till avfallsförebyggande. I framtiden kan vägning av restavfall från enskilda hushåll vara möjligt även i flerfamiljshus särskilt i scenarier med snabb teknisk utveckling och/ eller stark politisk styrning mot hållbarhet.

Statistik visar att den totala effekten av att introducera viktbaserad avfallstaxa för närvarande är betydande åtminstone i det korta perspektivet men att betydelsen av den ökade uppmärksamheten och det ekonomiska incitamentet inte är säker. Den ökade uppmärksamheten är av större betydelse i framtida scenarier med en hög miljömedvetenhet och det ekonomiska incitamentet spelar större roll i scenarier med större fokus på ekonomi. I det senare fallet är också risken större för illegal hantering och det är därför viktigare med ett väl utbyggt kontrollsystem i dessa scenarier.

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.

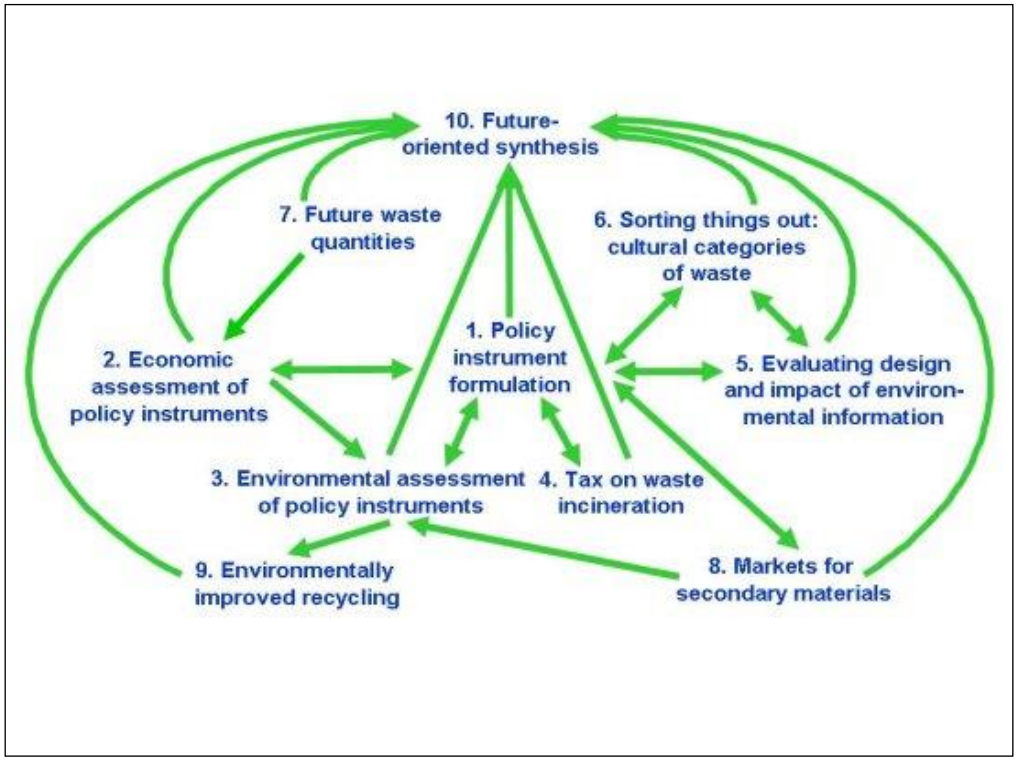

Figure 1. TOSUWAMA projects and the information flows between the projects.

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

Project 1 "Policy instrument formulation" has a central role in that it generates ideas for policy instruments to be assessed in the other projects, and collects results and conclusions from these assessments. The following policy instruments have been selected described in sufficient detail to facilitate assessment (Bisaillon et al. 2009):

- Information to households
- Information to companies
- Tax on raw materials
- Weight-based waste-collection fees
- Waste-collection fee differentiated for source-separation
- Industrial waste-plan requirements
- "Advertisments, yes please"
- Recycling certificates
- Improved collection systems
- Climate tax on waste incineration
- General tax on waste incineration
- Green electricity certificates at waste incineration
- Tax on hazardous substances
- Mandatory chemicals labelling
- Improved control by authorities
- Differentiated VAT
- Incineration ban for recyclables

To achieve a basis for conclusions regarding the sustainability of these policy instruments, they will be assessed in five different external scenarios for the year 2030:

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

These scenarios were developed as a first task in TOSUWAMA Project 10 "Future-oriented synthesis" (Dreborg & Tyskeng 2008). The scenarios are distinguished by

- the nature of international cooperation: either global cooperation or regional European cooperation, and
- the degree of political control and influence in matters that concern the environment and natural resources.

An important part of the assessment is made through combining a set of quantitative models (see Figure 2 and Östblom et al. 2010):

- the Environmental Medium term EConomic model (EMEC), a computational general equilibrium (CGE) model of the Swedish economy (Östblom & Berg 2006), which has been fitted with data on waste quantities as part of TOSUWAMA,
- NatWaste, a systems engineering model of the Swedish waste-management system (Ljunggren 2000), which has been refined and updated as part of TOSUWAMA, and
- the life cycle assessment (LCA) model SWEA, which has been developed within TOSUWAMA.

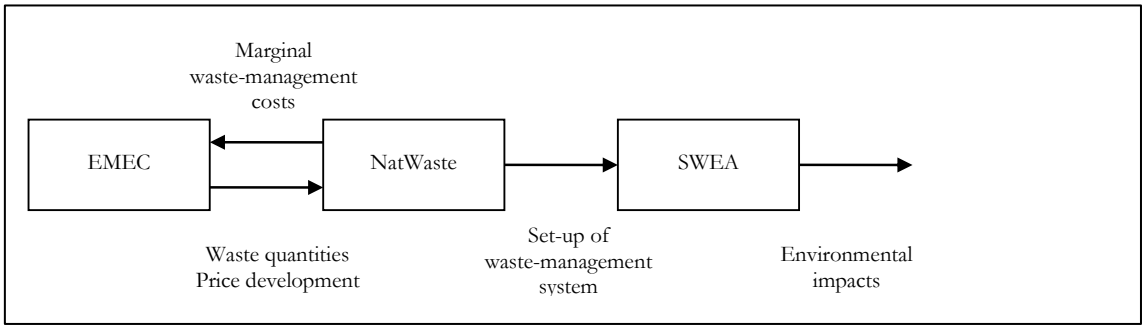

Figure 2. Combination of models for assessing policy instruments for sustainable waste management.

A vital strength in these types of models is their broad scope. A general equilibrium model covers the whole economy in a geographical area. NatWaste covers the waste management of most environmentally relevant waste streams in Swede. An LCA model like SWEA covers not only the waste-management system but also the energy and materials production systems that are affected by the waste management. This is essential since the environmental consequences of waste management often depend more on the impacts on surrounding system than on the emissions from the waste-management system itelf (Ekvall 1999).

However, a model is always a simplification of reality. When the model has a broad scope, the behavior of the model should represent the real behavior of the overall system, but the behavior of individual stakeholders and decision-makers is necessarily generalized. The level of aggregation is in the end delimited by access to consistent data. In EMEC, the final consumers of Swedish goods and services are divided into six representative households, the general government and the export market. It includes in total 33 industrial product categories, which are bought from domestic producers and/or imported. The domestic production is conducted in 26 different industrial sectors, and a public sector.

It is only possible, with EMEC, to analyze the aggregated products within the model. Thus one cannot distinguish between different products or services within the 33 categories. The chemical good, for example, consists of different plastics and rubber as well as all other chemical products. It is difficult, in EMEC, to study a policy instrument that focus on the production or waste management of plastic materials, because the model does not distinguish plastics from other chemical products. Additional information on the consequences of different policy instruments can be obtained through a more detailed analysis of the industries and products affected.

NatWaste is less aggregated compared to EMEC since it is restricted to the waste-management sector. However, NatWaste does not distinguish between different stakeholders within this sector. It calculates the least cost solution for the Swedish waste-management system, given specific boundary conditions and assumptions. In reality, the national waste-management system might not find an economic optimum, because each stakeholder in the system have an interest in optimizing their own economy etc. rather than the economy of the system as a whole. Additional information on the consequences of policy instruments can be obtained through an analysis of how different stakeholders in the waste-management system are affected.

1.2 Project 4: Institutional aspects

In this project (Project 4. Institutional aspects and the waste incineration tax) we have constructed a spreadsheet model to predict how the waste incineration tax that was introduced in the year 2006 and removed in 2010 would affect the Swedish waste flows (Sahlin et al. 2007). The tax was based on the Swedish average fossil carbon content of the incinerated waste. Our results indicate that the incineration tax may increase biological treatment of kitchen and garden waste from households by 9 percent, but that it is likely to have very small effects on other waste flows. We also used the spreadsheet model to investigate the effects of a tax based on the specific fossil carbon content of the waste in each waste incinerator (Sahlin et al. 2007). With this construction, the incentive to separate and compost kitchen and garden waste disappears, but the incentive to separate and recycle plastics becomes much greater.

Our spreadsheet model was designed to find the minimum cost solution for the waste management. It included a cost for the household time spent on source separation, as a measure of consumer resistance to increase their source separation. However, just like NatWaste it assumed that the waste-management system finds the solution that minimizes total system cost. To be true, this would require a set of unrealistic conditions: unrestricted and free transfer of costs between different parts of the waste-management system, perfect information among all stakeholders, and rational decision-making.

As an addition to the spreadsheet model, we discussed how the organisation and technology of the waste-management system affects the outcome of the waste incineration tax. This discussion continues in the present report.

1.3 The report

This report is part of the assessment of policy instruments in the research programme Towards Sustainable Waste Management. Here, we present an analysis on how the organisation of the waste-management system can affect the outcome of a few policy instruments:

- Climate tax on waste incineration
- Tax on raw materials
- Weight-based waste-collection fees

These were chosen because they were expected to be more dependant on the organisation than most of the other policy instruments studied in the program.

The report is complimentary to the EMEC and NatWaste calculations and to the model of Sahlin et al. (2007), because we focus on how different stakeholders are likely to respond to the policy instrument. Our analysis will give qualitative information on how this response will affect the consequences of the policy instruments. This information is intended to be used in the discussion of the quantitative results from the models, but it can also give insights that are useful in other contexts.

The report includes a section on each of these policy instruments. This section includes a description of the instrument, as defined by Bisaillon et al. (2009) and a discussion on what effects can be expected in the Reference scenario. It also includes a discussion on the effects in other scenarios or the effects of another version of the policy instrument.

2 Method

The method used in this report is a stakeholder analysis. Wikipedia (2011) explains this as a process of identifying the individuals or groups that are likely to affect or be affected by a proposed action, and sorting them according to their impact on the action and the impact the action will have on them. This information is used to assess how the interests of those stakeholders should be addressed in a project plan, policy, program, or other action.

Our stakeholder analysis was done by a small expert panel where the following questions were discussed:

- What stakeholders are affected by the policy instrument?
- Do these stakeholders have control over that which the policy instrument is intended to affect?
- What incentives do the policy instrument give these stakeholders?
- Through what interactions can the policy instrument have an indirect effect?
- How strong are the direct and indirect effects likely to be?

The policy instrument «climate tax om wste incineration» was also evaluated by a simple quantitave analysis (Sahlin et al. 2007). The findings and insights gained in the study of the waste incineration tax was an important input and starting point of the stakeholder analysis.

3 The stakeholders

Many different types of enterprises, organisations and public authorities affect, or are affected by, the waste management. A short discussion is given below and Table 1 presents a general overview of the stakeholders and how they are involved. Most stakeholders have several different roles at the same time. All of them can, for example, be waste generators and every waste generator have to physically handle the waste in some way. In this discussion and in the table we discuss their major roles only.

In the discussion below we have identified different important roles to explain how a stakeholder is influences or can make an influence on the waste management system:

- Waste generator: an organisation, entity, person or similar that generates essential amounts of waste
- Performer of waste management and treatment, for example companies that runs incineration plants, recycling plants, landfills, and so on.
- Seller/distributor of products that later is discarded and becomes a waste.
- Monitoring, supervision and inspection authority
- Permission and licencing authority
- Purchaser of recycled and recovered products (including energy) from waste
- Knowledge economy : organisations or entities producing educational and innovative intellectual products and services can be exported for a high value return
- Influence of public opinion

Households and private persons
Households (with private persons) are the major generators of household waste. In 2009 there were about 4.5 million households in Sweden (SCB 2010). The amount of household waste (excluded similar wastes from enterprises) was about 4 million tons (excluding rubber tires and discarded vehicles). An active participation of households is necessary for good source-separation results. The households are also addressees of some waste prevention policy instruments.

House owners and housing companies
In 2009 about 2.5 million households lived in apartment houses and similar, managed by different housing companies. These can be private as well as municipal enterprises. There were also about 2 million one-family houses, most of them owned by the people in the household (Statistics Sweden 2010).

It is the house-owners and landlords who have to organise the internal management of the household wastes. They also have to pay the waste management fee to the municipality. This means that in a one-family house the household itself is the recipient of the waste fee, but the tenant in an apartment or co-operative flat pay the fee as an invisible part of the ordinary rent.

Enterprises (in general)
Wastes are generated in all kinds of economic activities. In 2009 the Business Register in Sweden contains more than 980 000 enterprises and businesses (SCB 2011a). Enterprises generated in 2008 approximately 90 Mtonnes of waste, of which 59 Mtonnes were generated in the about 18 major facilities in the mining sector (SEPA 2010). Enterprises also generated some waste similar to household waste. The enterprises are required to ensure that the waste is managed in a health and environmentally sound manner.

Retail
As other enterpises also retail is a waste producer, but in this context the main role of the retail sector is that they sell and distribute products which later will become a waste.

Industry
Industry have several roles:

- All industries are waste generators (see "Enterprises" above). Approximately 13 million tons per year were generated by manufacturing industries in 2008.
- Several industries have their own waste treatment, for example landfills, recycling or combustion (use as fuel).
- Industry is also the major purchaser of recycled material. For example all recycled paper, plastic, glass and metals are purchased by industries.

Energy companies
Energy companies have a major role to treat and extract energy from combustible waste, both household waste and wastes from enterprises and business. In the year 2009, 12.3 MWh district heating and 1.6 TWh electricity were produced from waste in the energy sector (Swedish Waste Management 2010). Energy companies are also concerned in production and distribution of biogas. Energy companies also generate waste, particularly ashes and other waste from combustion.

Agriculture
Agriculture, including forestry and gardening are above all, in this context, potential purchasers of compost and digestate. Agriculture, as all other enterprises, also generate waste, but this is of less importance in this context. By-products such as straw, manure and felling residues are usually not classified as waste.

Soil manufacturers
Soil manufactures can be regarded as a part of the Industry, but has an important role as purchaser of compost, sludges and other organic and inorganic wastes that can be used in soil manufacture.

Waste management companies
In the Business Register, about 1300 of the enterprises were registered in the sector collection and treatment of waste (SCB 2011a). Many of them are privately owned, but there are also municipal-owned enterprises. The waste management companies are running on a commercial basis. Usually they are contracted by municipalities for collection and treatment of household waste, or contracted by industrial and other waste generating enterprises.

Producer's responsibility organisations
Sweden has legislated extended producer responsibility (EPR) for packages, newsprint, rubber tires, cars, pharmaceuticals and waste electric and electronic equipment (WEEE). The producers have initiated different organisations to manage the EPR. These organisations are responsible to organise and fund systems for collection and recycling of the wastes, and to fulfill the goals and requirements that have been set up in the EPR legislation.

Municipalities
There are 290 municipalities in Sweden. Municipalities have several different roles in the waste management

- Municipalities are responsible for the collection and treatment of household waste, including similar waste generated by enterprises.
- Some municipalities have formed special municipal companies that manage the household waste and often also manage other kind of wastes on a commercial basis.
- Municipalities are responsible for supervising the waste management at most enterprises in the municipality.
- Municipalities are responsible for the waste management planning for all waste generated within the border of the municipality. The waste-management plan shall contain a description of the conditions in the municipality that affects the quantity and/or composition of the waste: it shall contain information on the number of inhabitants, the

number of households in the municipality broken down for the accommodation form and the municipal industrial structure.The waste plan shall contain detailed information about household waste, and present an overview of other waste flows. The plan shall also contain detailed information about all licenced and permitted facilities for recovery or disposal of waste.

- The municpalities are also responsible for information to the public about household waste management issues, including the producer's responsibility wastes.

County administrative boards
There are 21 counties in Sweden. They are governed by county administrative boards, which are Governmental authorities. The county administrative boards' most important roles, in this context, are licencing/permission and supervision/control of environmentally dangerous activities (including waste management). The county administrative boards shall also compile the municipal waste plans in the county.

Swedish Environment Protection Agency
The Swedish Environmental Protection Agency is a Governmental public agency that has an overview of conditions in the environment and progress in environmental policy. The agency also has the task of coordinating, monitoring and evaluating efforts, involving many agencies, to meet the national environmental objectives.

Ministry of Environment and the Government
The Ministry of Environment has the major responsibility to implement the waste management policies decided by the Parliament. The Government has, for example, issued many ordinances in the waste sector.

The Parliament
The Parliament is the highest political organisation, elected by the people. The Parliament decides about environmental and waste management legislation, policies and objectives.

Environmental Courts
Several important, environmentally dangerous activities have to obtain a permit from the Environmental Court.

Consultants and Researches
Consultants and researchers, including universities and institutes, work with consulting, councelling, development and research in the waste management field. They work for most other kind of stakeholders.

Non-Governmental Organisations and interest organisations
Non-Governmental Organisations (NGOs) are defined by the World Bank as "private organizations that pursue activities to relieve suffering, promote the interests of the poor, protect the environment, provide basic social services, or undertake community development". Major NGO's that have been involved in waste-management issues in Sweden include Greenpeace and The Swedish Society for Nature Conservation (Naturskyddsföreningen).

The Keep Sweden Tidy Foundation is also a non-profit organsation that can be regarded as an NGO. It is a creator of public opinion that promotes recycling and combats litter through public awareness campaigns, awards, and environmental education. The Foundation strives to influence people's attitudes and behavior in order to encourage a sustainable development.

There are also different industrial or public interests organisations that play a role in the Swedish waste management. The Swedish municipalities and several private waste companies are organised in Swedish

Waste Management (Avfall Sverige). The municipalities and counties are also organised in the Swedish Association of Local Authorities and Regions. Some industrial interest organisations, also employer's organisations, also play an active role in the industrial waste management, for example the Swedish Recycling Industries' Association, Forest Industries, and the Swedish Steel Producers' Association.

The NGOs and interest organisations are also important for forming the public opinion.

Table 1. The major roles of different stakeholders in the waste system

Stakeholders	Waste generator	Performer of waste management and treatment	Seller/ distributor of products	Monitoring, supervision and inspections	Permission and licencing	Purchaser of products from waste	Knowledge economy	Influence of public opinion
Households (private persons)	X							
House owners and housing companies	X							
Enterprises (in general)	X							
Retail	(x)		X					
Industry	X	X	X			X		
Energy companies	(x)	X				X		
Agriculture	(x)					X		
Soil manufacturers		X				X		
Producer's responsibility organisations		X					X	X
Waste management companies		X					X	
Municipalities		X		X	X		X	X
County administrative boards				X	X			
Swedish Environment Protection Agency				X	(x)		X	
Environmental Courts					X			
Consultants and researchers							X	
Universities, Institutes							X	
NGO's							X	X
Industrial interest organisations							X	X

4 Results

4.1 Climate tax on waste incineration

4.1.1 Description of policy instrument

Bisaillon et al. (2009) describes this policy instrument as a tax on fossil CO_2 emissions from incineration of waste. The level of the tax is 0.95 SEK/kg CO_2 for waste-incineration plants with district heat production only or with electricity production at an efficiency of 5 percent or lower. This corresponds to more than 3000 SEK/tonne plastic waste. The tax is reduced for waste-incineration plants with electricity production. At an electricity efficiency of 15 percent or higher, the tax reduction reaches its maximum and the tax is only 0.15 SEK/kg CO_2.

4.1.2 Impact in Reference scenario

Three purposes of the tax were explicitly stated when a similar tax was introduced on household waste a few years ago (Ministry of Finance 2006):

- to increase the incentive for combined heat-and-power production based on waste,
- to increase the incentive for material recycling, including biological treatment, as it is becoming more economically competitive relative to waste incineration, and
- to complement the energy taxation system, where incineration of waste of fossil origin were previously not burdened with the energy and CO_2 tax carried by other fossil fuels.

The stakeholders directly affected by the tax are the owners of waste incineration plants. They get a direct incentive to co-produce heat and electricity. From the perspective of our stakeholder analysis the tax appears effective in this respect.

The incentive for material recycling is more problematic. As indicated by Bisaillon et al. (2009), the climate tax makes plastics recycling more profitable for the waste management system as a whole, since the incineration of plastics becomes more expensive. However, for the recycling to increase, the tax must directly or indirectly make recycling more attractive for the specific stakeholders that decides on the recycling rate. Today, this is to a large extent under the control of the stakeholders that generate waste, since an increase in recycling is most easily acquired through an increase in source separation. To some extent, the level of plastics recycling is also under the control of the recycling companies because improvements in the sorting and recycling technology can increase the share of the collected plastics that is actually recycled.

The quantity of plastics that is collected can also be indirectly affected by improved collection systems to make source separation easier and by information etc. that stimulate source separation.

However, the stakeholders that are in direct control of the level of recycling are not directly affected by the climate tax, which instead hits the waste incinerator plants. The tax would increase the running costs of each waste incinerator. To cover the increasing costs of an incineration tax, experience shows that the waste incinerators raise the gate fee, i.e. the price of taking care of the waste. This was also foreseen by the Ministry of Finance (2006). In theory, waste incinerators could instead raise the price of the district heat and electricity produced from the waste. In practice, however, they cannot make decisions on energy prices since these are defined by the energy markets.

A general increase in the gate fee at Swedish waste incinerators reduces the drivers for import of any waste for incineration in Sweden (cf. Olofsson et al. 2005). This could contribute to increasing landfilling, incineration and/or recycling of various kinds of waste in other countries.

An increase in the gate fee also results in an increase in the waste-collection fee for Swedish households (Ministry of Finance 2006). To the extent that the waste fee is based on the weight of the waste, this can contribute to an increase in source separation and recycling in general (i.e., not specifically for plastics; see Section 4.3). It can also result in the reduction of total registered waste quantities. To a lesser extent, such effects can also be expected in municipalities where the waste-collection fee is based on units other than weight: volume, frequency of collection, etc. (Dijkgraaf & Gradus 2003).

However, to be effective in reducing the incineration of plastics, the increase in gate fee should not be general but depend on the quantity of plastics in the waste delivered by individual waste generators. This would make further source separation of plastics more profitable for the waste generators. It might be possible to measure the quantity of plastics or fossil carbon in waste flows from individual industries and large businesses, particularly assuming continuing technological development until the year 2030. Based on these arguments, it can be assumed that the climate tax in the year 2030 will be effective for *commercial waste*: It can indirectly make plastics recycling more profitable for the generators of most of the commercial waste.

The effect of the tax on the flows of commercial waste can be estimated using the model NatWaste, which calculates an economic optimum mix of treatment technologies for the Swedish waste management (Östblom et al. 2010). Such calculations are made in Project 2 (Economic modeling) of the TOSUWAMA research programme (cf. Figure 1).

When interpreting the results from these calculations, it should be kept in mind that they are optimistic if they assume that an economic optimum will be obtained after the climate tax has been introduced. This would require that the quantity of plastics or fossil carbon from individual generators of all commercial waste will be identified and that this quantity will be the basis for the increase in gate fee of waste incinerators that result from the climate tax.

For *household waste*, the situation is more difficult. It is not reasonable to assume that the quantity of plastics or fossil carbon will be measured in the waste from individual households for reasons of technology, economy and, not least, privacy. The effect of the incineration tax on the management of waste from households was investigated by Sahlin et al. (2007). Their model indicated that incineration of plastic waste from households would be reduced by approximately 3 percent, calculated by mass. The total incineration of waste from households would be reduced by as little as 0.3 percent. This is mainly because the model assumes that:

1. an increase in recycling requires an increase in source separation,
2. there is a resistance in the households against such an increase, which can be quantified in terms of SEK/kg, and
3. the waste-management system finds the solution with the lowest total net cost, including the perceived cost of spending more time on source separation.

Assumption 1 is probably valid in Sweden for the foreseeable future. One reason is that the Swedish system and policy for recycling is based on source separation. Another reason is technological.

In principle, plastics can be separated after collection of mixed waste through manual picking and through automatic separation processes such as wind sieving or optical identification. Plastics are separated from a flow of mixed recyclable materials in, for example, Great Britain and Norway (Stenmarck & Sundqvist

2009). This system also requires source separation of the recyclable from the non-recyclable waste, however. Separation of recyclable materials from a stream of mixed municipal solid waste is more difficult. Golder Associates (2009) states that the experience from such processes is that the recovery rate is very low (5 to 10 percent) and that the recovered materials have low value due to the high level of contamination.

The year 2030 is fairly far into the future, and with further technological development and a possible shift in policy away from source separation, Assumption 1 might be wrong at this stage. If so, a climate tax will influence the recycling rate not by affecting the behaviour of households but through making separation of plastics more profitable for the waste companies. The effect of the tax is then likely to be greater. How much greater can be roughly estimated through one of the sensitivity analyses of Sahlin et al. (2007), where the cost of increasing source separation is excluded from the model. In this sensitivity analysis, the effect on the recycling of plastic packagings is more than doubled, but the effect is still moderate: the reduction in incineration of plastic waste from households would be in the order of 8 percent, calculated by mass.

All cost data in the model of Sahlin et al. (2007) are estimates of the costs at the time when the model was constructed. These will change until the year 2030, which means that the system might be much less or much more sensitive to a tax than the model indicates.

Regarding *Assumption 2*, it seems reasonable to assume that there is a resistance in the households against increasing the efforts on source separation. If there were no such resistance, the source separation would already be higher. Quantifying the resistance in terms of SEK/kg is problematic, however, making the results uncertain. It also varies greatly between different households (Berglund 2006). Sahlin et al. (2007) took into account this variability by assuming a large cost range associated to the time spent on source separation. They took into account the uncertainty through sensitivity analyses where the cost was varied by ±100 percent. The effect remained small to moderate in these sensitivity analyses: incineration of plastic waste from households would be reduced by approximately 2-8 percent, calculated by mass when the cost was varied by ±100 percent.

Using SEK/kg as a unit to measure the resistance to a change in behaviour is problematic also at a more principal level. The waste management in households is not governed by economic rationality but by habits, values, etc. For this reason a certain amount of money rewarded to households for increasing source separation will give different results depending on how and when the money and the information about this reward is given. This adds to the uncertainty of the model. However, this uncertainty is probably also accounted for in the sensitivity analyses, where the cost of the household time was varied by ±100 percent.

Assumption 3 is probably not valid: the waste-management system is unlikely to adapt to the tax by finding the solution with the lowest total net cost. This is precisely because the response to the tax depends on changes in the behaviour of households. The tax does not give the households a reason to change their behaviour. It gives the waste incinerators a reason to avoid incinerating plastics, but they do not decide on the recycling rate.

For the tax to have any effect at all on the recycling rate, it is necessary that the governing force of the tax be transferred to the people who decide whether the plastic waste goes to Swedish waste incineration or not. Theoretically the consumers would be motivated to increase the source separation of plastic waste if forced to pay for each kg of plastic waste in their mixed waste; as stated above, however, it does not seem realistic to measure the quantity of plastic waste from each separate household.

Another theoretical way to affect consumers would be to improve the collection systems, making it easier to deliver source-separated plastic waste. Municipalities and organisations responsible for waste collection can, for example, offer kerbside collection of source-separated waste to more households. If this results in a reduced quantity of waste plastics in the residual waste, they would have to pay less to have the waste incinerated.

A third way would be to stimulate source separation through information campaigns. This could be a feasible route for waste incinerators, but to make it cost-efficient, they should organise the information campaign on a national level, for example through the organisation Swedish Waste Management. Even so, the effects of information campaigns are difficult to quantify. The effect of a campaigne is usually also decreased after a while, so the campaign needs to be repeated.

To summarize, the climate tax on waste incineration will have any effect on the recycling of waste plastics from households if:

- the system of source separation is replaced by a system based on separation after collection of mixed waste,
- the increase in incinerator gate fees results in collection systems where it is easier to deliver source-separated waste, or
- the tax makes the waste-management companies influence the households through, for example, an information campaign.

Even in these cases, the reduction in incineration of plastic waste from households is likely to be small.

In the Reference scenario it does not seem unreasonable to assume that the tax reduces the incineration of plastic waste from households by 3 percent. However, the large uncertainties discussed above should be remembered. It should also be remembered that the climate tax can contribute to an increase in recycling of materials other than plastics, to the reduction of total registered waste quantities, and to an increase in landfilling, incineration and/or recycling in other countries.

The effect of the tax on recycling of commercial plastic waste can, as stated above, be estimated using the model NatWaste. It should be kept in mind that the NatWaste results will be optimistic if they are based on the assumption that the commercial waste generators are fully affected by the waste incineration tax.

4.1.3 Impact in other scenarios

The discussion above concludes that the climate tax on waste incineration can more easily affect the treatment on waste from households, if source separation is replaced by separation after collection of mixed waste. The likelihood of this happening is different in different future scenarios (Dreborg & Tyskeng 2008):

- the system of source separation is more likely to be abandoned in scenarios with little political control in environmental issues: Scenario 2 (Global markets) and Scenario 3 (Regional markets);
- separation of materials from mixed waste streams is more likely to be introduced in scenarios where raw material prices are high: particularly Scenarios 2 but also Scenario 3; and
- separation of plastics for recycling from flows of mixed waste requires further technological development, which makes it more likely in scenarios with rapid technological development: Scenario 1 (Global sustainability) and Scenario 2.

These factors all indicate that the climate tax is more likely to be effective in Scenario 2. The difference is difficult to quantify. A fairly realistic but perhaps still optimistic estimate is that the climate tax reduces the incineration of plastic waste from households by 8 percent. This is the effect obtained in the model of

Sahlin et al. (2007) when the resistance of households to increasing source separation is excluded from the calculations.

From the results we also expect the effect on commercial waste to be similar in all scenarios.

4.1.4 Fossil tax in producer responsibility

A more direct effect on the recycling of waste plastics could perhaps be obtained if the extended producer responsibility is adjusted to include a tax on the fossil carbon in the producer-responsibility material that is not recycled but incinerated. This would give the producers a direct economic incentive to stimulate increased source separation and recycling. The producers do not decide on what is source-separated in the households, but they have already the responsibility to see to it that producer-responsibility materials are recycled to an extent stipulated by the SEPA. An additional economic incentive would perhaps stimulate an effort to reach an even higher recycling rate for waste plastics, for example by adding more bring stations and extend kerbside collection of recyclable materials.

4.2 Raw material tax

4.2.1 Description of policy instrument

Bisaillon et al. (2009) describes this policy instrument as a package with two components:

- A 10 SEK/tonne tax on non-renewable materials (excluding fossil raw materials and plastics) extracted or imported and then used in Sweden.
- A tax on all fossil raw materials similar to the one currently applied on household heating oil (3804 SEK /m^3) and an associated 5000 SEK/tonne tax on imported plastics.

The tax is paid for material that ends up in Sweden only; material exported from Sweden is tax-exempt.

4.2.2 Impact of the tax as described

The raw material tax is paid by Swedish material producers and importers. The largest revenue from the raw material tax would probably come from the mine industry. The quantity of mineral waste from the mining industry was 62 Mtonne in the year 2006 (SEPA 2008). This corresponds to a tax revenue of 620 MSEK. In addition, the mining industry would pay tax for the share of their products that are used in Sweden; however, most of these products are exported and, hence, exempt from tax.

A large share of the mine tailings are generated by Boliden, which produces copper and other metals. They extracted just over 30 Mtonne ore in Swedish mines in 2010 (Boliden 2011). In addition, Boliden extracts 29.3 Mtonne waste rock. From the Swedish ore, they produced 126 ktonne zinc, and 67 ktonne copper in 2010, and smaller quantities of other metals. They generated a profit of approximately 5 billion SEK from a sales revenue of 37 billion SEK (Boliden 2011). With the raw material tax they would have paid approximately 0.6 billion SEK [10*60=600 MSEK]. This is a large sum of money, but it is still less than 2 percent of the turnover and just slightly more than 10 percent of the profit in 2010.

The other large mining company in Sweden is LKAB. In the year 2010, they extracted 44 Mtonne iron ore and waste rock (SGU 2011). They produced 26 Mtonne iron ore products, most of which have an iron content of 66 percent. Most of the products (21 Mtonne) was also exported. This was a record year for the company: they generated a profit before tax of more than 12 billion SEK from a turnover of 28.5 billion

SEK (LKAB 2011). With the raw material tax they would have paid 0.23 billion SEK [10*(44-21)=230 MSEK]. This is also a large sum of money but it would hardly have made a dent in the profit.

The year 2009 was much tougher for LKAB: they generated a profit of just 0.6 billion SEK before financial profit and before tax. The turnover was 11.6 billion SEK, and the extracted quantity of iron ore was 27.4 Mtonne. Assuming half of this quantity was exported as iron ore products (cf. 2010), the material tax would have been 0.3 billion SEK, which corresponds to half the profit. While 2009 was the toughest year, by far, since 2003, LKAB made even less profit in 2000-2002 (LKAB 2011).

Running the general equilibrium model EMEC, Forsfält (2011) found that the raw material tax would reduce the production by 4-4.5 percent in the Swedish non-iron metals industry and by 1-1.5 percent in the iron and steel industry. These results are consistent with the data above that indicate that the tax could make it more difficult for the mining companies to compete on an international market, particularly in tough years, and particularly for Boliden where nearly all of the extracted rock and ore ends up as waste. The tax might increase the cost of producing metals in Sweden by 25 SEK/tonne for virgin iron and steel [435/(26*0.66)=25 SEK/tonne], and by several thousand SEK per tonne of virgin metal from Boliden [675/(0.126+0.067)=3500 SEK/tonne]. This would probably not affect the world market prices for these metals, since the Swedish mining companies have a small share of the global market (Boliden 2011, LKAB 2011), but it would affect the profitability of Boliden and LKAB. When the mining have low profitability, the recent history of LKAB indicates that the mining activity decreases rapidly.

Since more than half of the waste from the mining industry seems to stem from the extraction of non-iron metals, the EMEC results on the mining production indicates that the quantity of waste from the mining industry would be reduced by 3-3.5 percent if the tax is introduced.

The price of materials and products that are used in Sweden would increase by approximately 10 SEK/tonne, since this is the increase in cost of importing the goods from the international markets. A raise by 10 SEK/tonne is a very small change in the price of nearly all products, and the EMEC results also indicate that the overall Swedish economy would not be affected by this part of the raw material tax. The effect on the waste quantities is also quite small in EMEC (Forsfält 2011), which does not include the mine tailings.

The effect that can be expected from a raise in price by 10 SEK/tonne is in the production and use of materials with a very low initial price per tonne. This could be heavy bulk materials that are easy to extract and used with no or little refinement: *sand*, *gravel*, and perhaps *concrete*. Sweden currently has a 10 SEK/tonne tax on natural gravel. This tax might have shifted the use somewhat from natural gravel to crushed rock, but the effect is not clearly distinguished in the statistics (Bisaillon et al. 2009).

The suggested raw material tax on *fossil raw materials* and imported *plastics* is much greater: 3804 SEK per m^3 of oil and 5000 SEK per tonne of plastics, respectively. Since EMEC does not distinguish the production and use of plastics from other chemical products, Forsfält (2011) models this tax as a 10-30 percent increase in the tax on chemical products in general. The revenues generated by this tax is in the model distributed to the households through increased transfer systems. Forsfält concludes that this tax and transfer increase affects the production in most economic sectors in the model. The policy instrument reduces the quantities of metal, mineral, and mixed waste, but increases the quantities of household and combustion waste. The effect on the total waste quantity is rather small in the model: the 30 percent tax reduces total waste quantity by less than 60 ktonne/year and no more than 0.2 percent of the total waste generated in any future scenario (Forsfält 2011).

Much of the chemicals industry use oil and natural gas as raw materials. With the raw material tax, the Swedish production of chemicals based on oil and natural gas will be more expensive. Hence, an effect similar to that modeled in EMEC are reasonable to expect. However, from a stakeholder perspective, other effects can also be expected:

First, it seems obvious that the tax on plastics will give Swedish industries that use plastics as raw material an economic incentive to reduce the material losses in the production processes, and also to use less plastics in products that are to be sold on the Swedish market. The quantity of plastics can be reduced through making the products more material-lean and/or through replacing plastics by other materials. All of these effects will reduce the quantity of plastic waste generated in Sweden.

Second, Swedish chemical producers will also get an incentive to use renewable or recycled raw materials in their production. The chemical industry in Stenungsund already has a vision to use only renewable raw materials in the year 2030. This vision has been called bold (SR 2010). With the raw material tax, the share of renewable raw materials might be greater and the chance of the vision coming true will also be greater. This would not affect the quantity of plastic waste, but will reduce the use of fossil resources and reduce of fossil carbon dioxide from waste incineration.

Third, the production of ore-based metals in Sweden would be affected if the coke used as reduction agent in the furnaces is included in the scope of the tax. In 2010. the steel-producer SSAB (2011) used 440 kg coal and coke for each tonne of steel produced, and 53 percent of the steel was ore-based. If the raw material tax for coal and coke is the same as for plastics (5 SEK/kg), the tax would increase the cost of ore-based steel production in Sweden by approximately 4000 SEK/tonne [5*440/0.53 = 4150 SEK/tonne]. Since SSAB produced more than 3 Mtonne of steel in 2010, they would pay over 12 billion SEK in raw material tax. This corresponds to more than half the sales value of the steel in that year. If the raw material tax is applied to coal and coke, this would seriously affect the competitiveness of Swedish ore-based steel production. The production of ore-based steel in Sweden is likely to be reduced or even eliminated.

The tax will affect the competitiveness of the production of other metals, but this effect will be less significant, because of the greater sales value per kg of metal. Boliden (2011) used approximately 1.8 TJ of coal and coke in the year 2010. With an energy content of 30 MJ/kg, the raw material tax for the coal and coke would be 0.3 billion SEK [$5*1.8*10^9/30 = 3*10^8$ SEK].

The competitiveness of the Swedish chemicals industry is also likely to be affected to the extent that fossil raw materials are used in the production process. The loss in competitiveness will be small for the Swedish producers of plastics for domestic use, however, because on the domestic market the Swedish plastic producers compete with imported plastics that also carry the raw material tax.

The consumer patterns of households and other end-consumers are likely not to be significantly affected by this tax. An increase in the cost of material means less to the price of the product the more it is refined, transported and retailed.

4.2.3 Raw material tax adjusted for competitiveness

As demonstrated in the previous section, the raw material tax presented by Bisaillon et al. (2009) will affect the competitiveness of Swedish mining industry and of the chemicals industry beyond plastics production. If applied on coal and coke used as reducing agents, it might eliminate Swedish ore-based steel production and also affect the production of other ore-based metals.

However, the tax can be adjusted with the aim not to affect competitiveness of the Swedish industry compared to the international market. The two parts of the policy instrument would then be as follows:

- A 10 SEK/tonne tax on non-renewable materials (excluding fossil raw materials and plastics) extracted for use in Sweden.
- A tax on all fossil raw materials used to produce goods used in Sweden, similar to the one currently applied on household heating oil (3804 SEK /m^3).

The tax would be paid by producers and importers of materials and other goods. The tax would be returned to exporters of goods from Sweden.

This policy instrument is significantly more difficult to administrate since it requires an estimate of the quantity of fossil and other non-renewable raw materials needed to produce each imported and exported product. However, in terms of complexity it seems not to be more demanding than the French requirement for a life-cycle based Environmental Product Declaration on all high-volume consumer products (Schenk 2009). Like the French requirement, it could be applied on high-volume goods only. When the origin of the materials in the imported products is unknown, a default value representing the global average production of these materials can be used. If, for example, the recycled content in imported products is unknown, the tax can be based on the global average of recycled and virgin production in the products.

The export industry is not likely to be affected by the adjusted raw material tax. They will pay a tax for materials extracted and imported, but they will get the same amount of money back when the products are exported.

The final use of materials and products in Sweden will be more expensive, however, regardless of whether the materials are produced in Sweden or abroad. The increase in price will be greater than with the tax presented by Bisaillon et al. (2009) because imported goods will not only carry the tax per kg of material in the product but also the tax of the estimated quantity of raw materials that was used for producing the product. This should give Swedish industry producing for the domestic market a greater incentive to use the material more efficiently, which would result in reduced quantities of production as well as post-consumer waste.

This effect is still likely to be the greatest for the industries that used fossil raw materials or plastics as raw materials. With a raw material tax corresponding to 3804 SEK per m^3 oil, they should get a significant economic incentive to use less of these raw materials by making the processes and products more efficient. This is likely to result in less plastic waste and in less chemical waste. The chemicals industry producing for the Swedish market will also get an incentive to use renewable or recycled raw materials.

It should be noted that the adjusted tax will still affect competitiveness on the Swedish market, but this will go both ways: Swedish materials produced from non-renewable natural resources will be less competitive compared to imported materials with unknown origin. Swedish materials produced from recycled raw materials will, on the other hand, be more competitive on the Swedish market. Imported products and materials will also get a competitive edge if they can be demonstrated to be based on recycled or renewable raw materials.

These effect on the economic competitiveness is likely to channel recycled plastics and renewable substitutes to fossil raw materials to the part of the Swedish industry that produces mainly for the domestic market. Creating a niche market for recycled plastics and renewable substitutes might stimulate technological and business development in this area and eventually help making the global market more established.

The effect on the extraction and use of non-renewable materials other than fossil fuel is still likely to be small. As discussed above, the tax of 10 SEK/tonne will hardly be noticed except for on the production and use of heavy bulk materials with a very low initial price. Such materials are unlikely to be imported, because of the transportation costs. The increase in cost for these materials is likely to be just 10 SEK/tonne also with the adjusted tax.

Since the adjusted tax have little impact on the export industry it might be possible to make it significantly higher than 10 SEK/tonne for more materials than fossil raw materials and plastics. The raw material tax could, perhaps, be defined as a 100 percent tax on raw materials production. This would double the cost of using raw materials in Sweden and give the industry (in Sweden and abroad) more of an economic incentive to be material-efficient when producing for the Swedish market.

The households and other end-consumers are still likely not to be significantly affected by the adjusted tax, because an increase in the cost of material still means less to the price of the product the more it is refined, transported and retailed.

4.3 Weight-based waste collection fee

4.3.1 Description of policy instrument

Bisaillon et al. (2009) proposes to assess a waste collection fee for households with a fixed part (850 SEK/household and year) and a variable part (2.12 SEK/kg residual waste).

4.3.2 Impact in Reference scenario

Based on observations by Dahlén & Lagerkvist (2008), Bisaillon et al. (2009) assumes that the weight-based collection fee will reduce the quantity of unsorted household waste by 20 percent in municipalities where it is introduced. They propose to calculate with three extreme scenarios on the reasons for this reduction:

A. Prevention of waste with the same composition as the average residual waste.
B. Increase in source separation, home composting and materials recycling.
C. Illegal treatment: burning of combustable waste in private stoves etc., and dumping of food and garden waste in the forest.

The stakeholders directly affected by a change in the waste-collection fee are house owners. Most *single-family houses* are owned by the people that live in the house and generate and source-separate the waste. They are in direct control over the quantity of residual waste in the house. A weight-based waste fee will, in theory give these households an economic incentive to reduce the weight of the residual waste by any means: waste prevention, increased source separation, illegal or irregular management. In practice, it is not clear if this economic incentive is significant.

In an ongoing study on the effects of a weight-based fee, IVL Swedish Environmental Research Institute made 21 interviews with residents in Askim, a wealthy suburb in Gothenburg where such a fee has been introduced. While the quantities of residual waste had been significantly or even drastically reduced in these households, the residents did not identify the weight-based fee as the main cause of this change. It is reasonable to believe that this is because the waste fee is too small to rationally affect the behaviour in wealthy households. This could also be expected in many other, albeight not all, owners of single-family houses, because they have more than average spending capacity. The disposable income of households

owning their residence is on average nearly 50 percent greater than households living in condominium and double the disposable income in households renting a residence. When the cost of housing has been paid, the difference is even greater (SCB 2011b).

A hypothesis based on the interviews in Askim is that the reduction in residual waste quantities is mainly a result of the information distributed to the households as the weight-based fee was introduced and/or the feedback given to the households on a regular basis at the invoices for waste collection. When the information is distributed as a change in the fee is introduced, the residents are likely to be motivated to read and absorb it. The absorbed information is likely to raise the attention of the house-owners to the waste management issues. Feedback on a regular basis can assist in keeping this attention. Being more attentive should make owners of single-family houses adjust their waste management, particularly if they have an initial interest in environment, resources, and/or household economy. If the driver for the adjustment is an interest in environment and resources, the effect should be increased source separation and, possibly, waste prevention. This is consistent with results from the Askim study. If the driver is an interest in household economy, the change in waste management can also include illegal or irregular management. Such an effect was not confirmed in the Askim study, but if it exist it would be difficult to detect through interviews.

On the other hand, if the weight-based fee did not give a noticeable economic incentive, the quantity of waste should only be affected by the introduction of a weight-based fee, not by the magnitude of this fee. Dijkgraaf & Gradus (2003), comparing the waste quantities in all Dutch municipalities, found that municipalities with a higher weight-based fee had lower total waste quantity and more source separation, compared to municipalities with a lower weight-based fee. The price elasticity for residual solid waste was estimated to be -0.69, which means that a 10 percent increase in the variable part of the fee will reduce the quantity of residual waste by 6.9percent.

There are significant possible sources of error in the Askim study as well as in the estimates of Dijkgraaf & Gradus (2003). The residents in Askim might have been influenced by an economic incentive without being aware of it, without being willing or able to communicate it in the interview, or without the interviewer understanding. The statistics indicating a significant price elasticity in Dutch municipalities might have other explanations. It might be a random effect because only 13 municipalities had a weight-based fee at that time. Residents in municipalities with a high weight-based fee might also have a high degree of environmental awareness, which will reduce the waste quantity even without any difference in the waste-collection fee (cf. Dijkgraaf & Gradus 2008).

If the effect of the economic incentive is uncertain in single-family buildings, it is clear that the weight-based fee currently gives little economic incentive to residents in *apartment houses*. The fee is paid by the owners of the house and the cost might then be distributed among the tenants. Each single household can do very little about how much they are charged for the waste collection. The owners of the house, on the other hand, get an economic incentive to reduce the quantity of residual waste by the means available, particularly if the rent cannot be easily raised. Irregular or illegal waste treatment can increase if this can be done with little risk to the house owners. In other cases, the fee mainly gives owners of apartment houses an incentive to improve the system for storage and collection of separated waste, making source separation easier for the residents. They might install equipment for composting. They can also post information on the waste flows and the cost of waste collection in an attempt to stimulate a collective responsibility for keeping this cost down among the residents. The weight-based fee will still give little economic incentive to tenants to reduce the quantity of residual waste, but it might indirectly improve their waste management if the house-owners decide to make source separation easier and/or raise the attention of the tenants to the waste quantities and waste management.

In the future, technological development might allow for weighting of the residual waste also from individual households in apartment house. To throw a garbage bag in an apartment building, the resident could, for example, be required to open a hatch with a code or key card specific for that household. A scale could be placed behind the hatch to weigh the garbage before it is mixed with the waste from other households. Such a solution might already have been tried and until the year 2030 it could be delevoped to be more efficient and affordable.
This policy instrument can also have indirect effects amoung neighbours in a way similar to the owners of single-family houses. A change in behaviour and, particularly, in the equipment in one household can be observed by neighours, adding to their attention to waste-management issues and reducing their threshold for action, making it more likely that they will do a similar change (see Figure 3).

On the other hand, the policy instrument might be counteractive in some cases. A weight-based fee gives the households a possibility to buy the right to generate a lot of waste. In cases where the large quantity of waste is a source of bad conscience in the household, the fee might reduce the bad conscience and reduce efforts to reduce the waste quantity.

All in all, the results of Dahlén & Lagerkvist (2008) indicate that the introduction of a weight-based fee has a significant effect on the quantity of residual waste. Similar results have been presented by others (e.g., Dijkgraaf & Gradus 2003, Constantino 2008). In the Askim study, the quantity of residual waste was reduced by approximately 60 percent in some households as the weight-based tax was introduced, although it cannot be confirmed that all of this reduction was because of the weight-based fee. Some investigations indicate that the effect is temporary only. If the main incentive for the change is an increased attention to waste-management issues, this can be explained by the fact that, over time, other things will require the attention of the households.

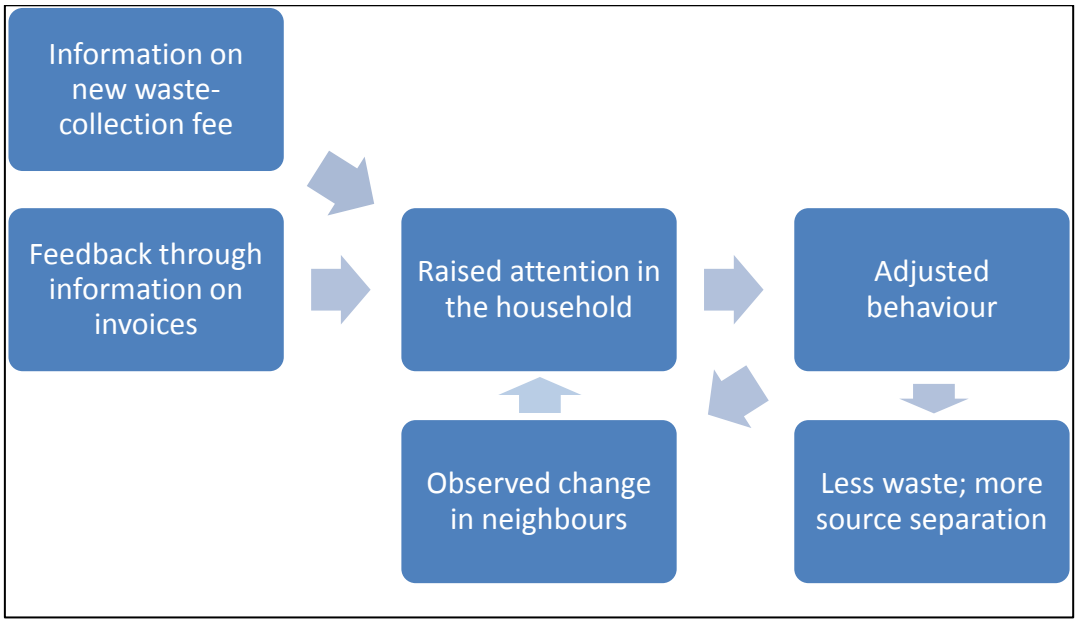

Figure 3: Indicated effects of information on the introduction of weight-based waste-collection fee.

4.3.3 Impact in other scenarios

The weight-based waste collection fee can take effect through two routes:

- an economic incentive to reduce the quantity of residual waste though prevention, recycling, or irregular or illegal waste treatment, and
- raised attention to waste-management issues that, at least temporarily, can result in waste prevention and increased recycling.

In future scenarios with a high degree of environmental awareness (Scenario 1 Global sustainability and Scenario 4 European sustainability; Dreborg & Tyskeng 2008), the effect is more likely to be driven by an initial interest in the environment and natural resources. Raising the attention to waste-management issues can then be expected to improve the waste-management of the households.

The economic incentive is likely to be more important in scenarios where the focus of house-owners is more on economic issues: Scenario 2 Global markets, and Scenario 3 Regional markets. If the policy instrument is introduced in these scenarios, it is more important to have a control system in place to combat the illegal waste treatment that may result from the introduction of the weight-based fee.

Further technological development is required for the weight-based waste fee to be directly applied to households in apartment buildings. Such development is more likely to occur in scenarios with a high rate of technological development (Scenario 1 Global sustainability and Scenario 2 Global markets). It is also more likely to occur in scenarios where environmentally adapted technological development can get economic support and/or expect a good market. Hence, this technological development is most likely to occur in Scenario 1 Global sustainability, where the technological development is rapid thanks to the continued globalization and where the political governance is strong towards environmental and resource efficiency (Dreborg & Tyskeng 2008). It is the least likely to occur in Scenario 3 Regional markets, where none of these factors are present.

5 Discussion and conclusions

This analysis highlights the insight that a policy instrument, to be effective, should give the right incentives to the correct stakeholders, i.e. stakeholders that have control over that which the policy instrument is intended to affect. The policy instrument can create such incentives if it is designed to affect the correct stakeholders directly. A policy instrument (for example a waste incineration tax) can also give incentives indirectly by making a third-party stakeholder (in this case the waste incinerators) create a correct incentive to the stakeholder in control (households and companies). The effect of such indirect incentives are more difficult to predict and there is a risk that the effect is weakened because more transfer costs etc. will be involved.

For a policy instrument to be effective, there must also be sufficient barriers to unwanted side-effects. Otherwise, a policy instrument that makes waste management significantly more expensive or difficult might result in illegal or irregular waste treatment and/or in creative definitions of words such as waste, recycling, and re-use.

In some cases, a policy instrument can be effective not by giving an incentive but by eliminating or reducing barriers to good actions. This is when the right incentives already exist. An example could be a requirement to provide kerbside collection of recyclable materials to all households in apartment buildings. This reduce the effort required to transport source-separated material from these households, thereby reducing the barrier to source separation and, probably, increasing the level of recycling.

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