LCA SCREENING OF

WASTE TREATMENT OPTIONS




for South Western Iceland

Lars Bodelius
Ulf Liljenroth
Anders Blomdahl
2008-12-12

Table of content

All photos in the report taken by the authors.

1 Summary

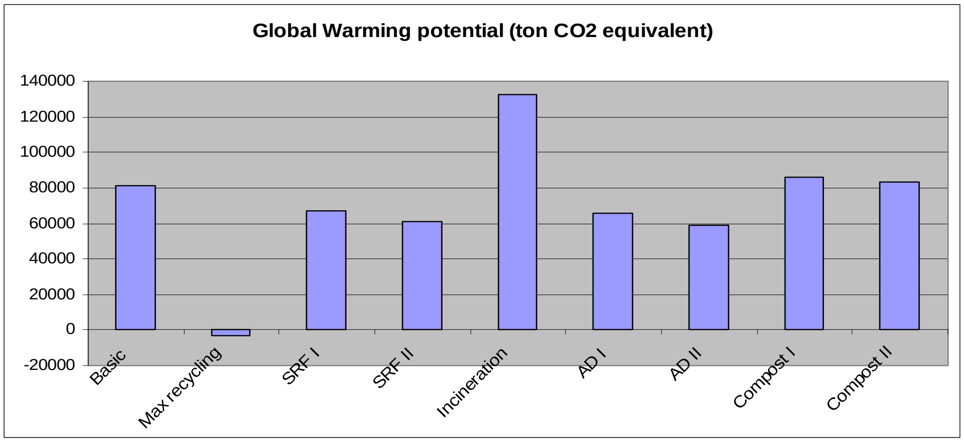
The purpose with this study is to serve as a help for future decisions concerning waste treatment options in southwestern Iceland (covering 34 of totally 79 municipalities and about 81 % of the Icelandic inhabitants). The scope of the task was to assess the environmental impact of specified treatment options with in the first place municipal waste and other waste categories similar to the municipal waste and in the second place other applicable waste categories. The work is performed with a LCA Screening method – which is a modern decision-making tool that makes it possible to consider the great amount of parameters necessary when waste and different waste treatment methods are involved. The waste treatment options have been analyzed in following scenarios, simulating a future waste treatment situation:

- Basic scenario (waste treatment similar to situation in 2008)
- Maximum recycling scenario
- Scenario focused on incineration
- Scenario focused on production of SRF (Solid Recovered Fuel)
- Scenario focused on anaerobic digestion (production of biogas)
- Scenario focused on composting

The study indicates that environmental impact categories of highest significance concerning waste treatment in Iceland are (1) Global warming (GW) and (2) Use of land.

Global warming

The results of the LCA analysis concerning Global Warming are summarized in the diagram below. The most appropriate scenario is the maximum recycling scenario. The most appropriate waste treatment method from a GW point of view will be anaerobic digestion and SRF production. The alternative scenarios I and II for different treatment methods displays result from plants with different capacities.



Transports of waste for anaerobic digestion treatment

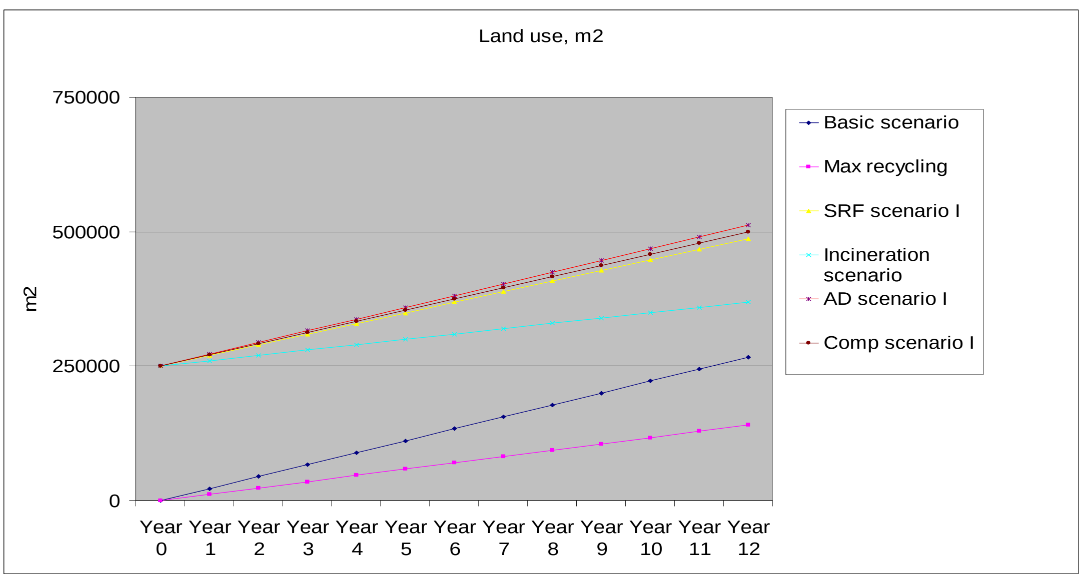
The environmental effect of transportation compared with the environmental credits performed with production of biogas was also studied.

If all potential biogas from one ton of waste is used to replace petrol in vehicles the total reduction of fossil CO_2 emissions will be leveled with CO_2 emissions from transports at a distance of a minimum of 1600 km. The distance is based on the most pessimistic assumption with use of waste collection trucks running on fossil based fuel. If the fossil based fuel is partly replaced by CH_4 the distance will be even further.

The result shows that it can be supportable - from a Global warming aspect - to have one large anaerobic digestion plant in Iceland, instead of several small plants.

Land use

The Land-use analysis (diagram below) shows that the scenario focusing on maximum recycling will result in the least land use and secondly the basic scenario (i. e. waste treatment similar to situation in 2008). After about 20 years practice the incineration scenario will however be in favor, compared with the basic scenario.



2 Introduction

In southwestern Iceland - covering 34 of totally 79 municipalities and about 81% of the Icelandic inhabitants - several waste treatment methods were evaluated during 2006 and 2007 from technical and cost point of view. All the recommended methods are regarded as “best available technology”. The different treatment methods, different plant sizes and various possible sites were used in a cost optimization model to calculate the most cost effective solution for the area as a whole. This has resulted in a common action plan for the four waste companies based on the following premises:

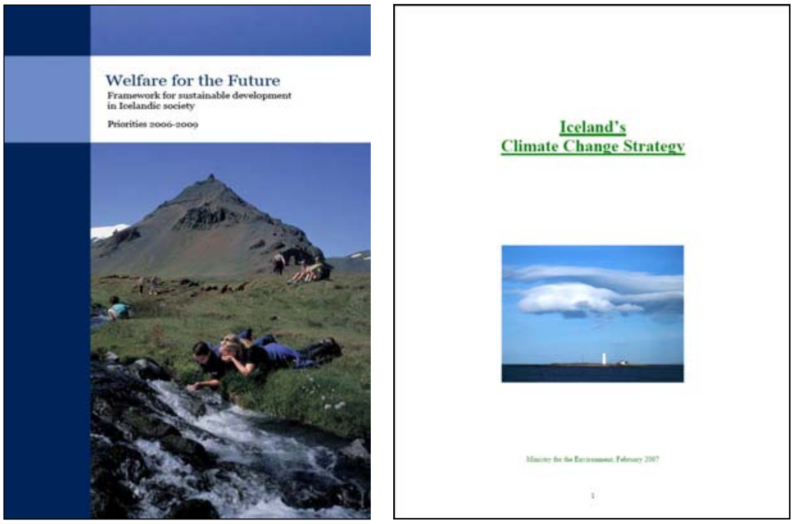
- All landfilling of organic and combustible waste will be terminated no later than 2020
- The hierarchy of waste treatment has been set forth based on the European waste hierarchy
- The available landfill sites for the next 12 years are clear
- Milestones for the next three years have been set

As a supplement study to this cost efficiency study an environmental impact assessment was regarded as necessary. In this study a simplified LCA, often known as screening LCA, has been used. This type of LCA will try to reduce data collection as much as possible and thus the total effort. As a starting point an introductory screening is performed aimed at identifying the most important environmental impacts throughout the process being studied.

Provided all upstream and downstream impacts are equal, the life cycle of waste starts when products/waste have been collected and ends when the waste material is degraded or brought back to the technological system through recycling and replaces other products. Hence, LCA in the waste management sector can be applied in order to compare the environmental performance of alternative waste treatment systems and identify areas for improvement.

However it is important to make some reservations regarding further implication of results of the LCA screening method outside the actual case. The results of this study are highly site-dependent and dependent on many assumptions and choices being made throughout the process.

3 Environmental strategies in Iceland



Picture 1: *The two environmental strategies Welfare for the future and Iceland's Climate Change Strategy*

In Iceland, the government has put environmental goals into practice through general policy formulation. In 1997, the government approved an extensive implementation plan, "*Sustainable development in Icelandic society, an implementation plan through the end of the century*", which was an attempt to introduce the viewpoint of sustainable development into the main industries and parts of society.

The Icelandic Ministry for the Environment formulates and enforces the Icelandic government policies for environmental affairs. Two such policies are possible to implement in the waste treatment management;

- Welfare for the Future – Framework for sustainable development in Icelandic society (Priorities 2006-2009)
- Iceland's Climate Change Strategy (admitted in February 2007)

3.1 Strategy for sustainable development

The Icelandic Government's strategy for sustainable development; "*Welfare for the Future – Framework for sustainable development in Icelandic society. Priorities 2006-2009*" states among others the following objectives;

- To ensure that Iceland's inhabitants breathe clean air, with air pollution levels below the strictest levels in the European Economic Area.
- To minimize air pollution caused by traffic, industry and other activities.

- To reduce air pollution in the greater Reykjavik area with the aim of significant improvement in the next few years.
- All inhabitants of the country should have access to abundant clean water unpolluted by chemicals and micro-organisms, for drinking and other uses.
- Pollution of rivers and lakes should be non-existent or so miniscule that it does not affect freshwater ecosystems, fish migration or the recreational value of an area.
- The use of chemicals and chemical products should not threaten the environment or human health.
- The disposal of materials hazardous to health and the environment should be limited as much as possible, and cease completely within 25 years.
- The diversity of species and habitat types should be conserved
- The diversity of geological formations should be conserved by protecting those formations that are distinct or unique regionally, nationally or globally.
- Large areas of wilderness should remain untouched in uninhabited areas of Iceland.
- Man-made structures should preferably be built outside of defined wilderness areas. When this is not deemed possible, care should be taken that the structures cause minimal damage and minimal visual effect.
- Waste generation should be reduced as much as possible and the handling of waste should cause minimal negative impact on the environment. It should be ensured that hazardous waste does not find their way into the environment.
- Current and future legislated targets for the recycling of different kinds of waste, including packaging, organic waste, electronic devices and equipment, should be met. Disposal expenses should be taken into account in the pricing of goods.
- Iceland should continue to show leadership in international cooperation on marine pollution prevention.
- Iceland should participate actively in international cooperation to combat dangerous disturbance of the earth’s climate by human activity through reduction of emissions and increased sequestration of greenhouse gases.
- The use of fossil fuels should be decreased.
- Efforts should be made to conserve the biodiversity of Icelandic habitat types and ecosystems by the protection of animals, plants and other organisms, together with their genetic resources and their habitats.
- All utilization of living natural resources should be sustainable.

3.2 Climate change strategy

The Iceland's Climate Change Strategy is the third strategy that the Icelandic government has adopted with respect to climate change issues. It is conceived as a framework for action and government involvement in climate change issues and will be reviewed regularly. The Strategy sets forth a long-term vision for the reduction of net emissions of greenhouse gases by 50-75% until the year 2050, using 1990 emissions figures as a baseline.

The Strategy sets forth the Icelandic government's five principal objectives with respect to climate change, which aim toward the realization of the above-described long-term vision:

- The Icelandic government will fulfill its international obligations according to the UN Framework Convention on Climate Change and the Kyoto Protocol.
- Greenhouse gas emissions will be reduced, with a special emphasis on reducing the use of fossil fuels in favor of renewable energy sources and climate-friendly fuels.
- The government will attempt to increase carbon sequestration from the atmosphere through afforestation, revegetation, wetland reclamation, and changed land use.
- The government will foster research and innovation in fields related to climate change affairs and will promote the exportation of Icelandic expertise in fields related to renewable energy and climate-friendly technology.
- The government will prepare for adaptation to climate change.

Waste handling is treated in the appendix; Climate Strategy and its implementation, with the following strategies:

- SORPA collects biomethane at the landfill in Álfsnes. It is estimated that the gas collected there would suffice for 4,000 – 6,000 biomethane-powered automobiles per year. Today there are only around 50 biomethane vehicles in Iceland, so the remainder of the biomethane is used for electricity production. These measures therefore reduce emissions by 30,000 CO_2 equivalents per year.
- A national plan for the handling of waste has been approved and launched. The aim is to reduce the burial of organic waste, which will result in a reduction in methane emissions.

4 Definition of impact categories

Picture 2: *Gullfoss, a good example of the unique and valuable nature in Iceland.*

Different waste treatment methods affects the environment in different ways regarding abiotic resources, global warming, toxicity, ground-level ozone, acidification and eutrophication. A general definition of the different waste impact categories will be summarized below, and the specific effect in Iceland from the different impact categories will be further discussed in chapter 8 below.

4.1 Depletion of abiotic resources

The term resource can include a wide range of different components of the environment, such as raw materials, energy sources, areas for recreation, wildlife and scenery (biodiversity), as well as essential life support system for humans. Resources are categorized as renewable or non-renewable and abiotic resources are almost always resources that are extracted from finite reserves.

The concept of biodiversity includes all the variety exhibited by living things, including the variation between species, the genetic variation within species and the diversity of natural habitats. It is important that the biological diversity will be preserved and used sustainable. All species, habitats and ecosystems must be safeguarded and humans must have access to a good natural environment rich in biological diversity.

Waste can be a resource, and it is important to use this resource to reduce the exploitation of natural resources. Under the EU waste strategy we must firstly minimize the generation of waste and secondly, if possible, reuse the waste we generate. Treating waste as a resource also reduces greenhouse gas emissions as well as the need for landfilling. Land-use for landfills, energy plants and others may contribute to the depletion of abiotic resources.

4.1.1 Status in Iceland

Iceland has some of the few remaining large wilderness areas in Europe, and their natural features are in many ways unique. The nature is valuable and conservation of the environment is a high priority for Iceland, as the country's economy and society are dependent on their natural resources and their sustainable management. Development pressures on wilderness areas are increasing, which calls for improved planning and nature conservation. One of the most serious environmental problems in Iceland is the loss of vegetation by wind erosion.

According to the strategy for sustainable development, Welfare for the Future, should efforts be made to conserve the biodiversity of Icelandic habitat types and ecosystems by the protection of animals, plants and other organisms, together with their genetic resources and their habitats.

4.2 Global warming

The increased volumes of greenhouse gases are believed to be the primary sources of the global warming that has occurred over the past 50 years. The greenhouse effect is an increase in the temperature of a planet, as heat energy from sunlight is trapped by the gaseous atmosphere. The increase in concentration of greenhouse gases such as carbon dioxide, methane and nitrous oxide increase this global warming effect.

Scientists from the Intergovernmental Panel on Climate carrying out global warming research have recently predicted that average global temperatures could increase between 1.4 and 5.8 °C by the year 2100. Changes resulting from global warming may include rising sea levels due to the warmer water, melting of the polar ice caps, melting glaciers, as well as an increase in occurrence and severity of storms and other severe weather events.

Carbon dioxide and nitrous oxide is, for example, emitted by the use of fossil fuels, transports and incinerations, while methane is released from landfill sites and composting facilities.

4.2.1 Status in Iceland

The global warming effects on Iceland, together with subsequent changes in precipitation, sea level and storm frequency, is likely to have severe effects on both the natural environment and human societies. During the past years, researchers have concluded that Iceland has seen a rise in average summer temperatures since the early 1980s.

A report from the Icelandic government's Committee on Climate Change warns that by the next century, Iceland's glaciers will have all but disappeared, adding to the threat of catastrophic sea level rise. For example, Breidamerkurjökull's massive snout ends close to the ocean. In its hasty retreat, the glacier has left the rapidly expanding lagoon, which is filled with icebergs calved from its front. The lagoon has nearly doubled its size during the past decade. Every year, it grows larger.

The Gulf Stream brings warmth to Iceland from southern waters. The increased heat in the northern hemisphere can increase the melting of Greenland’s glaciers. Scientific research shows it could have devastating effects on the area if the melting becomes too much. The melting of the glaciers in Greenland could prevent deep water currents from reaching Iceland’s shores.

A large amount of emissions of carbon dioxides in Iceland comes from transports, as Iceland has more emissions of carbon dioxides/kilometer than any country in the EU, over 200 g CO_2/km (Sweden, on second place, has about 195 g CO_2/km).

4.3 Toxicity

Toxic organic pollutants (DDT, PCB:s, pesticides, solvents, dioxins and similar) and heavy metals (mercury, cadmium and lead) are harmful to plants, animals and humans. They tend to accumulate in living organisms and can reach harmful levels, particularly in species at the top of food chains. The poisons are concentrated in fat and stored in vital organs, and remain there for a very long time, in the animal that has eaten poisoned prey. Top predator are exposed to high levels of such pollutants through their food.

Toxic pollutants has a capacity to transport long distances in the nature. A wide range of persistent organic pollutants and man-made persistent substances are making their way to and are being concentrated in the Arctic. For example has flame retardants been found on Polar Bears in the Arctic.

The primary damage caused by the organic pollutants is to disrupt neurological function. In addition to being neurotoxic, these compounds are profoundly immunotoxic and are often toxic to the endocrine system as well. Heavy metals are associated with many adverse health effects, including allergic reactions, neurotoxicity, nephrotoxicity and cancer.

Toxic pollutants are emitted by the use of chemicals and heavy metals in industries, industrial by-products which come from waste incineration, pesticides and hazardous waste. Landfills are another source of many chemical substances entering the soil environment and groundwater.

4.3.1 Status in Iceland

The problem with toxic pollutants are considered as high in Iceland as on any other place in the world. Their capacity to transport long distances makes them cause severe problems even far away from the pollutant. In Iceland, species like

Seals, Killer Whale, Polar Fox, Gyrfalcon and White-tailed Eagle are likely to be affected.

4.4 Photo-oxidant formation (ground-level ozone)

Ground-level ozone is formed by reactions between nitrogen oxides (NO_x) and volatile organic compounds (VOC), in the presence of heat and sunlight.

Ground-level ozone is harmful to the biotic. It is an air pollutant that damages human health and vegetation and it is a key ingredient of urban smog. It causes a variety of health problems, including asthma, reduced lung capacity, and increased susceptibility to respiratory illnesses like pneumonia and bronchitis. Ground-level ozone also damages the foliage of crops, trees and other plants.

Emissions of NO_x are produced primarily when fossil fuels are used in vehicles, power plants and industrial boilers. There are a lot of different sources of VOC emissions, including emissions from transports, chemical solvents and consumer products like paints. Methane released from landfill sites and composting facilities are sources of VOC-emissions.

4.4.1 Status in Iceland

There are a high number of cars and many large cars such as SUV:s and other four-wheel-drives in Iceland, compared to the number of inhabitants. They are causing air pollutions mainly in the Reykjavik area. In the Welfare for the Future there are strategies issued in reducing the air pollution in the greater Reykjavik area. The pollutions from transports may increase the formation of ground-level ozone. But as the reaction needs heat (most ozone is formed with temperatures over 20°C) and sunshine to be completed, is that considered to be a reduced factor in the formation of ground-level ozone in Iceland.

The emissions from industries and power plants can be considered as negligible, as the number of industries in Iceland is low and most of the energy is produced from geothermal power or hydro power plants. Very little energy is produced with fossil fuels - only 0,1% in 2006.

4.5 Acidification

Picture 3: *A natural source for sulfur emissions.*

The main source of acidification is emissions of sulfur from the combustion of fossil fuels like oil and coal. Deposition of nitrogen is another contributory cause of acidification. These gases can subsequently react in the atmosphere to produce acids that are dissolved in precipitation. Acidifying compounds may fall to the ground with rain or snow as wet deposition, or in the form of particles or gases as dry deposition.

Acidification represents a serious threat to many plants and animals, particularly in sensitive aquatic ecosystems. Changes in the pH of lakes and streams affected by acid rain can result in a decrease in the variety of fish, plants and animals living in or near the water. Some animals and plants cannot tolerate the higher levels of acid. Acid rain also impacts trees and plants by causing damage to leaves and dissolving nutrients in the surrounding soil. One of the most harmful impacts of acidification is that in acidic conditions toxic aluminum and heavy metal ions are more easily rinsed out of the soil and absorbed by living organisms.

Sulfur dioxide and nitrogen oxide are harmful pollutants before they combine with water and oxygen to form acid rain. These gases cause harmful particles that can be inhaled by humans, causing lung and heart disorders.

Acid rain can also have a devastating effect on man-made structures, such as those made of stone and metal. Bronze statutes and marble monuments are deteriorated by acid rain.

4.5.1 Status in Iceland

Acidification - measured as SO_2 equivalents - has never been regarded as a problem of magnitude in Iceland taking in account regional/national buffer capacity in comparison to actual acid production potential. The main acidification has been due to European pollution. This pollution has been reduced considerably in recent decades due to lower sulphur content of fuels in Europe and better flue gas cleaning.

4.6 Eutrophication

Nitrogen (including nitrogen oxides and ammonia) and phosphorus emissions to water and air are the main sources of eutrophication, which cause serious problems in seas, waters and forests. Eutrophication is widely seen as a negative trend in lakes and seas. Eutrophication generally promotes excessive plant growth, aquatic vegetation or phytoplankton can overgrow and toxic blue green algae are produced. It is likely to cause severe reductions in water quality. In aquatic environments the enhanced growth disrupts normal functioning of the ecosystem, causing a variety of problems such as a lack of oxygen in the water, essential for fish and shellfish. Human society is impacted as well as eutrophication decreases the resource value of rivers, lakes and estuaries and impacts recreation, fishing and hunting.

Sources for nitrogen and phosphorus emissions includes wastewater from industries, sewage treatment and drains, energy production, transports, incineration, runoff from agriculture and leachate from landfills.

4.6.1 Status in Iceland

Icelanders produce among the highest emission of nitrogen dioxide per capita in the world. The municipal waste water is not treated in a full-scale sewage treatment plant. The treatment works in two steps; settling and filtering. There is no destruction of organics or precipitation of nutrients. After filtering the waste water is pumped 3-5 km offshore.

Though, at sea off the Icelandic coast nutrients occurs in low concentrations and the concentrations are more or less constant. There is no indication of eutrophication at sea around Iceland and the Icelandic waters are considered as being one of the cleanest in the world.

In lakes and wetlands, the eutrophication impact may cause problems. For example, Lake Thingvallavatn is one of few lakes in the world which has nitrogen-limited production, as well as being home to endemic species of fish and some rare crustaceans. Increased eutrophication may lead to the lake appearing green rather than crystal clear. But there are no signs of eutrophication occurring in Icelandic freshwaters, as all lakes and wetlands are clear.

5 Methodology

Generally, life cycle assessment (LCA) can be defined as a method that studies the environmental aspects and potential impacts of a product or system from raw material extraction through production, use and disposal. LCA can also be used to assess a part of a lifecycle, i.e. comparing different methods to treat waste. The results of such a study are relative results comparing different methods of treatment rather than showing absolute results for any treatment option.

The general categories of environmental impacts to be considered include resource use, human health and ecological consequences as explained earlier in this report.

A number of relevant waste treatment scenarios are studied. The time perspective is about 2013. The choice is made due to many official objectives being set by the time of 2020, and 2013 is an intermediate milestone. However the amount of waste is not forecasted since the LCA study is only comparative. The composition of waste is assumed to be approximately the same.

Scenario 1: Basic scenario (scenario similar to the waste situation in 2007.)

Scenario 2: An anaerobic digestion scenario

Scenario 3: A composting scenario

Scenario 4: An incineration scenario

Scenario 5: A SRF-scenario (solid recovered fuel/ specified recovered fuel)

Scenario 6: A maximum recycling scenario

6 General presumptions

6.1 Credibility and validity

The purpose of the study is to grasp the situation in the topical region (municipalities in South Western Iceland). For the classification of waste composition data from municipal waste analysis done by SORPA were used. In some cases – due to lack of relevant data - experiences from other European countries has been used, mainly from Scandinavia. The industrial waste is – according to SORPAs experience - considered to have about the same composition as the municipal waste. Estimation of potential content of treatable waste (for example combustible or compostable content) and efficiency of separating waste follows mainly experience from Swedish and European practice.

6.2 Waste categories being studied

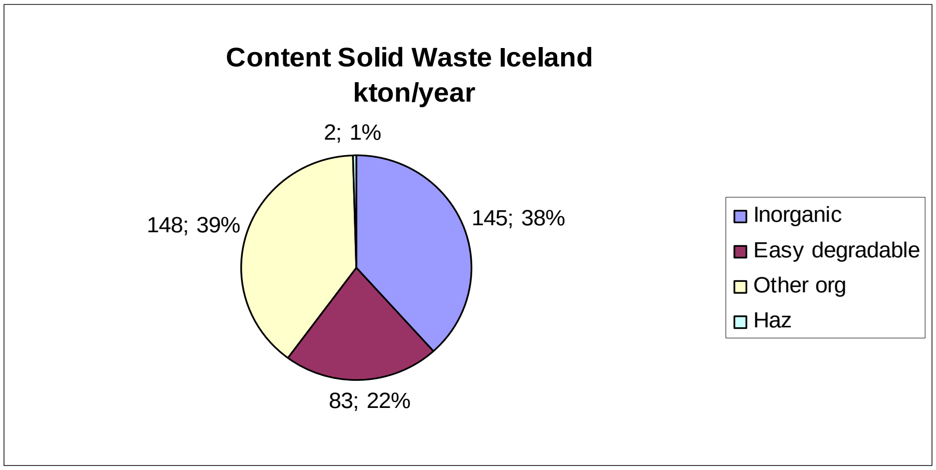


Figure 1: *Content in solid waste in Iceland kton /year (Source: SORPA 2008)*

The solid waste as a total in the topical area amounts in 2007 about 355 000 ton. Then WEEE, hazardous waste and bottom ashes are not counted. WEEE and hazardous wastes are not calculated because Iceland after January 1st 2009 will have a very well functioning producers responsibility system that probably will result in almost 100% collecting rate – and these waste categories are consequently not affecting the comparative LCA analysis. The bottom ashes emanates from waste already being processed and will be a part of the calculations regarding the incineration treatment.

The waste being considered can be divided into the following four main categories:

- Easy degradable
- Other organic waste
- Inorganic waste
- Hazardous waste

The waste categories are roughly labeled in accordance to the treatment technologies that could be close in mind. *Easy degradable* is the waste products that could be interesting to treat with biological treatment methods – i.e. composting or anaerobic digestion. Common examples are vegetables, tissue paper, meat, fish etc. *Other organic waste* is mainly the waste that – beside the easy degradable waste – is appropriate to incinerate in regard to the calorific value and absence of PVC and other agents not suitable for incineration. Consequently the *inorganic waste* is the remaining part - mainly consisting metals, concrete, earth, gravel, glass metals etc. Hazardous waste is not interesting in this study (see below) since it founds it own restricted paths.

In the first place the study will consider the waste categories that are possible to control by the municipality – i.e. the municipal solid waste and similar that is the municipalities responsibility according to the legislation. The municipal waste is generally the waste that is being collected with garbage trucks, together with commercial waste that is left at recycling centers. In addition the industrial and some other wastes that can be spotted as interesting for waste treatment by incineration, composting or anaerobic digestion.

6.3 Waste treatment methods and related waste

Garden waste is today put on countryside dumps. These dumps will soon be covered and ended as waste landfills according to the Iceland reg. no 738/2003 in landfill of waste. Consequently this waste will be regarded as combustible in all scenarios except scenario 1.

Animal manure (mainly from horses) is a rather great part of the total amount of solid waste – about 9%. The manure is today being spread on farmlands in a relatively disordered way. In scenario 1 and 2 the manure will be utilized as raw material in the process.

A major part of the slaughterhouse waste – mainly consisting of residuals after chicken slaughter – is recycled in a meat meal factory. A minor part is today landfilled, but will soon be treated according to the ABP[1]) regulations. Consequently, this waste will not be considered in this LCA study.

[1] Animal By Product

6.3.1 SRF Production (Solid Refuse Fuel)

In the process of SRF-production the non-combustible materials such as glass and metals are removed during the post-treatment processing cycle with an air knife or other mechanical separation processing. The residual material can be sold in its processed form (depending on the process treatment) or it may be compressed into pellets, bricks or logs and used for other purposes either stand-alone or in a recursive recycling process. In Sweden the BRINI system was regarded as an emerging technology during the 80th and 90th.

Advanced SRF processing methods (pressurized steam treatment in an autoclave) can remove or significantly reduce harmful pollutants and heavy metals for use as a material for a variety of manufacturing and related uses. SRF is extracted from MSW using mechanical heat treatment, mechanical biological treatment or waste autoclaves.

The best quality is achieved with carefully separated waste fractions of paper and plastics. To increase the amounts of separated waste it will probably be necessary to pick out waste a fraction that decreases the quality of SRF.

SRF can be used in a variety of ways to produce electricity. It can be used alongside traditional sources of fuel in coal power plants. SRF can also be used in the cement kiln industry, where the strict standards of the Waste Incineration Directives are met. However, the use of municipal waste contracts and the bank ability of these solutions is still a relatively new concept, thus SRF 's financial advantage may be debatable.

The biomass fraction of SRF has a monetary value under multiple greenhouse gas protocols, such as the European Union Emissions Trading Scheme and the Renewable Obligation Certificate program in the United Kingdom. Biomass is considered to be carbon-neutral since the CO_2 liberated from the combustion of biomass is recycled in plants. The combusted biomass fraction of SRF is used by stationary combustion operators to reduce their overall reported CO_2 emissions.

Several methods have been developed by the European CEN 343 working group to determine the biomass fraction of SRF. The initial two methods developed (CEN/TS 15440) were the manual sorting method and the selective dissolution method. Since each method suffered from limitations in properly characterizing the biomass fraction, an alternative method was developed using the principles of radiocarbon dating. A technical review (CEN/TR 15591:2007) outlining the carbon-14 method was published in 2007. A technical standard of the carbon dating method (CEN/TS 15747:2008) will be published in 2008. In the United States, there is already an equivalent carbon-14 method under the standard method ASTM D6866.

Although carbon-14 dating can determine with excellent precision the biomass fraction of SRF, it cannot determine directly the biomass calorific value.

Determining the calorific value is important for green certificate programs such as the Renewable Obligation Certificate program in the United Kingdom. These programs award certificates based on the energy produced from biomass. Several research papers, including the one commissioned by the Renewable Energy Association in the UK, have been published that demonstrate how the carbon-14 result can be used to calculate the biomass calorific value.

6.3.2 Incineration

Today Kalka operates an incineration plant in Helguvik (design capacity is 16 thousand metric tons/year). This plant is mainly erected as a treatment option for the waste emanating from the US Navy Campus outside Keflavik. The US Navy has left Iceland but the plant is still used by NATO and by waste from air traffic. The incinerator is five years old and designed according to EU regulations. The plant is equipped with fully functional heat recovery system with both turbine for electricity and condenser for heat production as well as flue gas cleaning according to EU regulation. The function of the flue gas cleaning undergoes regular inspection. In all scenarios incineration with 12 000 ton/year with the current site is used.

Concerns regarding the operation of incinerators include fine particulate, heavy metals, trace dioxin and acid gas emissions, even though these emissions are relatively low from modern incinerators. Other concerns include toxic fly ash and incinerator bottom ash management. Discussions regarding waste resource ethics include the opinion that incinerators destroy valuable resources and the fear that they may reduce the incentives for recycling and waste minimization activities. Incinerators have electric efficiencies on the order of 14-28%. The rest of the energy can be utilized for e.g. district heating but is otherwise lost as waste heat. In practice that means that the energy recovery will be of low interest with Icelandic current conditions.

6.3.3 Anaerobic digestion

Anaerobic digestion (AD) is a biological process in which biodegradable organic matters are broken-down by bacteria into biogas, which consists of biomethane (CH_4), carbon dioxide (CO_2), and other trace amount of gases. The biogas can be used to generate heat and electricity. An oxygen-free environment in the reactor is the primary requirement of AD to occur. Other important factors, such as temperature, moisture and nutrient contents, and pH are also critical for the success of AD.

The types of anaerobic digesters include Covered Lagoon, Batch Digester, Plug-Flow Digester, Completely Stirred Tank Reactor (CSTR), Upflow Anaerobic Sludge Blanket (UASB), and Anaerobic Sequencing Batch Reactor (ASBR), and others.

The complete-mix digester is a large, vertical poured concrete or steel circular container. Today's complete-mix digester can handle organic wastes with total solid concentration of 3% to 10%.

The basic plug-flow digester design is a long linear through, often built below ground level, with an air-tight expandable cover. Organic wastes is collected daily and added to one end of the trough. Each day a new "plug" of organic wastes is added, slowly pushing the other organic waste down the trough.

A cover lagoon is an earthen lagoon fitted with a floating, impermeable cover that collects biogas as it is produced from the organic wastes. The cover is constructed of an industrial fabric that rests on solid floats laid on the surface of the lagoon. The cover can be placed over the entire lagoon or over the part that produces the most methane. An anaerobic lagoon is best suited for organic wastes with a total solid concentration of 0.5%-3%. Cover lagoons are not heated.

Production of renewable energy – especially vehicle fuel - improvement on environmental pollution in air and water, reduction of agricultural wastes, and utilization of byproducts as soil improvement from anaerobic digestion (AD), has increased the attractiveness of the application of AD. AD technology is well developed worldwide. About the market for bioresiduals and compost in Iceland - see 6.3.4 Composting.

Of the estimated 5300-6300 MW worldwide anaerobic digestion capacity, Asia accounts for over 95% or 5000-6000 MW. Traditional, small, farm-based digesters have been used in China, India and elsewhere for centuries. The number of digesters of this type and scale is estimated to exceed 6 million. European (EU) companies are world leaders in development of the AD technology. Currently, EU has a total generating capacity of 307 MW from AD technology. The countries in EU with the largest development figures are Germany (150 MW), Denmark (40 MW), Italy (30 MW), Austria and Sweden (both 20 MW).

6.3.4 Composting

Industrial composting systems are increasingly being installed as a waste management alternative to landfills. Treating biodegradable waste before it enters a landfill reduces emissions from fugitive methane.

Most commercial and industrial composting operations use active composting techniques. These ensure that the process does not get out of control especially with the high through-put demand imposed by contracted, incoming waste. This means that as short as possible a processing time must be maintained to keep the facility properly functioning. Partly for this reason composters have declined to support compost maturity standards if it would increase the required holding time. The greatest amount of technological control of composting is seen in systems using an enclosed vessel and controlling its temperature, air flow, moisture and other parameters.

Large-scale composting systems are used by many urban centres around the world. Co-composting is a technique which combines solid waste with dewatered biosolids, which originated in the 1960s and has fallen somewhat out of favour due to difficulties controlling inert and plastic contamination from Municipal Waste. In Europe, mixed waste composting is literally illegal.

The potential market for bioresiduals and compost in Iceland is unknown. Normally compost emanating from waste is used in low standard sectors of application as landfill topsoil cover or replacement for peat moss with low requirement of purity. It is not yet common practise to use soil improvers produced from waste to replace chemical fertilizers even if many suppliers try to convince the market that it is the case. The market resistance to waste derived soil improvers is to a great extent emotional and profound.

6.3.5 Landfill gas collection emission and use

Picture 4: *The gas collected from landfills are used as fuel, to replace fossil fuel*

Emission from landfills are extremely difficult to model as they occur over a very long period of time and field data for modeling purpose are not available. The landfill model therefore must rely on several estimations and assumptions. It is also uncertain how reliable data from Sweden and Europe are in an Icelandic context.

One parameter of great uncertainty is the methane oxidation in top soil – currently and in the future. In Iceland the landfills are continually covered with layers that contain top soil with unknown oxidation capacity. During the last years some studies have been made concerning this issue - for example IPPC guidelines for national greenhouse gas Inventories 2006 and Methane from landfills in Sweden[2]. In these studies it is obvious that the parts of methane possible to oxidize in the top soil differ in a wide range – actually measured between 6 – 43%! The oxidation process is depending on many different parameters. The parameters we know of are for example climate, type of waste being landfilled, type of top soil construction etc. The last top soil construction is probably going to be more efficient for the future methane reduction as experiences from the landfills being covered today most likely will develop the knowledge.

In our case we have calculated following model (see figure) for the landfill gas collection, emission and use in Álfnes landfill (which is approximated to be about 95 % of all landfilled waste in 2013).

That makes a total balanced average of;

- Methane emission within ST: 25%
- Methane collection and utilization as vehicle fuel: 45%

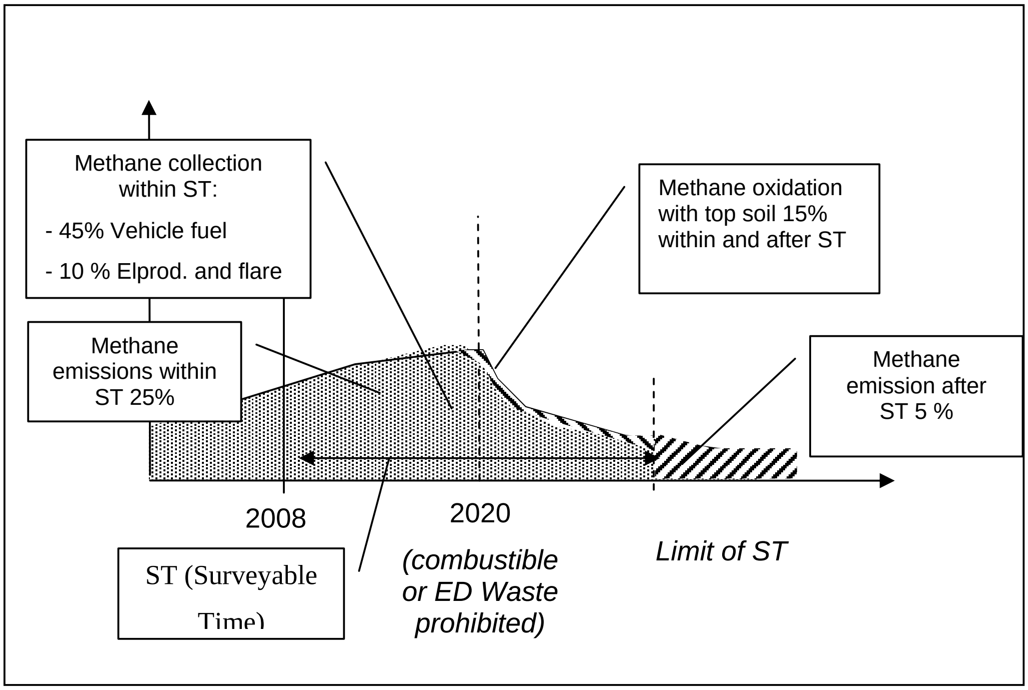


Figure 2: *Model for calculating the landfill gas collection (partly based on Björkman K, et al SORPA Álfsnes Deponigas, SWECO VIAK for SORPA)*

[2] STEM P10856-4 Project 2005

7 Scenarios

7.1 Basic scenario.

This scenario shows a situation similar to the current. Most of the waste is still landfilled. The total amount of waste is estimated to be as today. In the table below the amount of waste to different treatment is compared with the situation today.

	Landfill	Recycled	SRF	Incinerated	AD	Comp	Other	Total
Basic scenario	208 000	69 000	0	12 000	0	0	66 000	355 000
Situation today	223 000	54 000	0	12 000	0	0	66 000	355 000

Table 1*: Amount of waste in the basic scenario, compared with the situation today*

The waste treatment methods being used are landfilling, incineration and "other". The recycling rate is somewhat higher than in 2007 (in order to fulfill the objectives of the waste legislation). The landfill treatment will be 208 000 ton/year compared to the situation today when about 223 000 tons are landfilled.

By the "other treatment" means the following. Manure (horse manure) is spread in a primitive way and hardly used in an environmentally acceptable way. Some of the slaughter house waste is landfilled (mostly chicken), other is processed in meat meal plant. Fat from the plant is used for fuel or biodiesel. The unpainted wood is used by Elkem in their processes as a source of carbon and the white painted wood as landfill cover material.

7.2 Maximum recycling scenario.

This scenario is similar to the basic scenario but with a maximum of recycling. With recycling is meant material recycling and not energy recycling. Most of the material being recycled is landfilled in the basic scenario. In the table below the amount of waste to different treatment options is compared with the basic scenario.

	Landfill	Recycled	SRF	Incinerated	AD	Comp	Other	Total
Max recycling	111 000	170 000	0	12 000	0	0	62 000	355 000
Basic scenario	208 000	69 000	0	12 000	0	0	66 000	355 000

Table 2*: Amount of waste in the maximum recycling scenario, compared with the basic scenario*

From the households and industrial waste there are about 56% potential to recycle. Of the material possible to recycle, 80% is estimated to be recycled by source separation. Even if Iceland is not so used to source separation there is a great potential to be discovered. There are lots of examples in different parts of the world where people have converted from absolute negative to a positive attitude. The industrial waste is supposed to have about the same potential for recycling as the municipal waste (according to information from SORPA).

7.3 SRF-scenario I

This scenario is similar to the basic scenario but with a production of SRF, using suitable waste like paper and plastic from industry. In the table below the amount of waste to different treatment options is compared with the basic scenario.

	Landfill	Recycled	SRF	Incinerated	AD	Comp	Other	Total
SRF-scenario I	189 000	49 000	39 000	12 000	0	0	66 000	355 000
Basic scenario	208 000	69 000	0	12 000	0	0	66 000	355 000

Table 3*: Amount of waste in the SRF- scenario I, compared with the basic scenario*

The SRF Production is best performed with a content of - in the first place - paper and plastic from the industry. It is easy to store and transport selected from other waste without any great problems of hygiene or self-ignition. The sources in industrial are more easily identified than in the municipality waste. Furthermore the quality in SRF-scenario I will be higher than SRF scenario II and thereby it will be possible to keep up the prices. The SRF sources are taken half from waste that today goes to landfill and half from waste today being recycled.

7.4 SRF-scenario II

This scenario is similar to the basic scenario but with a production of SRF, using the same material as in SRF I, but also with the use of source separated waste from the households. The scenario focuses on maximum production possible – quantity instead of quality. In the table below the amount of waste to different treatment options is compared with the basic scenario.

	Landfill	Recycled	SRF	Incinerated	AD	Comp	Other	Total
SRF-scenario II	175 000	49 000	53 000	12 000	0	0	66 000	355 000
Basic scenario	208 000	69 000	0	12 000	0	0	66 000	355 000

Table 4*: Amount of waste in the SRF- scenario II, compared with the basic scenario*

The amounts of produced SRF in option II will raise from 39 000 to 53 000 ton/year. The additional waste – compared with scenario I – is taken from waste otherwise going to landfill. Unfortunately the quality will then be somewhat lower and the possibility to give quality guaranties is lower. Hygiene and self-ignition problems will significantly hazard storing and transportation of the SRF-product.

The amounts to be recycled, incinerated and “other” options will remain the same as in SRF-scenario I.

7.5 Incineration scenario

This scenario is similar to the basic scenario but with an incineration plant that have the capacity to incinerate a greater part of the solid waste. The purpose of incineration is partly to reduce the volume of the waste and partly to produce energy – normally focusing district heating due to the low calorific value of waste. In the table below the amount of waste to different treatment options is compared with the basic scenario.

	Landfill	Recycled	SRF	Incinerated	AD	Comp	Other	Total
Incineration scenario	99 000	49 000	0	148 000	0	0	59 000	355 000
Basic scenario	208 000	69 000	0	12 000	0	0	66 000	355 000

Table 5*: Amount of waste in the incineration scenario, compared with the basic scenario*

The amounts of waste being incinerated is raised from 12 000 to 148 000 ton/year. Still a great amount of waste will be landfilled. Beside current incineration plant a new plant have to be built. In this scenario the landfilling and the incineration option is rather equivalent. None of the treatment methods gives a great outcome[3]. The main purpose with incineration will be volume reduction – which is performed to an exceedingly high investment cost.

7.6 Anaerobic digestion scenario I

This scenario is similar to the basic scenario but with a treatment facility that can digest easy degradable waste – mainly from restaurants, catering and food industry. Waste going to composting or biodegradation has to be separated at source. All experience of automatic separation of mixed waste state that source separation is the only way to achieve sufficient quality. However the source for easy degradable waste is in the first place restaurants, large-scale catering, foodstuff manufacturing and similar. From these sources the waste is easily spotted to be separate collected. Only when these sources are implemented and working smoothly separation at households should be managed.

In the table below the amount of waste to different treatment options in scenario AD I is compared with the basic scenario.

---

[3] The bottom ash can certainly be used as road construction material and similar, but the market value must be considered as low.

	Landfill	Recycled	SRF	Incinerated	AD	Comp	Other	Total
AD scenario I	208 000	56 000	0	12 000	55 000	0	24 000	355 000
Basic scenario	208 000	69 000	0	12 000	0	0	66 000	355 000

Table 6*: Amount of waste in the AD- scenario I, compared with the basic scenario*

In this scenario rather clean material is selected from the industrial waste. In this case it is easier to define and guarantee the waste content and also the outcome consisting of biogas and "bioresiduals". The biogas production processes will be easier to supply and to operate. Landfilling, recycling and "other" treatment options will be affected. Fewer amounts will be landfilled. As a result less landfill gas will also be produced, but on the other hand the biogas production will be more efficient (more gas per waste volume) being performed in a digestion chamber.

7.7 Anaerobic digestion scenario II

This scenario is similar to the anaerobic scenario I but with a treatment facility that can digest almost all easy degradable waste – both from restaurants, catering, food industry (like in scenario I) and also source separated from the municipality. In the table below the amount of waste to different treatment options is compared with the basic scenario.

	Landfill	Recycled	SRF	Incinerated	AD	Comp	Other	Total
AD scenario II	199 000	54 000	0	12 000	66 000	0	24 000	355 000
Basic scenario	208 000	69 000	0	12 000	0	0	66 000	355 000

Table 7*: Amount of waste in the AD- scenario II, compared with the basic scenario*

In this case also so-urce separated waste from the municipalities will be collected and treated in addition to the amounts in scenario AD I. The amount of biologically treated waste is raised from 55 000 to 66 000 ton/year. The quality will be lower but the total amount of biogas will be significantly raised. At the same time the quality of bio-residuals will lower which naturally affects the value.

7.8 Composting scenario I.

This scenario is similar to the basic scenario but with a composting facility that can treat similar kind of waste as in AD – mainly from restaurants, catering and food industry. No investigation for the actual market of degraded organic waste has been made. Use of compost or residuals after biodegradation is supposed to be as covering material on landfills or other places were top-soil can be used. A sensitive study is made[4] in the case compost is used as fertilizers and the avoided energy due to less production of artificial fertilizers is credited.

In the table below the amount of waste to different treatment options is compared with the basic scenario.

	Landfill	Recycled	SRF	Incinerated	AD	Comp	Other	Total
Composting scenario I	198 000	54 000	0	12 000	0	67 000	24 000	355 000
Basic scenario	208 000	69 000	0	12 000	0	0	66 000	355 000

Table 8*: Amount of waste in the composting scenario I, compared with the basic scenario*

In this scenario rather clean material is selected compared to compost scenario II. It is easier to define and guarantee the waste content and also the end-product from the plant. The Production processes will be easier to supply and to operate. Landfilling, recycling and "other" treatment options will be affected. Less amounts will be landfilled.

7.9 Composting scenario II

This scenario is similar to the compost scenario I but with a treatment facility that can compost almost all degradable waste – both from restaurants, catering, food industry and source separated from the municipality. In the table below the amount of waste to different treatment options is compared with the basic scenario.

	Landfill	Recycled	SRF	Incinerated	AD	Comp	Other	Total
Composting scenario II	187 000	54 000	0	12 000	0	78 000	24 000	355 000
Basic scenario	208 000	69 000	0	12 000	0	0	66 000	355 000

Table 9*: Amount of waste in the composting scenario II, compared with the basic scenario*

In this case also source separated waste from the municipalities will be collected and treated in addition to the amounts in compost scenario I. The amount of biologically treated waste is raised from 67 000 to 78 000 ton/year. The quality will be lower but the total amount of compost will be significantly raised. At the same time the quality of compost will lower which naturally gives the compost material even lower value.

---

[4] Not referred in the study. The sensitive study is used only to test if the final conclusions can be jeopardized by manipulating parameters within a possible range.

8 Environmental impact

Picture 5: *Barrow's Goldeneye. Iceland is the only place in Europe where this species is breeding, which makes Iceland unique in this respect – like in many other respects regarding the environment*

Generally, life cycle assessment (LCA) can be used to study the environmental aspects and potential environmental impacts of a product or system, from raw material extraction through production, use and disposal.

Provided all upstream and downstream impacts are equal, the life cycle of waste starts when products/waste have been collected and ends when the waste material is degraded or brought back to the technological system through recycling and replaces other products. Hence, LCA in the waste management sector can be applied in order to compare the environmental performance of alternative waste treatment systems and identify areas for improvement.

In this study a simplified LCA, often known as screening LCA, has been used. This type of LCA will try to reduce data collection and thereby the total effort. The study will start with an introductory review of the most important environmental impact categories throughout the process that is of concern to the area subject to the study. Based on the result of review the LCA Screening will be focused on the most relevant environmental impact categories.

If a number of different waste treatment systems are being compared the functional unit should be ton waste of a specified composition.

An LCA study does not always need an impact assessment. In many cases inventory data alone are sufficient for an evaluation. The term LCI (life cycle inventory) is used to indicate that a study has excluded the impact assessment phase.

8.1 Life Cycle Inventory data; Treatment alternatives

If an LCA study involves specific waste treatment processes, attempts should be made to collect and apply data that are as specific as possible for these processes. In the case of more generic studies, such as e.g. a basis for political decisions, generic data should be applied. However, it is important that the generic data represent the specific waste treated and the system boundaries of the specific study.

Environmental impact of the treatment alternatives: Incineration, landfill, aerobic composting, anaerobic digestion and solid recovered fuel are discussed separately below.

Emissions of greenhouse gases, CO_2 and CH_4, depend on the content of fossil carbon per waste fraction and maximum CH_4 production potential per waste fraction[5]. Calculations are made to represent relevant emissions according to actual waste compositions for each scenario.

Emissions of greenhouse gases from other activities like treatment and transport of different waste fractions have not been taken into account. Most of the energy used in the process comes from renewable sources on Iceland and does not contribute to the greenhouse effect. Transports do have an impact but this contribution has been considered marginal in this report and therefore disregarded. Furthermore transports are a vital and relatively constant part of all scenarios and therefore do not contribute particularly to any specific scenario. Waste collection transports is mainly performed by trucks with about the same capacity unregarded the waste is separated or not. Since the total waste amount to be transported in both cases is the same the transport-labor will also be the same. Long distance transports are about 4 – 6 times more transport efficient than collection trucks – which makes these transports contribution very small.

Another argument to disregard emissions from transport is the fact that more and more biogas is used to fuel the transport vehicles, i.e. with a renewable fuel without GWP impact.

CH_4 is a more aggressive greenhouse gas than CO_2. It has a Greenhouse Warming Potential, GWP, 21 times higher than for CO_2.

8.1.1 Incineration

8.1.1.1 Emission of greenhouse gases

CO_2 emissions are estimated from the carbon content of the incinerated material. The carbon content contributes to greenhouse emissions such as CO_2 and CH_4. CO_2 is by far the component that binds most of the carbon (above 97%). Exhaust gas cleaning or incineration technology does not influence CO_2 emissions. It is therefore common to differentiate CO_2 emissions on waste composition only.

Emission of CO_2 from incineration of biological waste material does not contribute to net emissions of greenhouse gases and should therefore not be

---

[5] Guidelines for the use of LCA in the waste management sector. Nordtest Project nr. 1537-01. 2002.

accounted for. It is therefore necessary to separate between fossil carbon and biological carbon.

Calculation of net CO_2 emissions from waste incineration is based on the fossil carbon content of the waste (kg fossil carbon/kg waste), multiplied by the amount of CO_2 generated per amount of carbon (kg CO_2/kg fossil carbon).

8.1.2 Landfill

The landfill option is relevant to apply to both the direct municipal waste flow, and to residual waste flows resulting from other treatment methods, such as incineration and biological treatment.

8.1.2.1 Emission of greenhouse gases

Focus is on the bulk emissions to air, which is the greenhouse gases methane (CH_4) and carbon dioxide (CO_2). It is commonly assumed that approximately the first months there are aerobic conditions in the landfill, which means that CO_2 is formed. After that there are anaerobic conditions, which mean that CH_4 is formed in addition to CO_2.

The carbon content in the waste flow available for degradation decides the potential emissions of CO_2 and CH_4. It is important to use a product specific approach to estimate CH_4 and CO_2 generation. This is first of all because biologically based carbon is CO_2 neutral and a product specific approach is needed to keep track of the share of biological carbon. In this study all carbon in landfill is emitted in an infinite time perspective.

A share of the landfill gas is often collected to be used as a vehicle fuel and/or to be combusted to produce heat or electricity.

In this report calculation credits are based on the assumption that all collected biogas is used to replace petrol in vehicles: The use of 1 kg biomethane reduces CO_2 emissions by 2,83 kg when replacing petrol in vehicles[6].

8.1.3 Aerobic composting

The composting option is relevant to apply to organic waste. The end-result can be used as soil improvement.

8.1.3.1 Emission of greenhouse gases

As long as the waste that is degraded is organic waste and sufficient oxygen access is secured, generation of CH_4 is small. The emitted CO_2 is regarded to be greenhouse gas neutral and does not contribute to the greenhouse effect.

8.1.4 Anaerobic digestion

The anaerobic digestion option is also relevant to apply to organic waste. The main purpose of anaerobic digestion is to generate biogas that can be used as an

---

[6] Website of the Swedish Consumer Agency, 2008, www.konsumentverket.se

energy source. As in aerobic composting the process will also result in a bioresidual, possible to use as soil improvement material.

8.1.4.1 Emission of greenhouse gases

The process takes place in a closed and controlled environment with no access to air where bacteria digest the organic waste. The biogas (CH_4) is collected and used for different energy purposes. The heat consuming processes at the anaerobic digestion plant is often supplied with energy from the recovered biogas. In Iceland the geothermal heat is probably more appropriate to use in order to increase the usable biogas for vehicles.

As the waste flow is approximately 100% organic, all CO_2 emissions are greenhouse gas neutral. However CH_4 might be emitted due to fugitive emissions during biogas storage causing greenhouse effect.

8.1.4.2 Transports of waste to anaerobic digestion

A question raised during this project was how transports affected the environmental benefit of anaerobic digestion and collection of biogas. Longer transports of waste would lead to use of larger and more efficient facilities for AD and biogas collection but transports to these facilities would lead to emissions of CO_2 and also other emissions.

In order to estimate the maximum transport that can be motivated from an environmental point of view the following comparison has been made.
1 ton of easy degradable material produces maximum 99,4 kg CH_4 per ton waste in an AD process.

1 kg biogas (biomethane) reduces CO_2 emissions by 2,83 kg when replacing petrol in vehicles. Hence if all potential biogas from one ton of waste, 99,4 kg CH_4, is used to replace petrol in vehicles the total reduction of fossil CO_2 emissions is in total 280 kg CO_2.

On the other hand transport of the waste emits CO_2. For a collection truck - running on petrol or diesel - with a load of 5 ton emissions of CO_2 are approximately 0,17 kg/tonkm[7]. Following this theoretical comparison it could be motivated to transport 1 ton of waste up to a maximum of at least 1600 km (280/0,17). If the fossil based fuel is partly replaced by CH_4 the critical distance will be even further.

8.1.5 Solid recovered fuel (SRF)

SRF is extracted from MSW and/or industrial waste using mechanical heat treatment, mechanical biological treatment or waste autoclaves.

The best quality is achieved with carefully separated waste fractions of paper and plastics. SRF can be used in a variety of ways to produce electricity. It can

[7] The Network for Transport and Environment, 2008, http://www.ntm.a.se/index.asp

be used alongside traditional sources of fuel in coal power plants. SRF can also be used in the cement kiln industry, where the strict standards of the Waste Incineration Directives are met.

The biomass fraction of SRF has a monetary value under multiple greenhouse gas protocols, such as the European Union Emissions Trading Scheme and the Renewable Obligation Certificate program in the United Kingdom. This fraction is considered to be CO_2 neutral.

In this report calculations are based on production of a SRF fuel consisting of 1/3 plastic and 2/3 paper. The paper is a biomaterial not contributing to CO_2 emissions when used as a fuel but plastics are not and do contribute to CO_2 emissions.

The credit for using 1 kg SRF is a reduction of CO_2 emissions by 0,83 kg when replacing coal in incineration units (considering different heat values for both fuels)[8]. It should be noted that this CO_2 credit occurs in the place where the fuel is used, which not necessarily have to be in Iceland. Environmental impact for potential transport of the SRF fuel is also disregarded because boat transports capacity leaving Iceland is seldom fully utilized. Hence the impact of additional freight is marginal.

8.1.6 Material recycling

Recovered materials from waste fractions that are reprocessed can be used to replace virgin materials, and this may result in overall savings in raw materials and energy consumption and emissions to air, water and soil.

In the calculations done later in this report the environmental benefit of a maximum recycling scenario is estimated. In this scenario paper, plastics and paper is considered to be recycled and replacing virgin material.

These “environmental credit values” allow balancing different waste fractions, the environmental advantages and disadvantages of materials recycling processes against virgin materials production processes[9].

	CO_2 kg/ton	CH_4 kg/ton	GWP kg CO_2 ekv./ton
PET	-1340	0.9	-1321
Glass	-381	-3.7	-459
Paper	-355	-0.4	-363

Table 10*: Greenhouse Warming Potential, GWP, credits for recycled materials.*

[8] Energycontent and density for fuels, ÅF Energi & Miljöfakta, 2008.
[9] The Use of Life Cycle Assessment Tool for the Development of Integrated Waste Management Strategies for Cities and Regions with Rapid Growing Economies. LCA-IWM. EVK4-CT-2002-00087. Technische Universität Darmstadt (TUD).

8.2 Life Cycle Inventory data; Land use

In this study the additional amount of waste is considered. That means that if small amounts of waste are landfilled the occupied land area will be near zero. The implication is that the landfill as it is today will be sited where it is regardless how many tons of additional waste that is going to the landfill and also apart from what type of scenario is being used. The additional amount will only occupy the area it covers in the landfill plus some additional space for access roads etc.

Regarding the other waste treatment plants (for incineration, composting, fermentation or production of SRF) a special building will be erected together with access roads, storing areas etc and - not least – safety areas depending on environmental impact (visual impact, smell, noise pollution etc). That means that if small amounts of waste are treated in these facilities the occupied land area will in this case be extremely high.

That means that Land use as impact parameter is very sensitive to the surveyable time being used.

8.2.1 Waste treatment by Landfill

Waste treatment by landfilling means in the scenarios the landfill Álfsnes in Reykjavik and to some extent also the landfill sites in Fiflholt, Stafnes and Strönd.. They will probably be the only landfills that will be accepted in the future. The minor dumps in the countryside will be ended and covered in due time. In the scenario analysis the presumption is that they are closed.

Additional waste space for every ton of landfilled waste counts at Álfsnes about 0,11 (calculations based on information from SORPA). The safe space use around the landfill will not be affected by the single ton of waste being landfilled – since there will always be some solid waste that has to be landfilled and the single ton waste will not notably increase the odors as a total.

8.2.2 Waste treatment by SRF production

Storing facilities and facilities for the production of SRF should be located with local conditions in mind. Suitable safe distance should be decided according to the actual presumption on the spot. The distance to habitation is an important aspect to avoid or limit the effect of unpleasant odors. Other important parameters are the general direction of wind, type of habitations, restrictions in different municipal plans, character of intermediate space, etc. Also the design of the site, design of the treatment process, the total amount of collected waste, including methods at loading and offloading the waste.

In general the handling of industrial waste and mostly garden waste and similar is less delicate than handling of municipal waste and food waste.

In the scenario I only rather “clean” waste from industry – mostly paper and plastic – is handled. That requires a minor land use than in SRF scenario II –

where also source separated waste from household is used. In the SRF scenario I we recommend 1 ha as total land use area.

In Europe there are no general standard rules of safe distances to different waste treatment facilities. However there are experiences and there are advices according to different municipal and state environmental authorities. In our SRF scenario II the Icelandic advice in municipal general plans is used as guidance - that recommends 500 m as a safe distance to habitation. That means as a total about 25 ha of land use.

8.2.3 Incineration of waste

In the incineration scenario roads, loading and storing facilities and facilities for combustion etc should be located with local conditions in mind. Suitable safe distance should be decided according to the actual circumstances. The distance to habitation is an important aspect to avoid or limit the effect of unpleasant odors. In a modern incineration plant with flue gas cleaning meeting demands of EU directives for incineration the discharge is relatively negligible. Other important parameters are the general direction of wind, type of habitations, restrictions in different municipal plans, character of intermediate space, etc. Also the design of the site, design of the treatment process, the total amount of collected waste, including methods at loading and offloading the waste.

In general the handling of industrial source separated waste and similar is less delicate than handling of waste consisting of parts of municipal waste and food waste.

In the incineration scenario all types of combustible waste should be handled. In Europe there are no general standard rules of safe distances to incineration facilities. However there are experiences and there a re advices according to different municipal and state environmental authorities. In our incineration scenario the Swedish advice in municipal general plans is used as guidance - that recommends 500 m as a safe distance to habitation. That means as a total about 25 ha of land use.

8.2.4 Biological waste treatment – anaerobic digestion and composting

Access roads, storing facilities and all kinds of facilities for biological treatment should be located with local conditions in mind. Suitable safe distance should be decided according to the actual presumption on the spot. The distance to habitation is an important aspect to avoid or limit the effect of unpleasant odors – which use to be the major problem to get permits from the environmental authorities. Other important parameters are the general direction of wind, type of habitations, restrictions in different municipal plans, character of intermediate space, etc. Also the design of the site, design of the treatment process, the total amount of collected waste including methods at loading and offloading the waste.

In all biological treatment scenarios waste including different parts of food waste and household or similar waste will be handled.

In Europe there are no general standard rules of safe distances to different waste treatment facilities. However there are experiences and there are advices according to different municipal and state environmental authorities. In our biological treatment scenarios the Swedish advice in municipal general plans is used as guidance - that recommends 500 m as a safe distance to habitation. That means as a total about 25 ha of land use.

8.2.5 Sensitivity Control

The land use in the different scenarios is a rather complicated parameter – since the different plants being used for different kind of waste treatment are not decided in practice but only the result of a speculative reasoning. The local conditions will probably be differing within a very large range. In the LCA analysis the most important outcome is relative – which means that the figure itself might not be so important. To ensure the best result possible the different data for land use will be modified in a sensitivity control.

8.3 Calculations and discussions

8.3.1 Depletion of abiotic resources

Iceland's nature is valuable and conservation of the environment is a high priority for Iceland. According to the strategy for sustainable development, *Welfare for the Future*, efforts should be made to conserve the biodiversity of Icelandic habitat types and ecosystems by the protection of animals, plants and other organisms, together with their genetic resources and their habitats. Therefore, it is important to consider the valuable and unique nature when planning landfills, incineration plants and biogas plants that demands that new land-areas are taken in use.

With those aspects taken in consideration, the depletion of abiotic resources is one of the environmental impacts included in the LCA-analysis.

8.3.2 Global warming

A global warming effected increase of temperature in Iceland, together with subsequent changes in precipitation, sea level and storm frequency, is likely to have severe effects on both the natural environment and human societies. The Ministry for the Environment issued the Iceland's *Climate Change Strategy* in February 2007 in order to reduction the emissions of carbon dioxide and methane.

With those aspects taken in consideration, the global warming is one of the environmental impacts included in the LCA-analysis.

Based on prerequisites and assumptions made earlier in this report, calculations for the different scenarios are presented in the diagrams below (chapter 9.1) ranging from the scenario giving the least GWP impact to the scenario with the highest impact.

8.3.3 Toxicity

In all waste treatment options in this report, the use of the best available technique (BAT) is assumed. BAT means that the toxic pollutants will be treated with the best known technique, to prevent that they are polluting the air, water or soil.

This study also excludes the industrial hazardous waste, which is not handled by the municipalities. Hazardous waste is subordinated special legislation in Iceland. Imported or domestically produced items which can become hazardous waste after use carry a special fee. The fee is added when the product is imported and includes collection and disposal costs. The hazardous waste disposal cost is thus already paid when the product is bought – which greatly reduces the incentive for illegal dumping of the hazardous residuals. General waste landfilled in Iceland is as a result normally including a minimum of hazardous waste.

As the waste stream that can be regarded as hazardous is running under relatively good control regardless scenario, the study will not show any difference in environmental impact and will consequently not consider the toxicity.

With those aspects taken in consideration, the toxicity will not be included in the LCA- analysis.

8.3.4 Photo-oxidant formation

The pollutions from waste transports may increase the formation of ground-level ozone, but the number of transports for waste are negligible compared to all other the transports and the use of cars in general. Many waste transports are also made by vehicles using gas as fuel, which is a fossil fuel substitute that doesn’t contribute to the formation of ground-level ozone. The reaction needs temperatures over 20°C and sunshine to be completed, which is considered to be a reduced factor in the formation of ground-level ozone in Iceland. The formation of ground-level ozone are not considered as a problem outside Reykjavik, as the number of cars in the countryside are low and the air is in constant change.

It is also a positive effect on the environment in urban areas in general that many companies are operating their transportation needs with gas vehicles. The emissions of harmful substances such as nitrogen oxides, hydrocarbons and particulates will then be significantly reduced with a gas vehicle, compared with a car that runs on fossil fuel.

With those aspects taken in consideration, the ground-level ozone is not considered as a major environmental or health problem in Iceland and will not be included in the LCA- analysis.

8.3.5 Acidification

As the largest natural source for emissions of sulphur dioxide is geothermal activity such as volcanoes, hot springs and geysers and Iceland is richer in hot springs and high-temperature activity than any other country in the world, the contribution of sulphur-dioxide from human activities is negligible. There are also large areas were the ground is naturally basic in Iceland, which neutralize the acid emissions.

The addition of sulphur-dioxide from waste treatment is small and can be considered negligible in comparison with the rich presence of sulphur in Iceland in general. Many waste transports are also made by vehicles using gas as fuel instead of fossil fuel, which does not contribute to the acidification.

With those aspects taken in consideration, acidification is not considered as a major environmental or health problem in Iceland and will not be included in the LCA- analysis.

8.3.6 Eutrophication

There are no indication of eutrophication occurring in Iceland, as all lakes and freshwaters are crystal clear and at sea the nutrients occurs in low concentrations and the concentrations are more or less constant. Many waste transports are made by vehicles using gas as fuel, which does not contribute to the eutrophication.

With those aspects taken in consideration, eutrophication is not considered as a major environmental problem in Iceland and will not be included in the LCA-analysis.

9 Conclusions and results

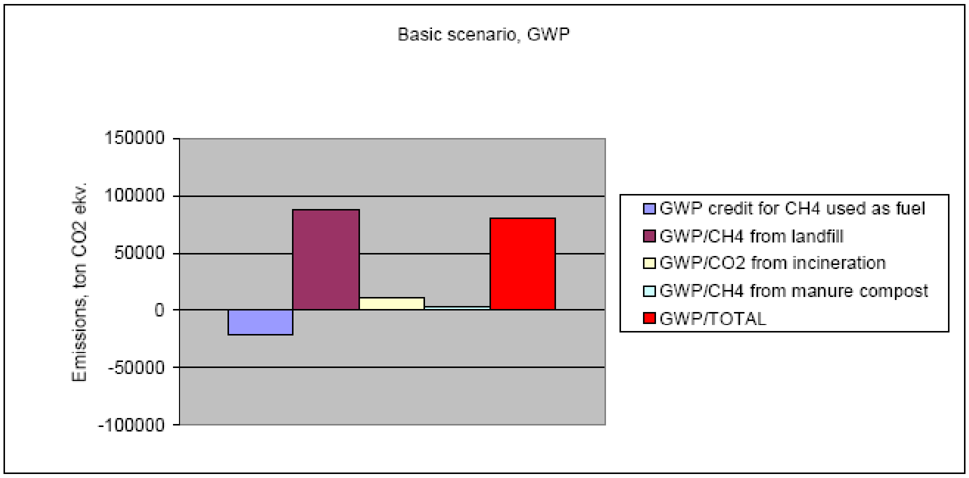
In accordance with the discussions in chapter 8.3, an environmental impact assessment has been made by LCA analysis for the categories of global warming, land use and transports in biogas production. All other environmental impact categories have in line with discussions earlier in the report been excluded from further studies.

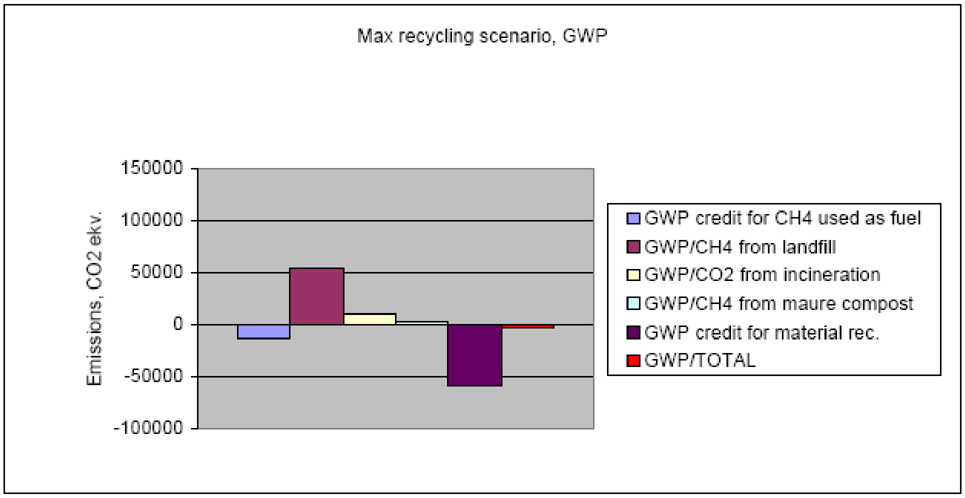
9.1 Global warming

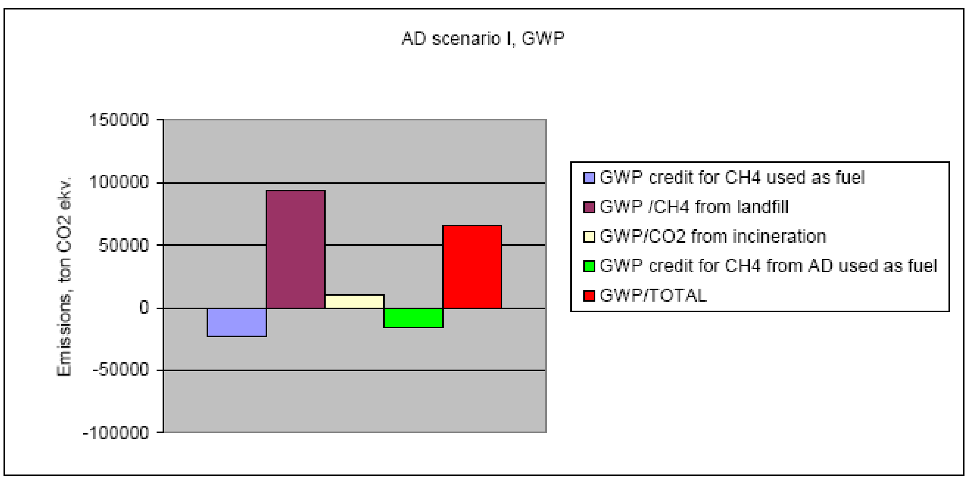
The results of the LCA analysis concerning global warming are summarized in the diagrams below, one diagram for each scenario that has been studied.

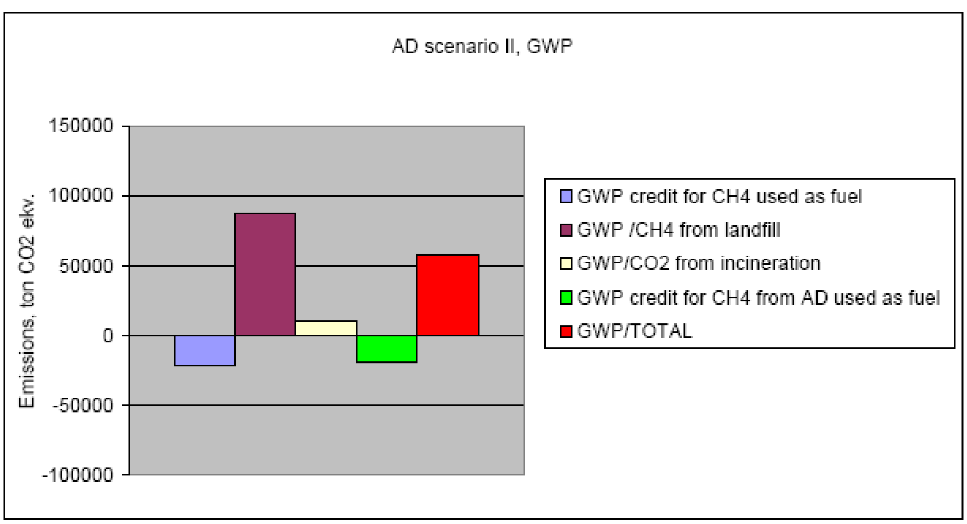
The bars in the diagrams shows the environmental emissions that occur in each scenario shown as ton CO_2 equivalents (positive bars), and the credit provided for environmental benefits (negative bars). The red bar to the right is the sum of all emissions and credits for the scenario, and the bar to be compared with the other scenarios.

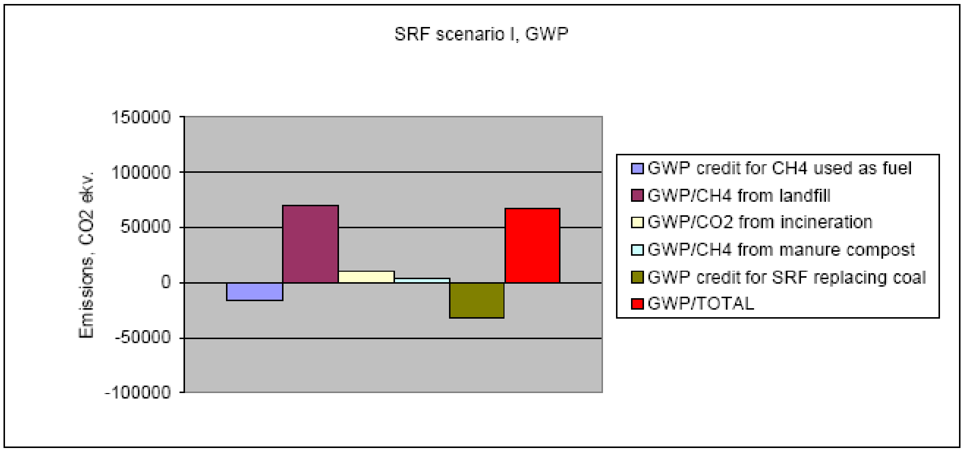
Diagram 1-9: *Global Warming Potential for each scenario studied.*

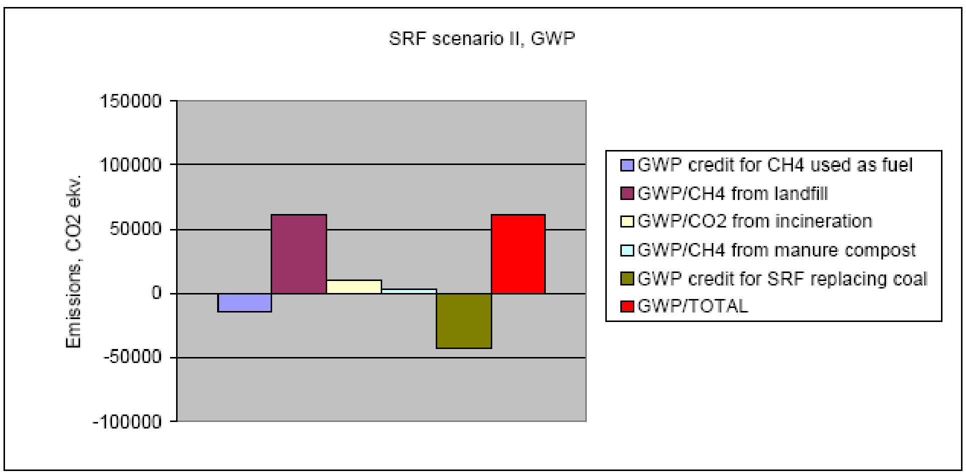


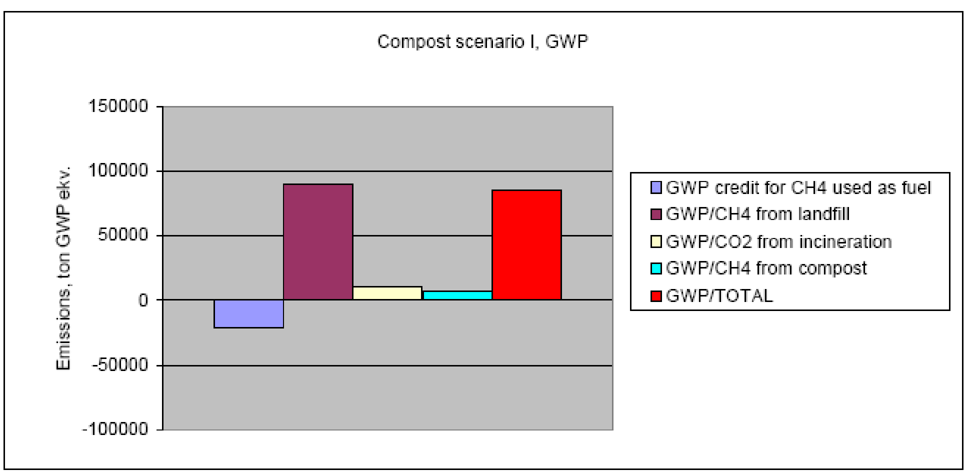

Max recycling scenario, GWP
150000
100000
50000
0
-50000
-100000
Emissions, CO2 ekv.
GWP credit for CH4 used as fuel
GWP/CH4 from landfill
GWP/CO2 from incineration
GWP/CH4 from maure compost
GWP credit for material rec.
GWP/TOTAL

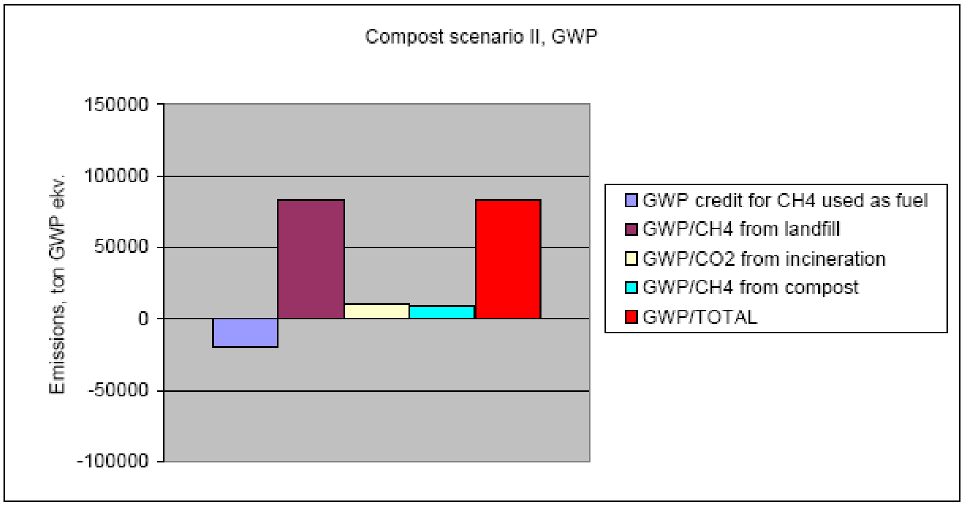

AD scenario I, GWP
150000
100000
50000
0
-50000
-100000
Emissions, ton CO2 ekv.
GWP credit for CH4 used as fuel
GWP /CH4 from landfill
GWP/CO2 from incineration
GWP credit for CH4 from AD used as fuel
GWP/TOTAL

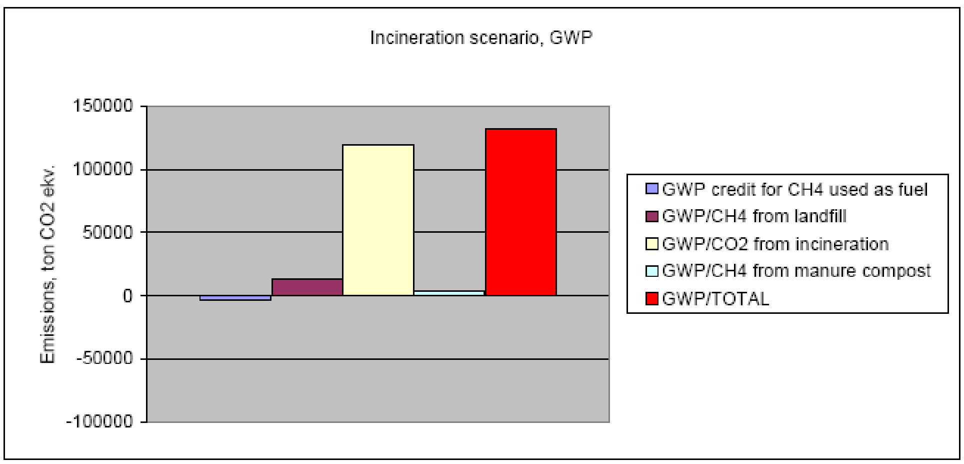

AD scenario II, GWP
150000
100000
50000
0
-50000
-100000
Emissions, ton CO2 ekv.
GWP credit for CH4 used as fuel
GWP /CH4 from landfill
GWP/CO2 from incineration
GWP credit for CH4 from AD used as fuel
GWP/TOTAL


SRF scenario I, GWP
Emissions, CO2 ekv.
150000
100000
50000
0
-50000
-100000
GWP credit for CH4 used as fuel
GWP/CH4 from landfill
GWP/CO2 from incineration
GWP/CH4 from manure compost
GWP credit for SRF replacing coal
GWP/TOTAL


SRF scenario II, GWP
Emissions, CO2 ekv.
150000
100000
50000
0
-50000
-100000
GWP credit for CH4 used as fuel
GWP/CH4 from landfill
GWP/CO2 from incineration
GWP/CH4 from manure compost
GWP credit for SRF replacing coal
GWP/TOTAL


Compost scenario I, GWP
Emissions, ton GWP ekv.
150000
100000
50000
0
-50000
-100000
GWP credit for CH4 used as fuel
GWP/CH4 from landfill
GWP/CO2 from incineration
GWP/CH4 from compost
GWP/TOTAL





9.1.1 Results: Global warming

When the results of the diagrams above are compared with each other, the following results are revealed (from least impact on global warming to the most):

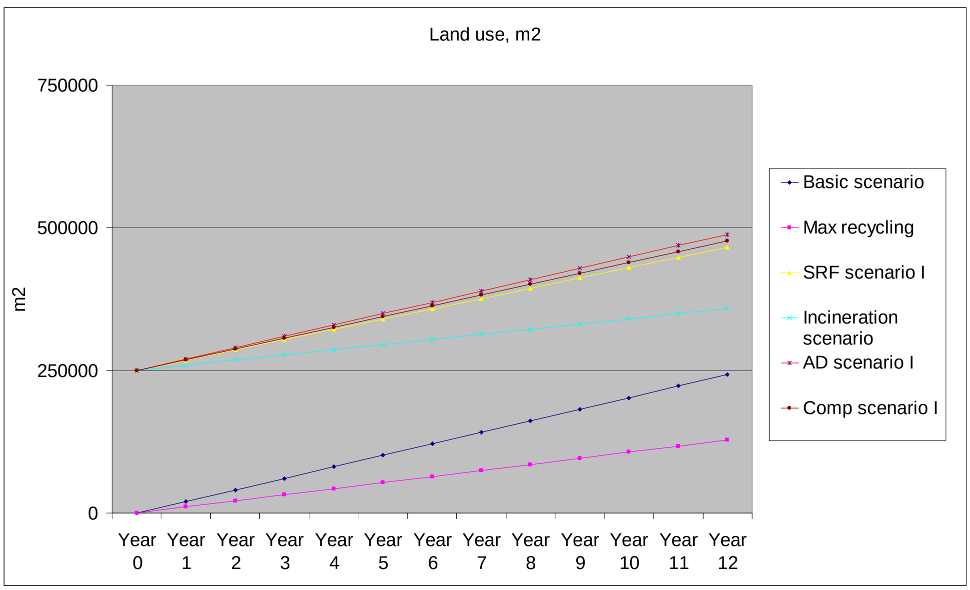
1. Maximum recycling scenario
2. Anaerobic digestion scenario II
3. SRF scenario II
4. Anaerobic digestion scenario I
5. SRF scenario I
6. Basic scenario
7. Composting scenario II
8. Composting scenario I
9. Incineration scenario

As shown above, the most appropriate way from a global warming point of view, would be to recycle as much waste as possible as material. As waste treatment method - unregarded the recycling option - aerobic digestion and SRF-production would be the most beneficial options, considering global warming potential for waste management in the surveyed area in Iceland.

Incineration appears to be the least favourable method from a global warming potential perspective, which is reinforced as Iceland has a limited market request for low quality energy.

9.2 Land use

The land use analysis is shown in the graph below, as m^2 land used per ton treated waste. As treatment plants has to be built in all scenarios - except the basic scenario and the maximum recycling scenario - the starting point for all other scenarios will be at 250 000 m^2 (calculated area for the treatment plant including the safety distance).



***Graph 1**: Calculated land use in m^2 for the different scenarios 2008 (year 0) to 2020 (year 12)*

9.2.1 Results: Land use

The maximum recycling scenario will initially result in the least land to be used per m^2 waste and secondly the basic scenario (situation similar to today). After about 20 years practice the incineration scenario will however be successively more favorable than the basic, while the three other scenarios (anaerobic digestion, SRF-production and composting) will be more land-consuming for a very long time – as new land has to be used when building the plants in those three scenarios.

9.3 Transportation limit in biogas production

The environmental impact of transportation compared with the environmental credits performed with production of biogas in an anaerobic digestion plant was also studied. Easy degradable waste treated by anaerobic digestion will produce a certain amount of biomethane gas that can be used as a vehicle fuel, replacing fossil fuels. The question was at what transport distance the emission of CO_2 from transports will exceed the reduction of CO_2 by replacement of fossil fuel with biomethane through the AD process.

9.3.1 Results: Transportation limit

If all potential biogas from one ton of waste is used to replace petrol in vehicles the total reduction of fossil CO_2 emissions is in total 280 kg CO_2.

If a common waste compacting truck running on fossil fuel is used for the transports of waste, the transportation distance limit will be at least 1600 km until the same amount of CO_2 is emitted. In reality the transportation limit could be even longer, since the solid waste should be transferred to more heavy loaded trucks to be cost efficient and since the fossil fuel will increasingly be replaced by biomethane.

The result shows that it can be supportable - from a global warming perspective - to have one large anaerobic digestion plant in Iceland, instead of several small plants.

10 Literature references

Björkman K, Brolin L, Collin J (2002) SORPA Alfsnes Deponigas, SWECO VIAK for SORPA

Energycontent and density for fuels, ÅF Energi & Miljöfakta, 2008.

Guidelines for the use of LCA in the waste management sector. Nordtest Project nr. 1537-01. 2002.

Iceland's Climate Change Strategy. The Ministry for the Environment in Iceland. February 2007.

RVF Utveckling 2005:06 Utvärdering av storskaliga system för kompostering och rötning av källsorteragt avfall.

RVF utveckling 2005:02 Avfall blir värme och el. En rapport om avfalls-förbränning.

STEM P10856-4 Project 2005. Metan från avfallsupplag i Sverige. Chalmers Tekniska Högskola, Göteborg och Linköpings Universitet, Linköping. December 2005

Strategic Planning on the Management of Waste 2008 – 2020. Memo for strategic evaluation – some basic data. (Mannvit)

The Network for Transport and Environment, 2008, http://www.ntm.a.se/index.asp

The Use of Life Cycle Assessment Tool for the Development of Integrated Waste Management Strategies for Cities and Regions with Rapid Growing Economies. LCA-IWM. EVK4-CT-2002-00087. Technische Universität Darmstadt (TUD).

Waste Management in Iceland (updated 20/2 2006). Information from Environmental Supervision Division, Environment and food agency of Iceland.

Website of the Swedish Consumer Agency, 2008, www.konsumentverket.se

Welfare for the Future. Iceland's National Strategy for Sustainable Development 2002 – 2020. The Ministry for the Environment in Iceland. August 2002.

Welfare for the Future – Framework for sustainable development in Icelandic society. Priorities 2006 – 2009. The Ministry for the Environment in Iceland.

11 Attachment

Calculation results all scenarios

Input basic scenarios

Calculations basic scenarios

Input Max Recycling Scenario

Calculations Max Recycling Scenario

Input SRF I Scenario

Calculations SRF I Scenario

Input SRF II Scenario

Calculations SRF II Scenario

Input Incineration scenario

Calculations Incineration scenario

Input Anaerobic Digestion I scenario

Calculations Anaerobic Digestion I scenario

Input Anaerobic Digestion II scenario

Calculations Anaerobic Digestion II scenario

Transport Anaerobic Digestion

Input Compost I scenario

Calculations Compost I scenario

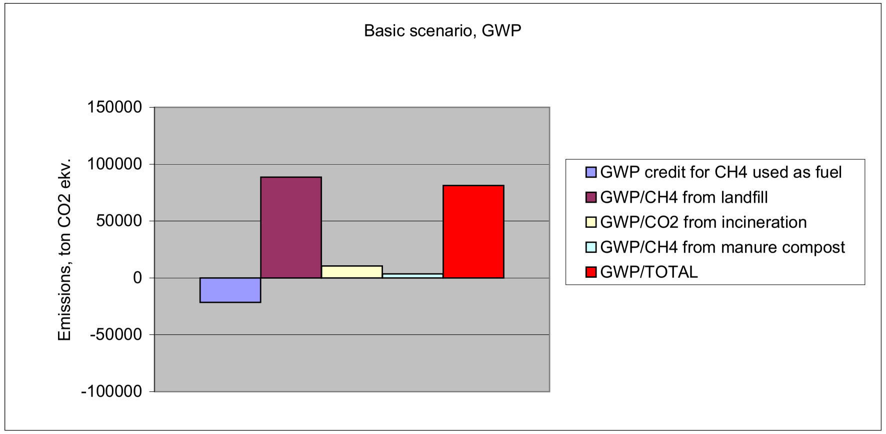
Input Compost II scenario

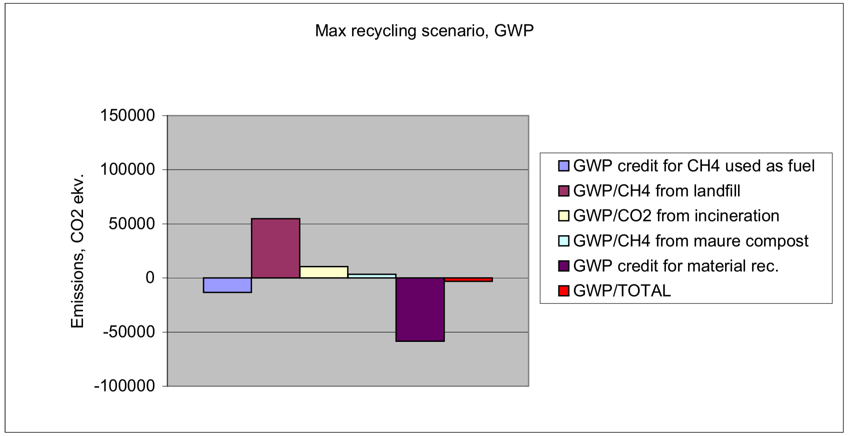
Calculations Compost II scenario

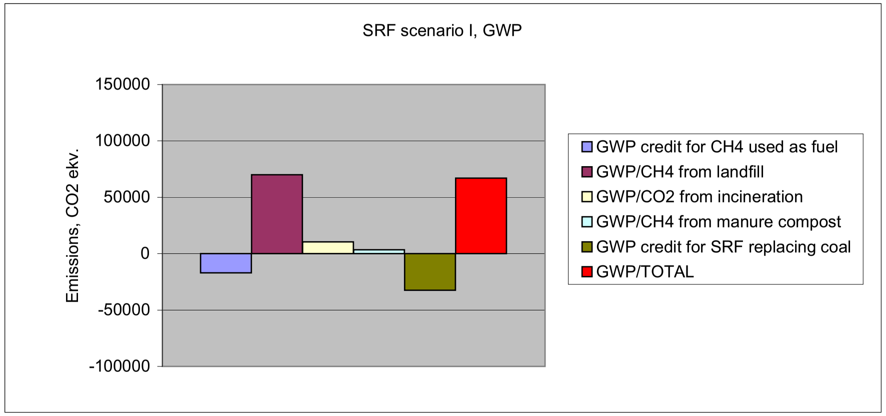
Calculation results all scenarios

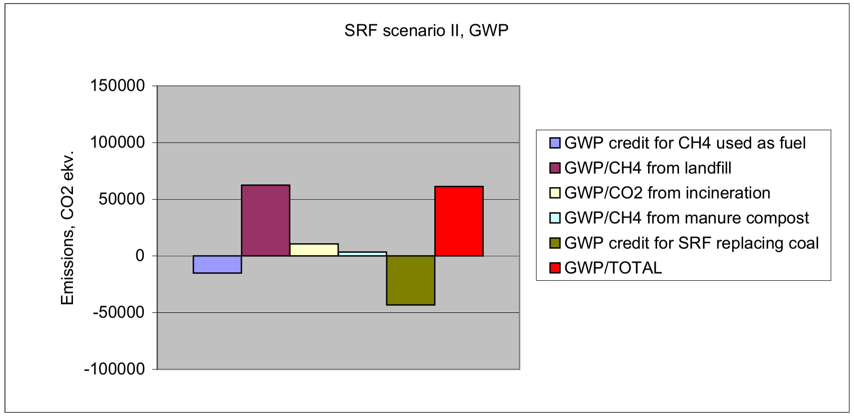
		Landfilled	Recycled	SRF	Incinerated	AD	Composted	Other	Total
		0	1	2	3	4	5	6	
1	Basic scenario	208	69		12			66	355
2	Max recycling	111	170		12			62	355
3	SRF scenario I	159	79	39	12			66	355
3	SRF scenario II	145	79	53	12			66	355
4	Incineration scenario	69	79		148			59	355
5	AD scenario I	178	84		12	55		24	353
5	AD scenario II	169	84		12	66		24	355
6	Comp scenario I	168	84		12		67	24	355
6	Comp scenario II	157	84		12		78	24	355

	Considerations related to potential total CH_4 emissions			
Collected as fuel from landfill	0.45			
Emitted from landfill	0.25			
Collected as fuel from AD	1			
Emitted from composting	0.05	Acc to RVF 0,01-11 kg/ton, corresponds to values 0-0,1		

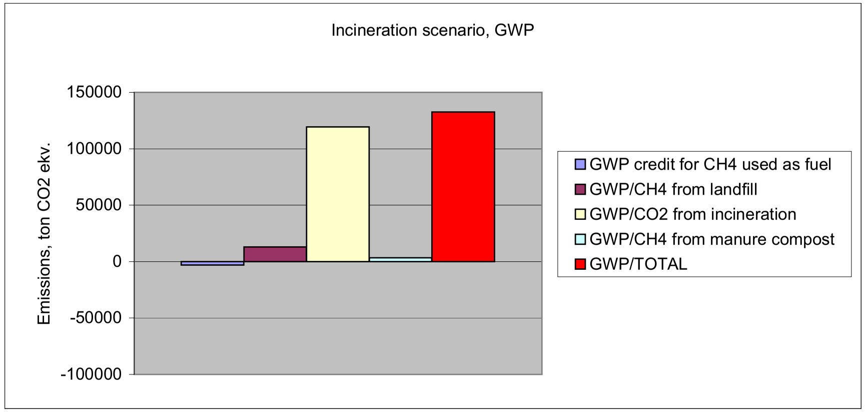


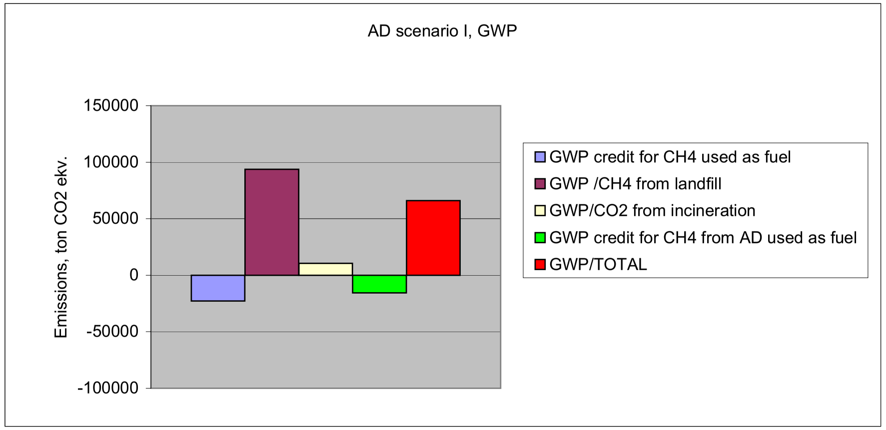


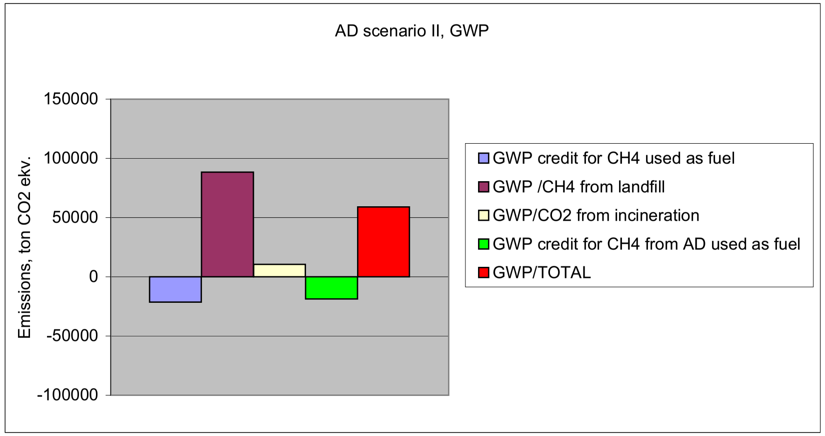


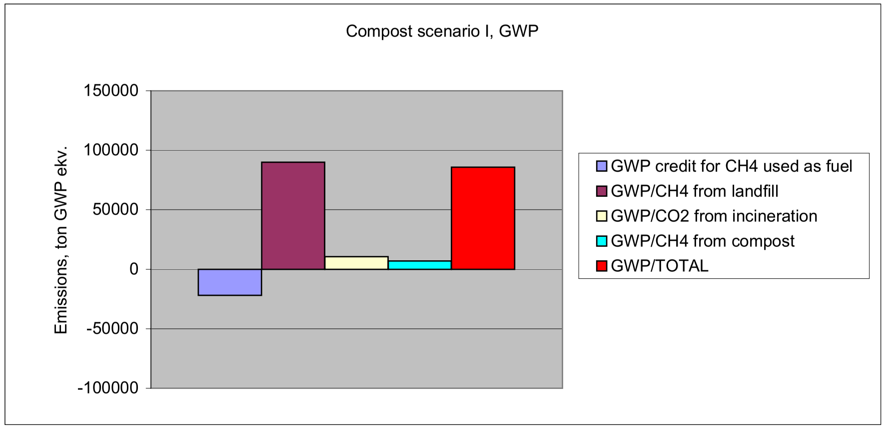


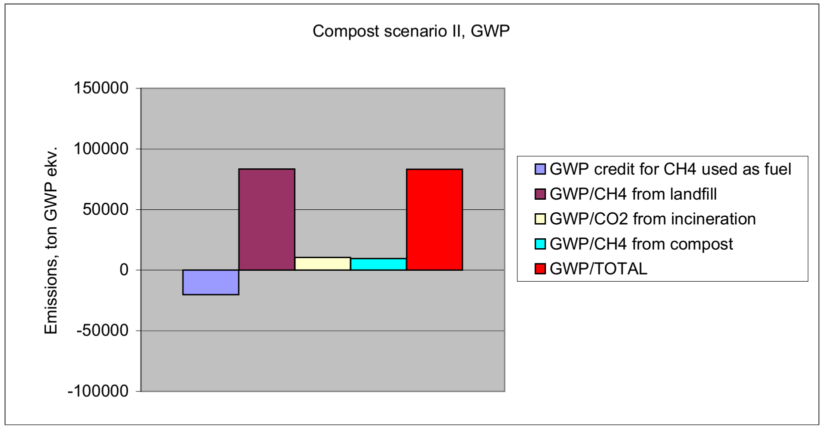
Calculation results all scenarios











Input basic scenario

	Content					Basic scenario				
		Combustable								
	Inert	Easy degr	other com	Haz	tot	Mtrl to LF	Mtrl to rec 3)	Incineration	Other treatm	Comments
Household o)	10	14	32		56	46	6	4		2)
Industrial	16	23	52	1	92	75.8	9	7		2)
Inerts, earth, glass, beton	51				51	51				This is mostly construction waste
Metals	27				27	0	27			
Tyres			3		3	0	3			Most of the tyres are recycled through private waste companies.
Construction waste	3				3	3				
Emballage not paper	6		2		8	8				
Garden			12		12	12				1)
Vegetable		5			5	1			4	
Animal manure		33			33	0			33	"recycled" in a simple way
Sewage sludge		2			2	2				
Slaughterhouse		6			6	1			5	Landfilled is mostly chicken (1), other (5) processed in meat meal plant. Fat from plant used for fuel or biodiesel.
Newsprint			5		5	0	5			
wood unpainted			17		17	0			17	Used as carbonsource at the Elkem FeSi plant
White painted wood			7		7	0			7	Landfill cover
Mixed wood			4		4	4				
Paper cardboard			12		12	0	12			
Furniture			2		2	1	1			
Textiles			1		1	0	1			
Mixed	3		6		9	3	5	1		recycling ???
Total	**116**	**83**	**155**	**1**	**355**	**208**	**69**	**12**	**66**	355

0) See tag "MSW Content"
1) Today dumped at dumping sites being closed
2) Suggested "normal" recycling rate 10%
3) With recycling means recycled as material

Calculation basic scenario

MSW content/ Industrial	Content	Percentage, weight	Inorganic	Easy degradable	Other org	HW	Incineration: Fossil C, gC/kg waste	Incineration: Fossil CO2 emissions, gCO2/kg waste	Incineration: Percentage, weight	Incineration: g CO2/kg MSW waste	Landfill: CO2 g/kg	Landfill: Total CH4 g/kg	Landfill: Percentage, weight	Landfill: g CH4/kg MSW waste
Cardboard	139	7%			139		0	0	0.07	0.0	0	240	0.07	17.5
Well	80	4%			80		0	0	0.04	0.0	0	240	0.04	10.1
Newsp	371	19%			371		0	0	0.19	0.0	0	240	0.19	46.6
Plastic PE	26	1%			26		856	2987	0.01	40.7	0	0.4	0.01	0.0
Plastic Hard	0	0%			0		656	2289	0.00	0.0	0	0.4	0.00	0.0
Glass no C	58	3%	58				0	0	0.03	0.0	0	3.3	0.03	0.1
Glass C	20	1%	20				0	0	0.01	0.0	0	3.3	0.01	0.0
Cloths	59	3%			59		278	970	0.03	30.0	0	159	0.03	4.9
Plastic bottle No C	249	13%			249		640	2234	0.13	291.3	0	0.4	0.13	0.1
Plastic bottle C	8	0%			8		640	2234	0.00	9.4	0	0.4	0.00	0.0
Al can	5	0%	5				0	0	0.00	0.0	0	0	0.00	0.0
Metal	46	2%	46				0	0	0.02	0.0	0	0	0.02	0.0
wood	22	1%			22		0	0	0.01	0.0	0	252	0.01	2.9
Milk beverag	0	0%			0		125	436	0.00	0.0	0	213	0.00	0.0
Garden w	13	1%			13		0	0	0.01	0.0	0	99.4	0.01	0.7
Diapers	105	6%			105		0	0	0.06	0.0	0	92.1	0.06	5.1
HW	14	1%				14	0	0	0.01	0.0	0	0	0.01	0.0
Stone, soil	1	0%	1				0	0	0.00	0.0	0	0	0.00	0.0
other	206	11%	206				0	0	0.11	0.0	0	0	0.11	0.0
food	477	25%		477			0	0	0.25	0.0	0	99.4	0.25	24.8
Carpets	8	0%			8		855	2984	0.00	12.5	0	19	0.00	0.1
WEEE	2	0%				2	0	0	0.00	0.0	0	0	0.00	0.0
Wax	0	0%		0			0	0	0.00	0.0	0	99.4	0.00	0.0
		100%	Inorganic	Easy degradat	Other org	HW			1.00	383.9			1.00	112.8
Total	1909		336	477	1080	16								

Waste fractions	Incineration: Fossil C, gC/kg waste	Incineration: Fossil CO2 emissions, gCO2/kg waste	Landfill: Total CH4 g/kg	Calculations, basic scenario: Mtrl to LF	Mtrl to rec 3)	Incineration	Other treatm	Comments	CH4 from landfill, ton	CO2 from incineration, ton	CH4 from manure composting, ton
Household		383.9	112.8	46.4	5.6	4	0	2)	5236	9158	
Industrial		383.9	112.8	75.8	9.2	7	0	2)	8554	0	
Inerts, earth, glass,	0	0	0	51	0	0	0	This is mostly construction w	0	0	
Metals	0	0	0	0	27	0	0	0	0	0	
Tyres	800	2792	0	0	3	0	0	Most of the tyres are recycled	0	0	
Construction waste	0	0	0	3	0	0	0	0	0	0	
Emballage not paper	400	1396	0	8	0	0	0	0	0	0	
Garden	0	0	99.4	12	0	0	0	1)	1193	0	
Vegetable	0	0	99.4	1	0	0	4	0	99	0	
Animal manure	0	0	99.4	0	0	0	33	"recycled" in a simple way	0	0	3280
Sewage sludge	0	0	99.4	2	0	0	0	0	199	0	
Slaughterhouse	0	0	99.4	1	0	0	5	Landfilled is mostly chicken (	99	0	
Newsprint	0	0	240	0	5	0	0	0	0	0	
wood unpainted	0	0	252	0	0	0	17	Used as carbonsource at the	0	0	
Painted wood	0	0	252	0	0	0	7	Landfill cover	0	0	
Mixed wood	0	0	252	4	0	0	0	0	1008	0	
Paper cardboard	0	0	240	0	12	0	0	0	0	0	
Furniture	0	0	200	1	1	0	0	0	200	0	
Textiles	278	970	159	0	1	0	0	0	0	0	
Mixed	400	1396	100	3	5	1	0	recycling ???	300	1396	
				208.2	68.8	12	66	355	16888	10554	3280

Collected as fuel	7600	Emitted as CH4	164
CO2 credit	-21507	GWP	3444
Emitted as CH4	4222		
GWP factor	88663	GWP/TOTAL	81154

Input max recycling scenario

	Content							Scenario max recycling				Comments	Recycling TODAY	Difference
		Combustable						Treated waste amount (LCA input)						
	Inert	Easy degradab	other combusti	Haz	tot	Pot recyclable 3)	% coll to rec	Mtrl to LF	Material to rec.	Incineration	Övrig behandl			
Household 0)	10	14	32		56	31	80%	27	**25**	**4**			**6**	19
Industrial	16	23	52	1	92	52	80%	44	**41**	**7**			**9**	32
Inerts, earth, glass,	51				51			5	**46**			This is mostly construction waste	**0**	46
Metals	27				27	27	100%	0	**27**				**27**	0
Tyres			3		3	3	100%	0	**3**			Most of the tyres are recycled through private waste companies.	**3**	0
Construction waste	3				3	0.9	50%	3	**0**				**0**	0
Emballage not pape	6		2		8	4	80%	5	**3**				**0**	3
Garden			12		12			12	**0**			1)	**0**	0
Vegetable		5			5			5	**0**				**0**	0
Animal manure		33			33			0			**33**	"recycled" in a simple way	**0**	0
Sewage sludge		2			2			2	**0**				**0**	0
Slaughterhouse		6			6			1			**5**	Landfilled is mostly chicken (1), other (5) processed in meat meal plant. Fat from plant used for fuel or biodiesel.	**0**	0
Newsprint			5		5	5	80%	0	**5**				**5**	0
wood unpainted			17		17			0			**17**	Used as carbonsource at the Elkem FeSi plant	**0**	0
White painted wood			7		7			0			**7**	Landfill cover	**0**	0
Mixed wood			4		4			4					**0**	0
Paper cardboard			12		12	12	100%	0	**12**				**12**	0
Furniture			2		2	1		1	**1**				**1**	0
Textiles			1		1			0	**1**				**1**	0
Mixed	3		6		9			3	**5**	**1**		recycling ???	**5**	0
Total	**116**	**83**	**155**	**1**	**355**	**136**	**7**	**111**	**170**	**12**	**62**	355	**69**	**101**

0) See tag "MSW Content"
1) Today dumped at dumping sites being closed
3) With recycling means recycled as material

Pot recyclable from Househ and Ind according to "MSW content"	**56%**
Pot recyclable construction	**30%**
Pot recyclable emballage	**50%**
Pot recyclable funiture	**50%**

4) With "recycling" means recycling as a material

Calculation max recycling scenario

MSW content/ Industrial	Content	Percentage, weight	Inorganic	Easy degradable	Other org	HW	Incineration: Fossil C, gC/kg waste	Incineration: Fossil CO2 emissions, gCO2/kg waste	Incineration: Percentage, weight	Incineration: g CO2/kg MSW waste	Landfill: CO2 g/kg	Landfill: Total CH4 g/kg	Landfill: Percentage, weight	Landfill: g CH4/kg MSW waste
Cardboard	139	11%			139		0	0	0.11	0.0	0	240	0.11	25.9
Well	80	6%			80		0	0	0.06	0.0	0	240	0.06	14.9
Newsp	0	0%			371		0	0	0.00	0.0	0	240	0.00	0.0
Plastic PE	26	2%			26		856	2987	0.02	60.3	0	0.4	0.02	0.0
Plastic Hard	0	0%			0		656	2289	0.00	0.0	0	0.4	0.00	0.0
Glass no C	58	4%	58				0	0	0.04	0.0	0	3.3	0.04	0.1
Glass C	20	2%	20				0	0	0.02	0.0	0	3.3	0.02	0.1
Cloths	59	5%			59		278	970	0.05	44.4	0	159	0.05	7.3
Plastic bottle No C	0	0%			249		640	2234	0.00	0.0	0	0.4	0.00	0.0
Plastic bottle C	8	1%			8		640	2234	0.01	13.9	0	0.4	0.01	0.0
Al can	5	0%	5				0	0	0.00	0.0	0	0	0.00	0.0
Metal	46	4%	46				0	0	0.04	0.0	0	0	0.04	0.0
wood	22	2%			22		0	0	0.02	0.0	0	252	0.02	4.3
Milk beverag	0	0%			0		125	436	0.00	0.0	0	213	0.00	0.0
Garden w	13	1%			13		0	0	0.01	0.0	0	99.4	0.01	1.0
Diapers	105	8%			105		0	0	0.08	0.0	0	92.1	0.08	7.5
HW	14	1%				14	0	0	0.01	0.0	0	0	0.01	0.0
Stone, soil	1	0%	1				0	0	0.00	0.0	0	0	0.00	0.0
other	206	16%	206				0	0	0.16	0.0	0	0	0.16	0.0
food	477	37%		477			0	0	0.37	0.0	0	99.4	0.37	36.8
Carpets	8	1%			8		855	2984	0.01	18.5	0	19	0.01	0.1
WEEE	2	0%				2	0	0	0.00	0.0	0	0	0.00	0.0
Wax	0	0%		0			0	0	0.00	0.0	0	99.4	0.00	0.0
		100%	Inorganic	Easy degradabl	Other org	HW			1.00	137.0			1.00	98.0
Total	1289		336	477	1080	16								

Waste fractions	Incineration: Fossil C, gC/kg waste	Incineration: Fossil CO2 emissions, gCO2/kg waste	Landfill: Total CH4 g/kg
Household		137.0	98.0
Industrial		137.0	98.0
Inerts, earth, glass,	0	0	0
Metals	0	0	0
Tyres	800	2792	0
Construction waste	0	0	0
Emballage not paper	400	1396	0
Garden	0	0	99.4
Vegetable	0	0	99.4
Animal manure	0	0	99.4
Sewage sludge	0	0	99.4
Slaughterhouse	0	0	99.4
Newsprint	0	0	240
wood unpainted	0	0	252
Painted wood	0	0	252
Mixed wood	0	0	252
Paper cardboard	0	0	240
Furniture	0	0	200
Textiles	278	970	159
Mixed	400	1396	100

Scenario max recycling

Waste fractions	% coll to rec	Treated waste amount (LCA input): Mtrl to LF	Material to rec.	Incineration	Övrig behandl	Comments	CH4 from landfill, ton	CO2 from incineration, ton	CH4 from manure composting, ton	Recycling 1000 ton	Recycling credits kg/ recycled ton		CO2 credits, total
Household	0.8	27	25	4	0	0	2637	9158		19	Paper		-25744
Industrial	0.8	44	41	7	0	0	4290	0		32		363	-11622
Inerts, earth, glass,	0	5	46	0	0	This is mostly construction waste	0	0		46	PET		-21114
Metals	1	0	27	0	0	0	0	0				1321	
Tyres	1	0	3	0	0	Most of the tyres are recycled throug	0	0			Glass		
Construction waste	0.5	3	0	0	0	0	0	0				459	
Emballage not paper	0.8	5	3	0	0	0	0	0					
Garden	0	12	0	0	0	1)	1193	0					
Vegetable	0	5	0	0	0	0	497	0					
Animal manure	0	0	0	0	33	"recycled" in a simple way	0	0	3280				
Sewage sludge	0	2	0	0	0	0	199	0					
Slaughterhouse	0	1	0	0	5	Landfilled is mostly chicken (1), othe	99	0					
Newsprint	0.8	0	5	0	0	0	0	0					
wood unpainted	0	0	0	0	17	Used as carbonsource at the Elkem	0	0					
Painted wood	0	0	0	0	7	Landfill cover	0	0					
Mixed wood	0	4	0	0	0	0	1008	0					
Paper cardboard	1	0	12	0	0	0	0	0					
Furniture	0	1	1	0	0	0	200	0					
Textiles	0	0	1	0	0	0	0	0					
Mixed	0	3	5	1	0	recycling ???	300	1396					
	6.7	111	170	12	62	355	10422	10554	3280				-58479

		Emitted as CH4	
Collected as fuel	4690		164
CO2 credit	-13273	GWP	3444
Emitted as CH4	2606		
GWP factor	54716	GWP/TOTAL	-3038

Input SRF I scenario

	Content					Pot recyclable 4)	Potential input for SRF 1)		Treated waste amount (LCA input)						
		Combustable									SRF I				
	Inert	Easy degr	other com	Haz	tot		I	II	Mtrl to LF	Recycled	% collected	Coll mtrl	Mtrl to Incin	Other	Comments
Household 1)	10	14	32		56	31		17	**46**	**6**	80%		**4**		
Industrial	16	23	52	1	92	52	28	28	**54**	**9**	80%	**22**	**7**		
Inerts, earth, glass, beton	51				51				**51**						This is mostly construction waste
Metals	27				27	27			**0**	**27**					
Tyres			3		3	3			**3**						Most of the tyres are recycled through private waste companies.
Construction waste	3				3	0.9			**3**						
Emballage not paper	6		2		8	4			**8**						
Garden			12		12				**12**						
Vegetable		5			5				**1**					**4**	
Animal manure		33			33				**0**					**33**	"recycled" in a simple way
Sewage sludge		2			2				**2**						
Slaughterhouse		6			6				**1**					**5**	Landfilled and processed in meat meal plant. Fat from plant used for fuel or biodiesel.
Newsprint			5		5	5	5	5	**0**		100%	**5**			
wood unpainted			17		17				**0**					**17**	Used as carbonsource at the Elkem FeSi plant
White painted wood			7		7				**0**					**7**	Landfill cover
Mixed wood			4		4				**4**						
Paper cardboard			12		12	12	12	12	**0**		100%	**12**			
Furniture			2		2	1			**1**	**1**					
Textiles			1		1				**0**	**1**					
Mixed	3		6		9				**3**	**5**			**1**		recycling ???
Total	**116**	**83**	**155**	**1**	**355**	**136**	**45**	**62**	**189**	**49**		**39**	**12**	**66**	355

1) Mainly paper and plastic in household and industry **30%**
4) With "recycling" means recycling as a material

Calculation SRF I scenario

MSW content/ Industrial	Content	Percentage, weight	Inorganic	Easy degradable	Other org	HW	
Cardboard	139	9%			139		
Well	80	5%			80		Bio coal
Newsp	160	10%			371		422
Plastic PE	26	2%			26		
Plastic Hard	0	0%			0		
Glass no C	58	4%	58				
Glass C	20	1%	20				
Cloths	59	4%			59		
Plastic bottle No C	160	10%			249		
Plastic bottle C	8	0%			8		
Al can	5	0%	5				
Metal	46	3%	46				
wood	22	1%			22		
Milk beverag	0	0%			0		
Garden w	13	1%			13		
Diapers	105	7%			105		
HW	14	1%				14	
Stone, soil	1	0%	1				
other	206	13%	206				
food	477	30%		477			
Carpets	8	0%			8		
WEEE	2	0%				2	
Wax	0	0%		0			
		100%	Inorganic	Easy degradat	Other org	HW	
Total	1609		336	477	1080	16	

MSW content/ Industrial	Incineration: Fossil C, gC/kg waste	Fossil CO2 emissions, gCO2/kg waste	Percentage, weight	g CO2/kg MSW waste	Landfill: CO2 g/kg	Total CH4 g/kg	Percentage, weight	g CH4/kg MSW waste
Cardboard	0	0	0.09	0.0	0	240	0.09	20.7
Well	0	0	0.05	0.0	0	240	0.05	11.9
Newsp	0	0	0.10	0.0	0	240	0.10	23.9
Plastic PE	856	2987	0.02	48.3	0	0.4	0.02	0.0
Plastic Hard	656	2289	0.00	0.0	0	0.4	0.00	0.0
Glass no C	0	0	0.04	0.0	0	3.3	0.04	0.1
Glass C	0	0	0.01	0.0	0	3.3	0.01	0.0
Cloths	278	970	0.04	35.6	0	159	0.04	5.8
Plastic bottle No C	640	2234	0.10	222.1	0	0.4	0.10	0.0
Plastic bottle C	640	2234	0.00	11.1	0	0.4	0.00	0.0
Al can	0	0	0.00	0.0	0	0	0.00	0.0
Metal	0	0	0.03	0.0	0	0	0.03	0.0
wood	0	0	0.01	0.0	0	252	0.01	3.4
Milk beverag	125	436	0.00	0.0	0	213	0.00	0.0
Garden w	0	0	0.01	0.0	0	99.4	0.01	0.8
Diapers	0	0	0.07	0.0	0	92.1	0.07	6.0
HW	0	0	0.01	0.0	0	0	0.01	0.0
Stone, soil	0	0	0.00	0.0	0	0	0.00	0.0
other	0	0	0.13	0.0	0	0	0.13	0.0
food	0	0	0.30	0.0	0	99.4	0.30	29.5
Carpets	855	2984	0.00	14.8	0	19	0.00	0.1
WEEE	0	0	0.00	0.0	0	0	0.00	0.0
Wax	0	0	0.00	0.0	0	99.4	0.00	0.0
			1.00	331.9			1.00	102.4

SRF	745	Kg CO2/ton
Coal	2604	Kg CO2/ton
Credit	-828	Kg CO2/ton

Waste fractions	Incineration: Fossil C, gC/kg waste	Fossil CO2 emissions, gCO2/kg waste	Landfill: Total CH4 g/kg	Mtrl to LF	Recycled	SRF I: % collected	Coll mtrl	Mtrl to Incin	Other	Comments	CH4 from landfill, ton	CO2 from incineration, ton	CH4 from manure composting, ton	Heat value KWh/ton	Kg CO2 from SRF per ton	CO2 credits, total ton
Household		331.9	102.4	46	6	1	0	4	0	0	4710	9158		SRF = 1/3 plastic plus 2/3 paper	Fossil coal	
Industrial		331.9	102.4	54	9	1	22	7	0	0	5521	0		4700	745	29096
Inerts, earth, glass, beton	0	0	0	51	0	0	0	0	0	This is mostly construction wa	0	0			Fossil plus bio coal	
Metals	0	0	0	0	27	0	0	0	0	0	0	0		Coal ekv.	1726	
Tyres	800	2792	0	3	0	0	0	0	0	Most of the tyres are recycled	0	0		7780		
Construction waste	0	0	0	3	0	0	0	0	0	0	0	0				
Emballage not paper	400	1396	0	8	0	0	0	0	0	0	0	0			CO2 from coal	
Garden	0	0	99.4	12	0	0	0	0	0	0	1193	0			2604	61466
Vegetable	0	0	99.4	1	0	0	0	0	4	0	99	0				
Animal manure	0	0	99.4	0	0	0	0	0	33	"recycled" in a simple way	0	0	3280			
Sewage sludge	0	0	99.4	2	0	0	0	0	0	0	199	0				
Slaughterhouse	0	0	99.4	1	0	0	0	0	5	Landfilled and processed in n	99	0				
Newsprint	0	0	240	0	0	1	5	0	0	0	0	0				
wood unpainted	0	0	252	0	0	0	0	0	17	Used as carbonsource at the	0	0				
Painted wood	0	0	252	0	0	0	0	0	7	Landfill cover	0	0				
Mixed wood	0	0	252	4	0	0	0	0	0	0	1008	0				
Paper cardboard	0	0	240	0	0	1	12	0	0	0	0	0				
Furniture	0	0	200	1	1	0	0	0	0	0	200	0				
Textiles	278	970	159	0	1	0	0	0	0	0	0	0				
Mixed	400	1396	100	3	5	0	0	1	0	recycling ???	300	1396				
				189	49	0	39	12	66	355	13329	10554	3280			-32370

Collected as fuel	5998	Emitted as CH4	164
CO2 credit	-16975	GWP	3444
Emitted as CH4	3332		
GWP factor	69979	GWP/TOTAL	67002

Input SRF II scenario

	Content					Pot recycl	Potential input for SRF		Treated waste amount (LCA input)						
		Combustable									SRF II				
	Inert	Easy degr	other com	Haz	tot		I	II	Mtrl to LF	Recycled	% collected	Coll mtrl	Mtrl to Incin	Other	Comments
Household 1)	10	14	32		56	31		17	**33**	**6**	80%	**13**	**4**		
Industrial	16	23	52	1	92	52	28	28	**54**	**9**	80%	**22**	**7**		
Inerts, earth, glass, beto	51				51				**51**						This is mostly construction waste
Metals	27				27	27			**0**	**27**					
Tyres			3		3	3			**3**						Most of the tyres are recycled through private waste companies.
Construction waste	3				3	0.9			**3**						
Emballage not paper	6		2		8	4			**8**						
Garden			12		12				**12**						
Vegetable		5			5				**1**					**4**	
Animal manure		33			33				**0**					**33**	"recycled" in a simple way
Sewage sludge		2			2				**2**						
Slaughterhouse		6			6				**1**					**5**	Landfilled and processed in meat meal plant. Fat from plant used for fuel or biodiesel.
Newsprint			5		5	5	5	5	**0**		100%	**5**			
wood unpainted			17		17				**0**					**17**	Used as carbonsource at the Elkem FeSi plant
White painted wood			7		7				**0**					**7**	Landfill cover
Mixed wood			4		4				**4**						
Paper cardboard			12		12	12	12	12	**0**		100%	**12**			
Furniture			2		2	1			**1**	**1**					
Textiles			1		1				**0**	**1**					
Mixed	3		6		9				**3**	**5**			**1**		recycling ???
Total	**116**	**83**	**155**	**1**	**355**	**136**	**45**	**62**	**175**	**49**		**53**	**12**	**66**	355

Calculation SRF II scenario

MSW content/ Industrial	Content	Percentage, weight	Inorganic	Easy degradable	Other org	HW	
Cardboard	139	9%			139		
Well	80	5%			80		Bio coal
Newsp	160	10%			371		422
Plastic PE	26	2%			26		
Plastic Hard	0	0%			0		
Glass no C	58	4%	58				
Glass C	20	1%	20				
Cloths	59	4%			59		
Plastic bottle No C	160	10%			249		
Plastic bottle C	8	0%			8		
Al can	5	0%	5				
Metal	46	3%	46				
wood	22	1%			22		
Milk beverag	0	0%			0		
Garden w	13	1%			13		
Diapers	105	7%			105		
HW	14	1%				14	
Stone, soil	1	0%	1				
other	206	13%	206				
food	477	30%		477			
Carpets	8	0%			8		
WEEE	2	0%				2	
Wax	0	0%		0			
		100%	Inorganic	Easy degradab	Other org	HW	
Total	1609		336	477	1080	16	

MSW content/ Industrial	Incineration: Fossil C, gC/kg waste	Incineration: Fossil CO2 emissions, gCO2/kg waste	Incineration: Percentage, weight	Incineration: g CO2/kg MSW waste	Landfill: CO2 g/kg	Landfill: Total CH4 g/kg	Landfill: Percentage, weight	Landfill: g CH4/kg MSW waste
Cardboard	0	0	0.09	0.0	0	240	0.09	20.7
Well	0	0	0.05	0.0	0	240	0.05	11.9
Newsp	0	0	0.10	0.0	0	240	0.10	23.9
Plastic PE	856	2987	0.02	48.3	0	0.4	0.02	0.0
Plastic Hard	656	2289	0.00	0.0	0	0.4	0.00	0.0
Glass no C	0	0	0.04	0.0	0	3.3	0.04	0.1
Glass C	0	0	0.01	0.0	0	3.3	0.01	0.0
Cloths	278	970	0.04	35.6	0	159	0.04	5.8
Plastic bottle No C	640	2234	0.10	222.1	0	0.4	0.10	0.0
Plastic bottle C	640	2234	0.00	11.1	0	0.4	0.00	0.0
Al can	0	0	0.00	0.0	0	0	0.00	0.0
Metal	0	0	0.03	0.0	0	0	0.03	0.0
wood	0	0	0.01	0.0	0	252	0.01	3.4
Milk beverag	125	436	0.00	0.0	0	213	0.00	0.0
Garden w	0	0	0.01	0.0	0	99.4	0.01	0.8
Diapers	0	0	0.07	0.0	0	92.1	0.07	6.0
HW	0	0	0.01	0.0	0	0	0.01	0.0
Stone, soil	0	0	0.00	0.0	0	0	0.00	0.0
other	0	0	0.13	0.0	0	0	0.13	0.0
food	0	0	0.30	0.0	0	99.4	0.30	29.5
Carpets	855	2984	0.00	14.8	0	19	0.00	0.1
WEEE	0	0	0.00	0.0	0	0	0.00	0.0
Wax	0	0	0.00	0.0	0	99.4	0.00	0.0
			1.00	331.9			1.00	102.4

Waste fractions	Incineration: Fossil C, gC/kg waste	Incineration: Fossil CO2 emissions, gCO2/kg waste	Landfill: Total CH4 g/kg	Mtrl to LF	Recycled	SRF II: % collected	Coll mtrl	Mtrl to Incin	Other	Comments
Household		331.9	102.4	32	6	1	13	4	0	0
Industrial		331.9	102.4	54	9	1	22	7	0	0
Inerts, earth, glass, beton	0	0	0	51	0	0	0	0	0	This is mostly construction w
Metals	0	0	0	0	27	0	0	0	0	0
Tyres	800	2792	0	3	0	0	0	0	0	Most of the tyres are recycle
Construction waste	0	0	0	3	0	0	0	0	0	0
Emballage not paper	400	1396	0	8	0	0	0	0	0	0
Garden	0	0	99.4	12	0	0	0	0	0	0
Vegetable	0	0	99.4	1	0	0	0	0	4	0
Animal manure	0	0	99.4	0	0	0	0	0	33	"recycled" in a simple way
Sewage sludge	0	0	99.4	2	0	0	0	0	0	0
Slaughterhouse	0	0	99.4	1	0	0	0	0	5	Landfilled and processed in
Newsprint	0	0	240	0	0	1	5	0	0	0
wood unpainted	0	0	252	0	0	0	0	0	17	Used as carbonsource at the
Painted wood	0	0	252	0	0	0	0	0	7	Landfill cover
Mixed wood	0	0	252	4	0	0	0	0	0	0
Paper cardboard	0	0	240	0	0	1	12	0	0	0
Furniture	0	0	200	1	1	0	0	0	0	0
Textiles	278	970	159	0	1	0	0	0	0	0
Mixed	400	1396	100	3	5	0	0	1	0	recycling ???
				175	49	0	52	12	66	354

Waste fractions	CH4 from landfill, ton	CO2 from incineration, ton	CH4 from manure composting, ton	Heat value KWh/ton	Kg CO2 from SRF per ton	CO2 credits, total ton
Household	3277	9158		SRF = 1/3	Fossil coal	
Industrial	5521	0		4700	745	38775
Inerts, earth, glass, beton	0	0			Fossil plus bio coal	
Metals	0	0		Coal ekv.	1726	
Tyres	0	0		7780		
Construction waste	0	0				
Emballage not paper	0	0			CO2 from coal	
Garden	1193	0			2604	81913
Vegetable	99	0				
Animal manure	0	0	3280			
Sewage sludge	199	0				
Slaughterhouse	99	0				
Newsprint	0	0				
wood unpainted	0	0				
Painted wood	0	0				
Mixed wood	1008	0				
Paper cardboard	0	0				
Furniture	200	0				
Textiles	0	0				
Mixed	300	1396				
	11896	10554	3280			-43138

Collected as fuel	5353	Emitted as CH4	164
CO2 credit	-15149	GWP	3444
Emitted as CH4	2974		
GWP factor	62454	GWP/TOTAL	61302

Input incineration scenario

	Content					Pot recyclable	Pot input for incin	Treated waste amount (LCA input)					Comments
		Combustable								Incinerated			
	Inert	Easy degr	other com	Haz	tot			Mtrl to LF	Recycled	% collected	Mtrl to incin	Other	
Household 1)	10	14	32		56	31	48	12	6	80%	38		
Industrial	16	23	52	1	92	52	78	20	9	80%	63		
Inerts, earth, glass, be	51				51			51					This is mostly construction waste
Metals	27				27	27		0	27				
Tyres			3		3	3		3					Most of the tyres are recycled through private waste companies.
Construction waste	3				3	0.9	1	2		100%	1		
Emballage not paper	6		2		8	4	1	7		100%	1		
Garden			12		12		12	0		100%	12		
Vegetable		5			5						1	4	
Animal manure		33			33			0				33	"recycled" in a simple way
Sewage sludge		2			2			2					
Slaughterhouse		6			6			1				5	Landfilled and processed in meat meal plant. Fat from plant used for fuel or biodiesel.
Newsprint			5		5	5	5	0		100%	5		
wood unpainted			17		17			0			0	17	Used as carbonsource at the Elkem FeSi plant
White painted wood			7		7			0			7		Landfill cover
Mixed wood			4		4		4	0		100%	4		
Paper cardboard			12		12	12	12	0		100%	12		
Furniture			2		2	1		0	1		1		
Textiles			1		1			0	1				
Mixed	3		6		9			1	5		3		recycling ???
Total	**116**	**83**	**155**	**1**	**355**	**136**		**99**	**49**		**148**	**59**	**355**

4) With "recycling" means recycling as a material

Calculation incineration scenario

MSW content/ Industrial	Content	Percentage, weight	Inorganic	Easy degradable	Other org	HW
Cardboard		0%			139	
Well		0%			80	
Newsp		0%			371	
Plastic PE		0%			26	
Plastic Hard		0%			0	
Glass no C	58	6%	58			
Glass C	20	2%	20			
Cloths	59	7%			59	
Plastic bottle No C		0%			249	
Plastic bottle C		0%			8	
Al can	5	1%	5			
Metal	46	5%	46			
wood		0%			22	
Milk beverag	0	0%			0	
Garden w		0%			13	
Diapers		0%			105	
HW	14	2%				14
Stone, soil	1	0%	1			
other	206	23%	206			
food	477	53%		477		
Carpets	8	1%			8	
WEEE	2	0%				2
Wax	0	0%		0		
		100%	Inorganic	Easy degradat	Other org	HW
Total	896		336	477	1080	16

MSW content/ Industrial	Incineration: Fossil C, gC/kg waste	Fossil CO2 emissions, gCO2/kg waste	Percentage, weight	g CO2/kg MSW waste	Landfill: CO2 g/kg	Total CH4 g/kg	Percentage, weight	g CH4/kg MSW waste
Cardboard	0	0	0.00	0.0	0	240	0.00	0.0
Well	0	0	0.00	0.0	0	240	0.00	0.0
Newsp	0	0	0.00	0.0	0	240	0.00	0.0
Plastic PE	856	2987	0.00	0.0	0	0.4	0.00	0.0
Plastic Hard	656	2289	0.00	0.0	0	0.4	0.00	0.0
Glass no C	0	0	0.06	0.0	0	3.3	0.06	0.2
Glass C	0	0	0.02	0.0	0	3.3	0.02	0.1
Cloths	278	970	0.07	63.9	0	159	0.07	10.5
Plastic bottle No C	640	2234	0.00	0.0	0	0.4	0.00	0.0
Plastic bottle C	640	2234	0.00	0.0	0	0.4	0.00	0.0
Al can	0	0	0.01	0.0	0	0	0.01	0.0
Metal	0	0	0.05	0.0	0	0	0.05	0.0
wood	0	0	0.00	0.0	0	252	0.00	0.0
Milk beverag	125	436	0.00	0.0	0	213	0.00	0.0
Garden w	0	0	0.00	0.0	0	99.4	0.00	0.0
Diapers	0	0	0.00	0.0	0	92.1	0.00	0.0
HW	0	0	0.02	0.0	0	0	0.02	0.0
Stone, soil	0	0	0.00	0.0	0	0	0.00	0.0
other	0	0	0.23	0.0	0	0	0.23	0.0
food	0	0	0.53	0.0	0	99.4	0.53	52.9
Carpets	855	2984	0.01	26.6	0	19	0.01	0.2
WEEE	0	0	0.00	0.0	0	0	0.00	0.0
Wax	0	0	0.00	0.0	0	99.4	0.00	0.0
			1.00	90.5			1.00	63.8

Waste fractions	Incineration: Fossil C, gC/kg waste	Fossil CO2 emissions, gCO2/kg waste	Landfill: Total CH4 g/kg
Household		90.5	63.8
Industrial		90.5	63.8
Inerts, earth, glass,	0	0	0
Metals	0	0	0
Tyres	800	2792	0
Construction waste	0	0	0
Emballage not paper	400	1396	0
Garden	0	0	99.4
Vegetable	0	0	99.4
Animal manure	0	0	99.4
Sewage sludge	0	0	99.4
Slaughterhouse	0	0	99.4
Newsprint	0	0	240
wood unpainted	0	0	252
Painted wood	0	0	252
Mixed wood	0	0	252
Paper cardboard	0	0	240
Furniture	0	0	200
Textiles	278	970	159
Mixed	400	1396	100

Mtrl to LF	Recycled	Incinerated % collected	Mtrl to incin	Other	Comments		CH4 from landfill, ton	CO2 from incineration, ton	CH4 from manure composting, ton
12	6	1	38	0	0		761	113762	
20	9	1	63	0	0		1305	0	
51	0	0	0	0	This is mostly constructio		0	0	
0	27	0	0	0	0		0	0	
3	0	0	0	0	Most of the tyres are recy		0	0	
2	0	1	1	0	0		0	0	
7	0	1	1	0	0		0	1396	
0	0	1	12	0	0		0	0	
0	0	0	1	4	0		0	0	
0	0	0	0	33	"recycled" in a simple way		0	0	3280
2	0	0	0	0	0		199	0	
1	0	0	0	5	Landfilled and processed		99	0	
0	0	1	5	0	0		0	0	
0	0	0	0	17	Used as carbonsource at		0	0	
0	0	0	7	0	Landfill cover		0	0	
0	0	1	4	0	0		0	0	
0	0	1	12	0	0		0	0	
0	1	0	1	0	0		0	0	
0	1	0	0	0	0		0	0	
1	5	0	3	0	recycling ???		100	4188	
99	49	0	148	59	355		2464	119346	3280
						Collected as fuel	1109	Emitted as CH4	164
						CO2 credit	-3138	GWP	3444
						Emitted as CH4	616		
						GWP factor	12937	GWP/TOTAL	132589

Input AD I scenario

	Content					Pot recyclable 4)	Pot input to AD		Treated waste amount (LCA input)						
		Combustable										Anaerobic dig I			
	Inert	Easy degradabl	other combust	Haz	tot		I	II	Mtrl to LF	Recycled	Incin	% collected	Mtrl to AD	Other	Comments
Household 1)	10	14	32		56	31		14	43	6	7	80%	0		1)
Industrial	16	23	52	1	92	52	23	23	61	9	4	80%	18		1)
Inerts, earth, glass, beton	51				51				51						This is mostly construction waste
Metals	27				27	27			0	27					
Tyres			3		3	3			3						Most of the tyres are recycled through private waste companies.
Construction waste	3				3	0.9			3						
Emballage not paper	6		2		8	4			8						
Garden			12		12				12						
Vegetable		5			5		5	5	1			80%	4		
Animal manure		33			33		33	33	7			80%	26		"recycled" in a simple way
Sewage sludge		2			2		2	2	0			80%	2		
Slaughterhouse		6			6		6	6	1			80%	5		Landfilled/ processed in meat meal plant. Fat from plant used for fuel or biodiesel.
Newsprint			5		5	5			0	5					
wood unpainted			17		17				0					17	Used as carbonsource at the Elkem FeSi plant
White painted wood			7		7				0					7	Landfill cover
Mixed wood			4		4				4						
Paper cardboard			12		12	12			10	2					
Furniture			2		2	1			1	1					
Textiles			1		1				0	1					
Mixed	3		6		9				3	5	1				recycling ???
Total	**116**	**83**	**155**	**1**	**355**	**136**	**69**	**83**	**208**	**56**	**12**		**55**	**24**	355

1) Easy degradable potential **25%**
4) With "recycling" means recycling as a material

Calculation AD I scenario

MSW content/ Industrial	Content	Percentage, weight	Inorganic	Easy degradable	Other org	HW	Incineration: Fossil C, gC/kg waste	Fossil CO2 emissions, gCO2/kg waste	Percentage, weight	g CO2/kg MSW waste	Landfill: CO2 g/kg	Total CH4 g/kg	Percentage, weight	g CH4/kg MSW waste
Cardboard	139	8%			139		0	0	0.08	0.0	0	240	0.08	19.5
Well	80	5%			80		0	0	0.05	0.0	0	240	0.05	11.2
Newsp	371	22%			371		0	0	0.22	0.0	0	240	0.22	52.0
Plastic PE	26	2%			26		856	2987	0.02	45.4	0	0.4	0.02	0.0
Plastic Hard	0	0%			0		656	2289	0.00	0.0	0	0.4	0.00	0.0
Glass no C	58	3%	58				0	0	0.03	0.0	0	3.3	0.03	0.1
Glass C	20	1%	20				0	0	0.01	0.0	0	3.3	0.01	0.0
Cloths	59	3%			59		278	970	0.03	33.4	0	159	0.03	5.5
Plastic bottle No C	249	15%			249		640	2234	0.15	324.9	0	0.4	0.15	0.1
Plastic bottle C	8	0%			8		640	2234	0.00	10.4	0	0.4	0.00	0.0
Al can	5	0%	5				0	0	0.00	0.0	0	0	0.00	0.0
Metal	46	3%	46				0	0	0.03	0.0	0	0	0.03	0.0
wood	22	1%			22		0	0	0.01	0.0	0	252	0.01	3.2
Milk beverag	0	0%			0		125	436	0.00	0.0	0	213	0.00	0.0
Garden w	13	1%			13		0	0	0.01	0.0	0	99.4	0.01	0.8
Diapers	105	6%			105		0	0	0.06	0.0	0	92.1	0.06	5.6
HW	14	1%				14	0	0	0.01	0.0	0	0	0.01	0.0
Stone, soil	1	0%	1				0	0	0.00	0.0	0	0	0.00	0.0
other	206	12%	206				0	0	0.12	0.0	0	0	0.12	0.0
food	280	16%		477			0	0	0.16	0.0	0	99.4	0.16	16.3
Carpets	8	0%			8		855	2984	0.00	13.9	0	19	0.00	0.1
WEEE	2	0%				2	0	0	0.00	0.0	0	0	0.00	0.0
Wax	0	0%		0			0	0	0.00	0.0	0	99.4	0.00	0.0
		100%	Inorganic	Easy degrada	Other org	HW			1.00	428.1			1.00	114.4
Total	1712		336	477	1080	16								

Waste fractions	Incineration: Fossil C, gC/kg waste	Fossil CO2 emissions, gCO2/kg waste	Landfill: Total CH4 g/kg
Household		428.1	114.4
Industrial		428.1	114.4
Inerts, earth, glass,	0	0	0
Metals	0	0	0
Tyres	800	2792	0
Construction waste	0	0	0
Emballage not paper	400	1396	0
Garden	0	0	99.4
Vegetable	0	0	99.4
Animal manure	0	0	99.4
Sewage sludge	0	0	99.4
Slaughterhouse	0	0	99.4
Newsprint	0	0	240
wood unpainted	0	0	252
Painted wood	0	0	252
Mixed wood	0	0	252
Paper cardboard	0	0	240
Furniture	0	0	200
Textiles	278	970	159
Mixed	400	1396	100

					Other	Comments				
Mtrl to LF			Anaerobic dig I							
0	Recycled	Incin	% collected	Mtrl to AD	0			CH4 from landfill, ton	CO2 from incineration, ton	CH4 from AD, ton
43	6	7	1	0	0	1)		4919	9158	0
61	9	4	1	18	0	1)		6932	0	0
51	0	0	0	0	0	This is mostly constructio		0	0	0
0	27	0	0	0	0	0		0	0	0
3	0	0	0	0	0	Most of the tyres are recy		0	0	0
3	0	0	0	0	0	0		0	0	0
8	0	0	0	0	0	0		0	0	0
12	0	0	0	0	0	0		1193	0	0
1	0	0	1	4	0	0		99	0	397.6
7	0	0	1	26	0	"recycled" in a simple way		656	0	4453.12
0	0	0	1	2	0	0		40	0	159.04
1	0	0	1	5	0	Landfilled/ processed in m		119	0	477.12
0	5	0	0	0	0	0		0	0	0
0	0	0	0	0	17	Used as carbonsource at		0	0	0
0	0	0	0	0	7	Landfill cover		0	0	0
4	0	0	0	0	0	0		1008	0	0
10	2	0	0	0	0	0		2400	0	0
1	1	0	0	0	0	0		200	0	0
0	1	0	0	0	0	0		0	0	0
3	5	1	0	0	0	recycling ???		300	1396	0
208	56	12	0	55	24	355		17866	10554	5487
							Collected as fuel	8040		5487
							CO2 credit	-22753		-15528
							Emitted as CH4	4467		
							GWP factor	93799	GWP/TOTAL	66072

Input AD II scenario

	Content					Pot recyclab	Pot input to AD		Treated waste amount (LCA input)						Comments
		Combustable										Anaerobic dig II			
	Inert	Easy degr	other com	Haz	tot		I	II	Mtrl to LF	Recycled	Incin	% collected	Mtrl to AD	Other	
Household	10	14	32		56	31		14	32	6	7	80%	11		1)
Industrial	16	23	52	1	92	52	23	23	61	9	4	80%	18		1)
Inerts, ear	51				51				51						This is mostly construction waste
Metals	27				27	27			0	27					
Tyres			3		3	3			3						Most of the tyres are recycled through private waste companies.
Construct	3				3	0.9			3						
Emballage	6		2		8	4			8						
Garden			12		12				12						
Vegetable		5			5		5	5	1			80%	4		
Animal manure		33			33		33	33	7			80%	26		"recycled" in a simple way
Sewage sludge		2			2		2	2	0			80%	2		
Slaughterhouse		6			6		6	6	1			80%	5		Landfilled/ processed in meat meal plant. Fat from plant used for fuel or biodiesel.
Newsprint			5		5	5			0	5					
wood unpainted			17		17				0					17	Used as carbonsource at the Elkem FeSi plant
White painted wood			7		7				0					7	Landfill cover
Mixed wood			4		4				4						
Paper cardboard			12		12	12			12						
Furniture			2		2	1			1	1					
Textiles			1		1				0	1					
Mixed	3		6		9				3	5	1				recycling ???
Total	**116**	**83**	**155**	**1**	**355**	**136**	**69**	**83**	**199**	**54**	**12**		**66**	**24**	355

1) Easy degradable p 25%
4) With "recycling" means recycling as a material

Calculation AD II scenario

MSW content/ Industrial	Content	Percentage, weight	Inorganic	Easy degradable	Other org	HW
Cardboard	139	8%			139	
Well	80	5%			80	
Newsp	371	22%			371	
Plastic PE	26	2%			26	
Plastic Hard	0	0%			0	
Glass no C	58	3%	58			
Glass C	20	1%	20			
Cloths	59	3%			59	
Plastic bottle No C	249	15%			249	
Plastic bottle C	8	0%			8	
Al can	5	0%	5			
Metal	46	3%	46			
wood	22	1%			22	
Milk beverag	0	0%			0	
Garden w	13	1%			13	
Diapers	105	6%			105	
HW	14	1%				14
Stone, soil	1	0%	1			
other	206	12%	206			
food	280	16%		477		
Carpets	8	0%			8	
WEEE	2	0%				2
Wax	0	0%		0		
		100%	Inorganic	Easy degradabl	Other org	HW
Total	1712		336	477	1080	16

MSW content/ Industrial	Incineration: Fossil C, gC/kg waste	Fossil CO2 emissions, gCO2/kg waste	Percentage, weight	g CO2/kg MSW waste
Cardboard	0	0	0.08	0.0
Well	0	0	0.05	0.0
Newsp	0	0	0.22	0.0
Plastic PE	856	2987	0.02	45.4
Plastic Hard	656	2289	0.00	0.0
Glass no C	0	0	0.03	0.0
Glass C	0	0	0.01	0.0
Cloths	278	970	0.03	33.4
Plastic bottle No C	640	2234	0.15	324.9
Plastic bottle C	640	2234	0.00	10.4
Al can	0	0	0.00	0.0
Metal	0	0	0.03	0.0
wood	0	0	0.01	0.0
Milk beverag	125	436	0.00	0.0
Garden w	0	0	0.01	0.0
Diapers	0	0	0.06	0.0
HW	0	0	0.01	0.0
Stone, soil	0	0	0.00	0.0
other	0	0	0.12	0.0
food	0	0	0.16	0.0
Carpets	855	2984	0.00	13.9
WEEE	0	0	0.00	0.0
Wax	0	0	0.00	0.0
			1.00	428.1

MSW content/ Industrial	Landfill: CO2 g/kg	Total CH4 g/kg	Percentage, weight	g CH4/kg MSW waste
Cardboard	0	240	0.08	19.5
Well	0	240	0.05	11.2
Newsp	0	240	0.22	52.0
Plastic PE	0	0.4	0.02	0.0
Plastic Hard	0	0.4	0.00	0.0
Glass no C	0	3.3	0.03	0.1
Glass C	0	3.3	0.01	0.0
Cloths	0	159	0.03	5.5
Plastic bottle No C	0	0.4	0.15	0.1
Plastic bottle C	0	0.4	0.00	0.0
Al can	0	0	0.00	0.0
Metal	0	0	0.03	0.0
wood	0	252	0.01	3.2
Milk beverag	0	213	0.00	0.0
Garden w	0	99.4	0.01	0.8
Diapers	0	92.1	0.06	5.6
HW	0	0	0.01	0.0
Stone, soil	0	0	0.00	0.0
other	0	0	0.12	0.0
food	0	99.4	0.16	16.3
Carpets	0	19	0.00	0.1
WEEE	0	0	0.00	0.0
Wax	0	99.4	0.00	0.0
			1.00	114.4

Waste fractions	Incineration: Fossil C, gC/kg waste	Incineration: Fossil CO2 emissions, gCO2/kg waste	Landfill: Total CH4 g/kg
Household		428.1	114.4
Industrial		428.1	114.4
Inerts, earth, glass, beton	0	0	0
Metals	0	0	0
Tyres	800	2792	0
Construction waste	0	0	0
Emballage not paper	400	1396	0
Garden	0	0	99.4
Vegetable	0	0	99.4
Animal manure	0	0	99.4
Sewage sludge	0	0	99.4
Slaughterhouse	0	0	99.4
Newsprint	0	0	240
wood unpainted	0	0	252
Painted wood	0	0	252
Mixed wood	0	0	252
Paper cardboard	0	0	240
Furniture	0	0	200
Textiles	278	970	159
Mixed	400	1396	100

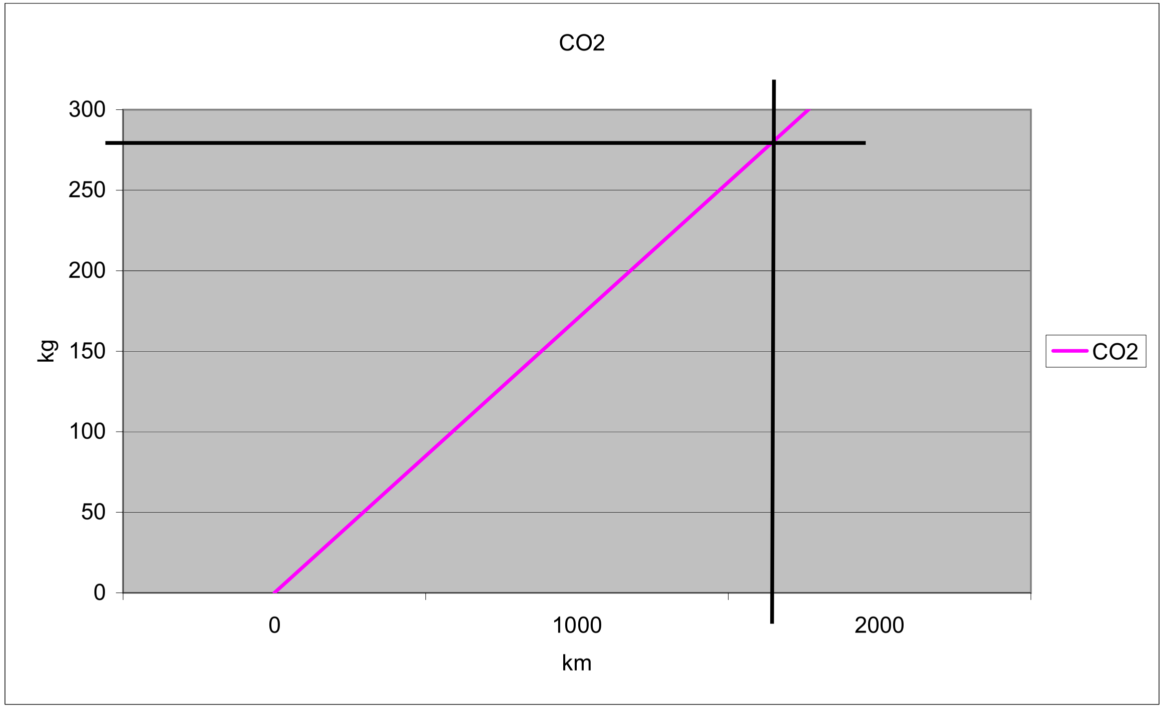
Waste fractions	Mtrl to LF			Anaerobic dig II		Other	Comments			
	0	Recycled	Incin	% collected	Mtrl to AD	0		CH4 from landfill, ton	CO2 from incineration, ton	CH4 from AD, ton
Household	34	6	7	1	0	0	1)	3889	9158	0
Industrial	61	9	4	1	18	0	1)	6932	0	0
Inerts, earth, glass, beton	51	0	0	0	0	0	This is mostly construction	0	0	0
Metals	0	27	0	0	0	0	0	0	0	0
Tyres	3	0	0	0	0	0	Most of the tyres are recycl	0	0	0
Construction waste	3	0	0	0	0	0	0	0	0	0
Emballage not paper	8	0	0	0	0	0	0	0	0	0
Garden	12	0	0	0	0	0	0	1193	0	0
Vegetable	1	0	0	1	4	0	0	99	0	397.6
Animal manure	7	0	0	1	26	0	"recycled" in a simple way	656	0	5546.52
Sewage sludge	0	0	0	1	2	0	0	40	0	159.04
Slaughterhouse	1	0	0	1	5	0	Landfilled/ processed in me	119	0	477.12
Newsprint	0	5	0	0	0	0	0	0	0	0
wood unpainted	0	0	0	0	0	17	Used as carbonsource at th	0	0	0
Painted wood	0	0	0	0	0	7	Landfill cover	0	0	0
Mixed wood	4	0	0	0	0	0	0	1008	0	0
Paper cardboard	10	0	0	0	0	0	0	2400	0	0
Furniture	1	1	0	0	0	0	0	200	0	0
Textiles	0	1	0	0	0	0	0	0	0	0
Mixed	3	5	1	0	0	0	recycling ???	300	1396	0
	199	54	12	0	66	24	355	16837	10554	6580
							Collected as fuel	7577		6580
					11		CO2 credit	-21442		-18622
							Emitted as CH4	4209		
							GWP factor	88394	GWP/TOTAL	58884

Transport AD scenario

1 ton of easy degradable material produces maximun 99,4 kg CH_4 per ton waste in an AD process.

1 kg biomethane reduces CO_2 emissions by 2,83 kg when replacing petrol in vehicles.

99,4 kg biomethane replacing petrol in vehicles reduces fossil CO_2 emissions in total 280 kg CO_2.



Distance	**0**	**1000**	**2000**	**km**
CO2 emissions	**0**	**170**	**340**	**kg**

	Använd fordonstyp	Utsläpp av CO2 per tonkm (NTM)	Uppskattning av transportarbete	Årliga utsläpp av koldioxid
Båt	Lastfartyg > 8 000 dwt	0,012 kg	10 000 000 tonkm	120 ton
Lastbil	Tung lastbil med släp	0,047 kg	100 000 tonkm	4,7 ton
Lastbil	Distributionsbil	0,17 kg	10 000 tonkm	1,7 ton

http://www.ntm.a.se/index.asp

Input compost I scenario

	Content					Pot recyclable 4)	Pot input to Comp		Treated waste amount (LCA input)						
		Combustable										Comp I			
	Inert	Easy degr	other com	Haz	tot		I	II	Mtrl to LF	Recycled	Incin	% collected	Mtrl to Comp	Other	Comments
Household	10	14	32		56	31		14	43	6	7	80%	0		1)
Industrial	16	23	52	1	92	52	23	23	61	9	4	80%	18		1)
Inerts, earth, glass	51				51				51						This is mostly construction waste
Metals	27				27	27			0	27					
Tyres			3		3	3			3						Most of the tyres are recycled through private waste companies.
Construction wast	3				3	0.9			3						
Emballage not pap	6		2		8	4			8						
Garden			12		12		12	12	0				12		1)
Vegetable		5			5		5	5	1			80%	4		
Animal manure		33			33		33	33	7			80%	26		"recycled" in a simple way
Sewage sludge		2			2		2	2	0			80%	2		
Slaughterhouse		6			6		6	6	1			80%	5		Landfilled/ processed in meat meal plant. Fat from plant used for fuel or biodiesel.
Newsprint			5		5	5			0	5					
wood unpainted			17		17				0					17	Used as carbonsource at the Elkem FeSi plant
White painted wood			7		7				0					7	Landfill cover
Mixed wood			4		4				4						
Paper cardboard			12		12	12			12						
Furniture			2		2	1			1	1					
Textiles			1		1				0	1					
Mixed	3		6		9				3	5	1				recycling ???
Total	**116**	**83**	**155**	**1**	**355**	**136**	**81**	**95**	**198**	**54**	**12**		**67**	**24**	355

1) Easy degradable potential 25%
4) With "recycling" means recycling as a material

Calculation compost I scenario

MSW content/ Industrial	Content	Percentage, weight	Inorganic	Easy degradable	Other org	HW	Incineration: Fossil C, gC/kg waste	Incineration: Fossil CO2 emissions, gCO2/kg waste	Incineration: Percentage, weight	Incineration: g CO2/kg MSW waste	Landfill: CO2 g/kg	Landfill: Total CH4 g/kg	Landfill: Percentage, weight	Landfill: g CH4/kg MSW waste
Cardboard	139	8%			139		0	0	0.08	0.0	0	240	0.08	19.5
Well	80	5%			80		0	0	0.05	0.0	0	240	0.05	11.2
Newsp	371	22%			371		0	0	0.22	0.0	0	240	0.22	52.0
Plastic PE	26	2%			26		856	2987	0.02	45.4	0	0.4	0.02	0.0
Plastic Hard	0	0%			0		656	2289	0.00	0.0	0	0.4	0.00	0.0
Glass no C	58	3%	58				0	0	0.03	0.0	0	3.3	0.03	0.1
Glass C	20	1%	20				0	0	0.01	0.0	0	3.3	0.01	0.0
Cloths	59	3%			59		278	970	0.03	33.4	0	159	0.03	5.5
Plastic bottle No C	249	15%			249		640	2234	0.15	324.9	0	0.4	0.15	0.1
Plastic bottle C	8	0%			8		640	2234	0.00	10.4	0	0.4	0.00	0.0
Al can	5	0%	5				0	0	0.00	0.0	0	0	0.00	0.0
Metal	46	3%	46				0	0	0.03	0.0	0	0	0.03	0.0
wood	22	1%			22		0	0	0.01	0.0	0	252	0.01	3.2
Milk beverag	0	0%			0		125	436	0.00	0.0	0	213	0.00	0.0
Garden w	13	1%			13		0	0	0.01	0.0	0	99.4	0.01	0.8
Diapers	105	6%			105		0	0	0.06	0.0	0	92.1	0.06	5.6
HW	14	1%				14	0	0	0.01	0.0	0	0	0.01	0.0
Stone, soil	1	0%	1				0	0	0.00	0.0	0	0	0.00	0.0
other	206	12%	206				0	0	0.12	0.0	0	0	0.12	0.0
food	280	16%		477			0	0	0.16	0.0	0	99.4	0.16	16.3
Carpets	8	0%			8		855	2984	0.00	13.9	0	19	0.00	0.1
WEEE	2	0%				2	0	0	0.00	0.0	0	0	0.00	0.0
Wax	0	0%		0			0	0	0.00	0.0	0	99.4	0.00	0.0
		100%	Inorganic	Easy degradat	Other org	HW			1.00	428.1			1.00	114.4
Total	1712		336	477	1080	16								

Waste fractions	Incineration: Fossil C, gC/kg waste	Incineration: Fossil CO2 emissions, gCO2/kg waste	Landfill: Total CH4 g/kg	Mtrl to LF	Recycled	Incin	Comp I: % collected	Mtrl to Comp	Other	Comments		CH4 from landfill, ton	CO2 from incineration, ton	CH4 from comp, ton
Household		428.1	114.4	43	6	7	1	0	0	1)		4919	9158	0
Industrial		428.1	114.4	61	9	4	1	18	0	1)		6932	0	0
Inerts, earth, glass, beton	0	0	0	51	0	0	0	0	0	This is mostly construction		0	0	0
Metals	0	0	0	0	27	0	0	0	0	0		0	0	0
Tyres	800	2792	0	3	0	0	0	0	0	Most of the tyres are recycl		0	0	0
Construction waste	0	0	0	3	0	0	0	0	0	0		0	0	0
Emballage not paper	400	1396	0	8	0	0	0	0	0	0		0	0	0
Garden	0	0	99.4	0	0	0	0	12	0	1)		0	0	1192.8
Vegetable	0	0	99.4	1	0	0	1	4	0	0		99	0	397.6
Animal manure	0	0	99.4	7	0	0	1	26	0	"recycled" in a simple way		656	0	4453.12
Sewage sludge	0	0	99.4	0	0	0	1	2	0	0		40	0	159.04
Slaughterhouse	0	0	99.4	1	0	0	1	5	0	Landfilled/ processed in me		119	0	477.12
Newsprint	0	0	240	0	5	0	0	0	0	0		0	0	0
wood unpainted	0	0	252	0	0	0	0	0	17	Used as carbonsource at th		0	0	0
Painted wood	0	0	252	0	0	0	0	0	7	Landfill cover		0	0	0
Mixed wood	0	0	252	4	0	0	0	0	0	0		1008	0	0
Paper cardboard	0	0	240	12	0	0	0	0	0	0		2880	0	0
Furniture	0	0	200	1	1	0	0	0	0	0		200	0	0
Textiles	278	970	159	0	1	0	0	0	0	0		0	0	0
Mixed	400	1396	100	3	5	1	0	0	0	recycling ???		300	1396	0
				198	54	12	0	67	24	355		17154	10554	6680
											Collected as fuel	7719	CH4 emissions	334
											CO2 credit	-21845	GWP factor	7014
											Emitted as CH4	4288		
											GWP factor	90057	GWP/TOTAL	85779

Input compost II scenario

	Content					Pot recyclable 4)	Pot input to Comp		Treated waste amount (LCA input)						
		Combustable										Comp II			
	Inert	Easy degrad	other combusti	Haz	tot		I	II	Mtrl to LF	Recycled	Incin	% collected	Mtrl to Comp	Other	Comments
Household	10	14	32		56	31		14	32	6	7	80%	11		1)
Industrial	16	23	52	1	92	52	23	23	61	9	4	80%	18		1)
Inerts, earth, glass, beton	51				51				51						This is mostly construction waste
Metals	27				27	27			0	27					
Tyres			3		3	3			3						Most of the tyres are recycled through private waste companies.
Construction waste	3				3	0.9			3						
Emballage not paper	6		2		8	4			8						
Garden			12		12		12	12	0				12		1)
Vegetable		5			5		5	5	1			80%	4		
Animal manure		33			33		33	33	7			80%	26		"recycled" in a simple way
Sewage sludge		2			2		2	2	0			80%	2		
Slaughterhouse		6			6		6	6	1			80%	5		Landfilled/ processed in meat meal plant. Fat from plant used for fuel or biodiesel.
Newsprint			5		5	5			0	5					
wood unpainted			17		17				0					17	Used as carbonsource at the Elkem FeSi plant
White painted wood			7		7				0					7	Landfill cover
Mixed wood			4		4				4						
Paper cardboard			12		12	12			12						
Furniture			2		2	1			1	1					
Textiles			1		1				0	1					
Mixed	3		6		9				3	5	1				recycling ???
Total	**116**	**83**	**155**	**1**	**355**	**136**	**81**	**95**	**187**	**54**	**12**		**78**	**24**	355

1) Easy degradable potential 25%
4) With "recycling" means recycling as a material

Calculation compost II scenario

MSW content/ Industrial	Content	Percentage, weight	Inorganic	Easy degradable	Other org	HW	Incineration: Fossil C, gC/kg waste	Incineration: Fossil CO2 emissions, gCO2/kg waste	Incineration: Percentage, weight	Incineration: g CO2/kg MSW waste	Landfill: CO2 g/kg	Landfill: Total CH4 g/kg	Landfill: Percentage, weight	Landfill: g CH4/kg MSW waste
Cardboard	139	8%			139		0	0	0.08	0.0	0	240	0.08	19.5
Well	80	5%			80		0	0	0.05	0.0	0	240	0.05	11.2
Newsp	371	22%			371		0	0	0.22	0.0	0	240	0.22	52.0
Plastic PE	26	2%			26		856	2987	0.02	45.4	0	0.4	0.02	0.0
Plastic Hard	0	0%			0		656	2289	0.00	0.0	0	0.4	0.00	0.0
Glass no C	58	3%	58				0	0	0.03	0.0	0	3.3	0.03	0.1
Glass C	20	1%	20				0	0	0.01	0.0	0	3.3	0.01	0.0
Cloths	59	3%			59		278	970	0.03	33.4	0	159	0.03	5.5
Plastic bottle No C	249	15%			249		640	2234	0.15	324.9	0	0.4	0.15	0.1
Plastic bottle C	8	0%			8		640	2234	0.00	10.4	0	0.4	0.00	0.0
Al can	5	0%	5				0	0	0.00	0.0	0	0	0.00	0.0
Metal	46	3%	46				0	0	0.03	0.0	0	0	0.03	0.0
wood	22	1%			22		0	0	0.01	0.0	0	252	0.01	3.2
Milk beverag	0	0%			0		125	436	0.00	0.0	0	213	0.00	0.0
Garden w	13	1%			13		0	0	0.01	0.0	0	99.4	0.01	0.8
Diapers	105	6%			105		0	0	0.06	0.0	0	92.1	0.06	5.6
HW	14	1%				14	0	0	0.01	0.0	0	0	0.01	0.0
Stone, soil	1	0%	1				0	0	0.00	0.0	0	0	0.00	0.0
other	206	12%	206				0	0	0.12	0.0	0	0	0.12	0.0
food	280	16%		477			0	0	0.16	0.0	0	99.4	0.16	16.3
Carpets	8	0%			8		855	2984	0.00	13.9	0	19	0.00	0.1
WEEE	2	0%				2	0	0	0.00	0.0	0	0	0.00	0.0
Wax	0	0%		0			0	0	0.00	0.0	0	99.4	0.00	0.0
		100%	Inorganic	Easy degrada	Other org	HW			1.00	428.1			1.00	114.4
Total	1712		336	477	1080	16								

Waste fractions	Incineration: Fossil C, gC/kg waste	Incineration: Fossil CO2 emissions, gCO2/kg waste	Landfill: Total CH4 g/kg
Household		428.1	114.4
Industrial		428.1	114.4
Inerts, earth, glass,	0	0	0
Metals	0	0	0
Tyres	800	2792	0
Construction waste	0	0	0
Emballage not	400	1396	0
Garden	0	0	99.4
Vegetable	0	0	99.4
Animal manure	0	0	99.4
Sewage sludge	0	0	99.4
Slaughterhouse	0	0	99.4
Newsprint	0	0	240
wood unpainted	0	0	252
Painted wood	0	0	252
Mixed wood	0	0	252
Paper cardboard	0	0	240
Furniture	0	0	200
Textiles	278	970	159
Mixed	400	1396	100

Waste fractions	Mtrl to LF	Recycled	Incin	Comp II: % collected	Mtrl to Comp	Other	Comments	CH4 from landfill, ton	CO2 from incineration, ton	CH4 from comp, ton
Household	32	6	7	1	11	0	1)	3661	9158	1258.333
Industrial	61	9	4	1	18	0	1)	6932	0	0
Inerts, earth, glass,	51	0	0	0	0	0	This is mostly constructi	0	0	0
Metals	0	27	0	0	0	0	0	0	0	0
Tyres	3	0	0	0	0	0	Most of the tyres are rec	0	0	0
Construction waste	3	0	0	0	0	0	0	0	0	0
Emballage not	8	0	0	0	0	0	0	0	0	0
Garden	0	0	0	0	12	0	1)	0	0	1192.8
Vegetable	1	0	0	1	4	0	0	99	0	397.6
Animal manure	7	0	0	1	26	0	"recycled" in a simple wa	656	0	5546.52
Sewage sludge	0	0	0	1	2	0	0	40	0	159.04
Slaughterhouse	1	0	0	1	5	0	Landfilled/ processed in	119	0	477.12
Newsprint	0	5	0	0	0	0	0	0	0	0
wood unpainted	0	0	0	0	0	17	Used as carbonsource a	0	0	0
Painted wood	0	0	0	0	0	7	Landfill cover	0	0	0
Mixed wood	4	0	0	0	0	0	0	1008	0	0
Paper cardboard	12	0	0	0	0	0	0	2880	0	0
Furniture	1	1	0	0	0	0	0	200	0	0
Textiles	0	1	0	0	0	0	0	0	0	0
Mixed	3	5	1	0	0	0	recycling ???	300	1396	0
	187	54	12	0	78	24	355	15895	10554	9031
					11		Collected as fuel	7153	CH4 emissions	452
							CO2 credit	-20243	GWP factor	9483
							Emitted as CH4	3974		
							GWP factor	83451	GWP/TOTAL	83245