Sweden, Country Report Update 2012

Update on policy and legislation affecting energy recovery from waste

The overall Swedish environmental policy and objective regarding waste management haven't changed, but some legal instruments have been adopted or altered.

The tax on incineration of MSW for example was abolished again in 2010. The tax was constructed both to favor material recycling (including biological treatment) and to give an incentive for combined heat and power generation from the waste. The report preceding the abolishment of the tax stated that it was not the right instrument to fulfill the main purpose which was to favor material recycling and biological treatment [Hjalmarsson 2009].

Another policy instrument from 2010 is the tax exemption for biogas (usually upgraded biogas) that is transported in pipelines. This tax exemption applies all the way to the client. The instrument had influence on the development of AD plants and in particular the downstream treatment and use of biogas. Furthermore landfill gas was redefined in such a way that it is now included into biogas legislation.

In 2012 the Swedish Environmental Protection Agency established a new national waste plan for the period 2012-2017 [Naturvårdverket 2012] which in accordance with EU regulations for example defines measures for waste prevention and implements definitions for by-product or end-of waste criteria. Furthermore new National Environmental Targets were introduced as well. As an example the new target regarding the treatment of food waste states that by 2018 at least 50 percent of food waste from households, restaurants, large-scale kitchens and stores shall be treaded biological for nutrition recovery, with total 40 percent including even energy recovery. At the same time the overall food waste generation shall decrease by 20 percent compared to the amount in 2010. The waste plan also generally sets focus on moving up in the waste hierarchy, which might affect waste-to-energy in the long run. One of the targets set is also that waste-to-energy plants should have installed continuous sampling of dioxins and furans in 2015. However the national waste plan has no real juridical status, but indicates the direction in which the EPA will work.

During 2011 and 2012 a public inquiry was made on the subject of solid waste management. The focus of the study has been to give a general overview of Swedish waste management and to suggest improvements. A special focus was put on the responsibility for collection and treatment of waste from households, but commercial and industrial waste is also included. The resulting report (Ekecrantz 2012) contains a number of suggestions to improve waste management. It put heavy emphasis on the waste hierarchy and that measures should be taken to move upwards in the hierarchy. It also suggests that a public inquiry should be initiated on the subject of a ban or a tax on incineration of selected materials. It also suggests that biological treatment without the recovery and reuse of nutrients should be classified at the same level as waste-to-energy.

Starting with 2013 the Swedish EfW incineration plants are almost exclusively included into the third EU Emission Trading System (ETS) period 2013-2020. The inclusion is not by opt-in but by considering the plants as co-incineration plants due to their high energy efficiency. Due to the constant decrease in free allocation of CO_2 certificates the impact of the ETS will increase over the following years. This inclusion also has added an uncertainty about monitoring and reporting of CO_2 since the regulations are not well suited for complex fuels as waste.

Current situation for MSW management

The amount of treated MSW in 2011 stayed nearly unchanged at 4.35 Mt when compared with figures from 2007 [Avfall Sverige 2012]. After a steady rise in the first years of the new millennium it peaked at 2007/2008 with around 4.5 Mt, followed by a decline the next two years. Last year an increase in treated MSW could be seen again, but the absolute volume was still lower than in 2007. Whether this development primarily depends on the economy crises or whether this is already a real change towards reduction in waste generation will be seen in the following years.

The breakdown numbers for the single treatment methods biological treatment, incineration with energy recovery, material recycling and landfill are displayed in Figure 1 in comparison for the years 2011 and 2007[1]. The development during the last 10 years can be seen at Figure 2[2].

Treatment method	2011		2007[1]	
	Amount (tons)	Amount (kg/capita)	Amount (tons)	Amount (kg/capita)
Material Recycling	1 425 690	150,3	1 591 180	173,3
Biological Treatment	650 300	68,6	561 300	61,1
Incineration with Energy Recovery	2 235 720	235,8	2 190 980	238,6
Landfill	38 200	4,0	186 490	20,3
Total	**4 349 910**	**458,7**	**4 529 950**	**493,3**

Figure 1 Treated MSW volumes in Sweden for 2011 and 2007 (Source Avfall Sverige 2012)

[1] Values for 2007 have been altered from last country report due to the fraction of office paper, which has been included in the material recycling amount before, is not considered anymore. Furthermore the amount of hazardous waste that was reported as an own treatment method in the last report has now been distributed into to the actually used treatment methods.

[2] The altered values between 2007 and 2011 (change due to new definition of office paper and hazardous waste treatment) have been officially published by Avfall Sverige [Avfall Sverige 2012]. The values for material recycling and total waste (dotted lines) for 2001 - 2006 have been altered by own hand using reported figures for office paper and hazardous waste streams in these years.

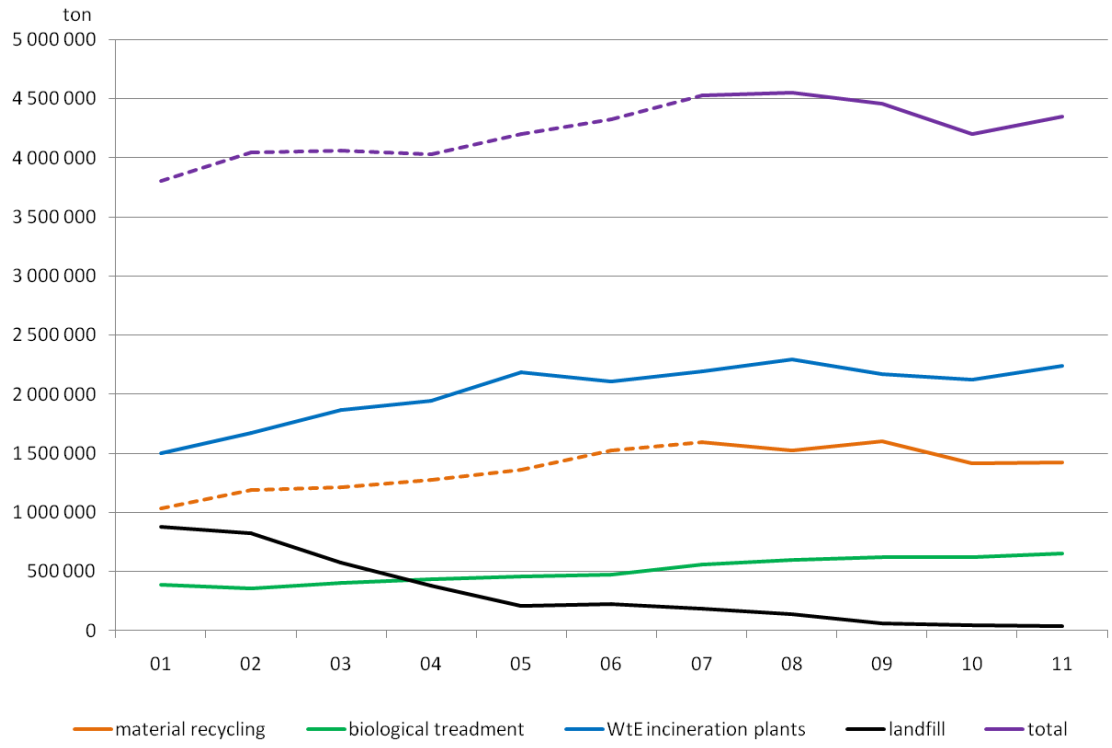

Figure 2 Treated MSW volumes in Sweden between 2001 and 2011 (Source Avfall Sverige)

While the volume of MSW treated with incineration and material recycling remained static or even decreased a distinct development can be observed for landfill and biological treatment.

Landfilled waste decreased from more than 20 kg/capita to 4 kg/capita which means that less than 1 percent of MSW is landfilled nowadays compared to around 4 percent in 2007.

Biological treatment of MSW increased to 650 kt or 68.6 kg/capita despite the stagnation of total MSW generation. This represent a relative increase of almost 16 percent for the total mass or 12.3 percent for mass per capita, respectively. The biological treatment methods Composting and Anaerobic Digestion are now used for nearly 15 percent of all MSW. Composting still accounts for the main part of biological treatment with a total mass of 450 kt of which about 320 kt is park and garden waste. That means about 200 kt - food waste from households and equivalent activities like schools, restaurants or shops - are sent to AD plants for nutrient and energy recovery. This volume is steadily rising, on the one hand due to an increasing amount of food waste that is sent to AD instead of composting. On the other hand the total amount of collected food waste is increasing as well since more and more municipalities implement separate collection systems for food waste. Nowadays almost 60 percent of the Swedish municipalities do already have separate food collection, with additionally 70 municipalities planning to implement such a collection system. Despite this increase in biological treatment of food waste the National Environmental Target to treat at least 35 percent of food waste through a biological method in 2010 was missed, the actual figure was about 25 percent.

The reduction in material recycling arises mainly due to a decrease in collection of paper and packaging material. It remains to be seen whether this reduction is due to worse sorting at households or due to changes in waste generation itself based for example on changes in economy or a reduced consumption of newspapers and magazines, respectively.

Role of energy recovery from waste; Update on type & number of EfW plants

Thermal treatment

EfW play an important role in the Swedish energy system. The heat generated from EfW plants corresponds to more than 20 percent of the Swedish district heating demand, at some places EfW plants account for even up to half of the heating demand [Naturvårdsverket 2010].

Currently there are 30 incineration plants in operation that burn MSW, the waste treatment capacity per plant varies between 20 and 700 kt. A minority of 6 plants is generating only heat, while the other plants have at least one line running in CHP configuration. Compared with 2007 there is an increase of treatment capacity due to the start-up of two new plants as well as due to capacity increase at existing plants.

All plants take in additional waste beside MSW, with shares for Swedish MSW between 15 and 90 percent of the treated waste mass. In total 4.9 Mt (46 percent MSW) have been treated at all 30 incineration plants, generating 12.2 TWh of heat and 1.8 TWh of electricity (including support fuels). A list of all plants is given in Figure 3 along with the treated waste amount for each plant in 2011.

Regarding the ownership of the incineration plants the plants either belong to privately or state owned companies or to municipal companies, which itself are owned either by one municipality alone or a group of several municipalities.

Since the actual development of MSW generation over the last years did not meet the capacity increase at incineration plants, the share of commercial and imported waste treated in these plants has increased. Especially the waste import has changed significantly during the last years. A total of 813 kt of waste was imported and treated at the Swedish EfW plants. About 152 kt of that total amount was MSW, mainly imported from Norway.

Beside the incineration plants from Figure 3 there are further EfW plants that burn exclusively commercial and industrial waste. These plants are either directly connected to industry locations or in operation as CHP plants connected to a district heating network. Since some of the formerly classified industry waste – for example residues from wood, paper- and pulp industry – has been reclassified as by-product the total amount of waste incinerated as well as heat generated from waste incineration is reduced despite the fact that these volumes are still burned.

Municipality	Plant	Swedish MSW [kt]	Total waste [kt]
Avesta	Källhagsverket	29	56
Boden	Bodens Värmeverk	35	99
Bollnäs	Säverstaverket	32	40
Borlänge	Fjärrvärmeverket, Bäckelund	33	89
Borås	Ryaverket	25	110
Eda	Åmotsfors Energi	14	71
Eksjö	Eksjö Energi AB	21	50
Finspång	FTV Värmeverket	24	28
Göteborg	Sävenäs avfallskraftvärmeverk	249	536
Halmstad	Kristineheds avfallsvärmeverk	100	190
Hässleholm	Beleverket i Hässleholm	26	45
Jönköping	Kraftvärmeverket Torsvik	41	165
Karlskoga	Karlskoga Kraftvärmeverk	35	86
Karlstad	Avfallsvärmeverket på Heden	45	51
Kiruna	Kiruna Värmeverk	11	70
Kumla	SAKAB Förbränning	40	163
Köping	Norsa avfallsförbränningsanläggning	23	28
Lidköping	PC Filen	45	98
Linköping	Gärstadverket	143	297
Ljungby	Ljungby Energi AB	48	59
Malmö	Sysav förbränningsanläggning	174	549
Mora	Avfallsförbränningen Mora	15	20
Norrköping	E.ON Händelöverket	205	336
Skövde	Värmekällan	28	56
Stockholm	Högdalenverket	436	702
Sundsvall	Korsta kraftvärmeverk	101	209
Uddevalla	Lillesjö Avfallskraftvärmeverk	49	100
Umeå	Dåva kraftvärmeverk	51	121
Uppsala	Vattenfall AB Värme Uppsala	157	324
Västervik	Stegeholmsverket	13	47
Total		2 236	4 893

Figure 3 List of Swedish MSW incineration plants including treated volumes for 2011 (Source Avfall Sverige)

Biological Treatment

Aerobic treatment of biodegradable waste is carried out at several composting plants in Sweden. The majority of plants tread only park- and garden waste, while about 15 plants also accept source separated food waste. The total amount of food waste that is sent to composting plants is steadily decreasing (e.g. with nearly 25 percent in 2011) since more and more food waste is treaded anaerobic. The remaining product from a composting plant can be sold as a soil improver. A system for certification of compost is available.

Anaerobic treatment of source separated food waste was conducted at 19 so called co-digestion plants as well as at some of the 135 digestion plants at waste water treatment facilities [Energigas Sverige 2012]. The number of co-digestions plants has not changed much compared to 2007 despite the start-up of new plants. That is mainly due to reclassification of some plants which are now classified as digestion plants at waste water treatment facilities since they treat food waste together

with sewage sludge. Other substrates at these plants are manure, food industry waste, slaughterhouse waste (co-digestion plants) as well as sewage sludge (only at waste water treatment facilities). Anaerobic digestion produces biogas which can directly or after a further upgrade to SNG be used for CHP/heat generation at site, as vehicle fuel or by feeding into a gas grid. In 2011 an amount of about 0.42 TWh of biogas was generated in the co-digestion plants, nearly the whole volume was upgraded to SNG (about 0.38 TWh). The AD plants at waste water treatment facilities which as well partly use food waste from households and industries generated around 0.64 TWh of biogas, while ca. 0.35 TWh were upgraded to SNG. The remaining digestate can be used as fertilizer in agriculture if the contamination ratio is within the required limits. At the moment over 90 percent of the digestate from co-digestion plants is used as fertilizer while the amount from AD plants at waste water treatment facilities is less than 25 percent. Certification systems for digestate from AD are available. Regarding the co-digestion plants the certification is also approved by the Swedish organic label “KRAV” and the Swedish Seal of Quality “Svenskt Sigill Kvalitetsråd”. At current 13 co-digestion plants are certified.

Landfill

In 2011 waste was landfilled at 79 landfill sites, most of them only accept non-hazardous waste. Compared to 2007 this is a huge reduction down from 170 sites. Most landfill sites were closed when the much stricter EU-regulations regarding landfilling took effect on December 31, 2008.

Landfill gas was still recovered at 55 sites, although the amount is steadily decreasing. The recovered gas volume in 2011 was around 0.27 TWh. Landfill gas is mainly used for heat and CHP generation, a minor part is flared to reduce the environmental impact of methane emissions.

Characteristics of waste

Biogenic content

The determination of the biogenic content of MSW was and will continue to be important for the Swedish waste incineration plants. There are different units used for reporting the biogenic content mainly depending on the measuring method and the purpose of the declaration, that is to state either the biogenic energy generation or fossil CO_2 emissions. Common units for the biogenic/fossil content are the energy share in percent of total energy (usually based on NCV/LHV), the mass share in percent of total waste mass, the fossil carbon mass in percent of total waste mass or the fossil carbon share in percent of total carbon. Units used for defining the discharge of fossil/biogenic CO_2 are fossil CO_2 emissions in mass per waste mass or in mass per waste energy. The conversion of these units into each other is possible but requires of course information about the waste characteristics itself (carbon content, calorific values) which is often lacking from individual figures.

When the tax on MSW incineration was implemented in 2006 a standard value for the fossil carbon content was set which assumed that 12.6 percent of the MSW mass consisted of fossil carbon. A fixed value was chosen because it was regarded as too difficult and expensive to measure the actual values. The total fossil mass share as well as the fossil energy share is of course higher than the fossil carbon figure. One common number which was used by authorities in the past to determine and report biogenic heat and power generation from waste was a 50 percent share based on energy. Nowadays even a different value is used. The Act Concerning Guarantees of Origin (Lagen om ursprungsgarantier) from 2010 defines a energy share of 60 percent of MSW as to be renewable. With respect to the new ETS period the Swedish Environmental Protection Agency recently published standard factors for the discharge of fossil CO_2 from waste incineration plants. These standard factors state a discharge of 30.2 ton CO_2 per TJ waste energy valid for MSW as well as 36.8 ton CO_2 per TJ waste energy for commercial waste. The factors can be used by plants of category A and presumable at least in the beginning as well for plants of category B.

All these figures derived from surveys that have been concluded during the last years. A survey from 2003 [Sundberg & Olofsson 2003] reported an average fossil content of 14 percent of the total waste mass treated at Swedish incineration plants as well as an average fossil energy share of 40 percent. These numbers were calculated based on composition and calorific value of typical Swedish waste. A similar survey from 2008 confirmed a biogenic energy share between 50-60 percent. A recently finished project [Blomqvist & Jones 2012] where different method to determine the fossil carbon content were used at 7 Swedish waste incineration plants concluded in an average fossil carbon share of 36 percent of total carbon. This average was obtained through C^{14} analysis of solid waste samples. The average carbon share for flue gas samples using the same method was 38 percent. With respect to waste composition and energy values this corresponds to an average fossil carbon content of about 10 percent of total waste mass. For the two plants which only burned MSW the average carbon content from the waste samples was about 8 percent while the samples from the other 5 plants which incinerated mixtures of municipal and commercial waste resulted in an average carbon content of about 11 percent. Worth mentioning is that at these plants the variation of commercial waste share which was between 20 and 80 percent indicated no clear influence on the results.

Calorific value

It should be expected that the calorific value of treated waste in incineration plants should increase with increased source separation of food waste as well as with increased share of commercial waste. This is mainly due to the fact that higher shares of fractions with low calorific values like moist food waste or other moist fractions (e.g. diapers) decrease the overall calorific value. The NCV/LHV of the waste samples from the fossil carbon study [Blomqvist & Jones 2012] was about 11 MJ/kg as an average for all samples with an average moisture content of 38 percent. When the figures from the two plants which only burned MSW where separated from the plants which burn mixed waste the average NCV/LHV of the MSW samples results in about 9.7 MJ/kg with a moisture content of 44 percent. The average NCV/LHV for the mixed waste samples would at the same time increase to about 11.3 MJ/kg (10.8-12.1 MJ/kg) with a moisture content of 36 percent.

Future for energy recovery from waste

The thermal and biological treatment capacities are expected to grow over the next years as new plants are built as well as due to capacity expansion at existing plants. According to a report from 2012 [Sahlin et al. 2012] the incineration capacity for MSW and commercial waste will increase from about 5.4 Mt today till 5.8-7 Mt in 2018. The lower value represents projects that are already under construction today, while the larger value will be reached if all planned projects are built as well. In the same time frame even the biological treatment capacity at AD plants is expected to grow significantly to meet the new National Environmental Target regarding food waste treatment.

With all plans for treatment capacity expansion carried out and based on the assumed development of waste generation until 2020 an over capacity is expected at the Swedish incineration plants during the next years. The amount of over capacity will be depending on level of food waste collection and other recycling figures as well as the actual development of waste generation itself. The issue of waste import and waste trading will grow in importance.

Other important influences on the future waste management will be the development of market prices for waste and products as well as changes in tax and incentive systems. Further measures have to be researched and implemented to reduce operation costs and increase recovery efficiencies. In thermal treatment an increase in efficiency could for example be an improvement in heat utilization, e.g. through heat use from flue gas condensation that already have been implemented at some plants. Regarding AD plants the operation costs will - beside process efficiency optimization - to a great amount be influenced by the future development of regulations as well as prices for fertilizer and upgraded biogas (mainly used as vehicle gas at the moment).

Special circumstances/barriers

The inclusion of the Swedish EfW incineration plants into the third ETS period will most likely increase operation costs. Depending on the dimension of increase this could weaken energy recovery from waste through incineration but at the same time make other treatment technologies more attractive.

Another special issue for the Swedish market is the pressure on incineration plans that arises from low electricity prices when both large Swedish energy sources - water and nuclear power - are running on full capacity. This can challenge the overall economic performance of the plants as well as affect planning reliability for new plants

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