Methods to calculate GHG mitigation potentials in Solid Waste Management

Workshop on behalf of a project commissioned by

Umweltbundesamt (Federal Environment Agency) Germany

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Minutes

The general scope of the workshop was to discuss the different methods of calculating GHG mitigation potentials in solid waste management, especially different approaches in studies using the LCA approach.

After the **address of welcome by Volker Weiss from UBA Germany** and a brief round of introduction, Marlene Sieck from UBA Germany lead through the workshop presentations.

Regine Vogt from IFEU Heidelberg gave a short overview of GHG accounting methods which can be differentiated into three categories: methods with the main purpose of reporting (e.g. Kyoto-Protocol, GHG protocol), methods to calculate GHG reductions meant to be traded in the GHG market (e.g. approved CDM methodologies) and Life Cycle Assessment as a method for system comparison. When the LCA approach is applied, differences are mainly due to varying objective & scope of a study (questions to be answered), determination of avoided processes (substitution potential of secondary products and energy) and underlying data (especially data which are difficult to measure like waste composition or landfill gas emissions).

Thomas Christensen from DTU Environment Denmark pointed out that different methods are not comparable but technological data where all methods are based on can be harmonized. In general, studies shall be precise about technical data and how they are used. Transparency is of main importance. A data table should not only include emission factors (kg CO_2eq/t) but also clearly state what is accounted and what is not accounted in the study. Most crucial factors in GHG accounting are indirect downstream data (data from avoided processes due to substitution of primary products or energy), reference level, characterization factors and waste management data, especially waste composition.

In general, referencing should be avoided because otherwise results cannot be compared[1].

Characterization factors shall be consistently applied especially concerning the assessment of biogenic carbon (overall neutrality to GWP when emitted (GWP=0), so release to be

[1] E.g. results from studies that use landfill as reference level and only document differences of waste management activities compared to landfilling.

debited when before credited as biogenic carbon bound). Keeping separate track of methane emissions facilitates the variation of the associated characterization factor e.g. in sensitivity analysis (value subject to scientific debate).

Waste composition is subject to weekly and/or seasonal fluctuation. It makes no sense to take one value from short term measures. Data derived from nationwide sorting analysis are desirable but unlikely to get due to high costs for such campaigns. As an approach to get better data the waste composition should be monitored at big plants.

Downstream data (avoided processes) bring the main difficulties in GHG accounting. The question of “what is substituted” is very difficult to answer due to lack of information (e.g. fate of paper for recycling) and changes over time (e.g. electricity grid, Denmark goal of 0% fossil in 2050). There is no ready answer or even recommendation. It is important to make sure that credited benefits really take place (e.g. verification by interviews). Thomas Christensen prefers the marginal approach instead of the attributional[2] and would recommend to deduce the marginal based on political goals instead of economic cost[3].

In the discussion following the presentation it was agreed that transparency is of main importance. Studies shall make very clear what their objective and therefore chosen method is, and data used shall be well documented e.g. in a data table as presented by Thomas Christensen.

Emmanuel Gentil from the Copenhagen Resource Institute presented the EEA waste model which last is described in the EEA study “MSW management and GHG modeling in Europe”, released in 2011. The original scope of the study is threefold, asking for changes in waste volume over time, improvement in waste management and GHG mitigation potential. The developed model involves a time series, and is a waste statistics model using life cycle data. Each year considered gives a “snapshot” of a country and/or the EU situation. Therefore, avoided processes are assessed with the attributional approach. Forecasting of MSW generation is based on econometric projection (historical and forecast development of private consumption in the EU). The model cannot be used as technology comparison tool or to answer “what if” questions. Challenges are the underlying assumptions for back- and forecasting especially with the landfill module, and simplifications like constant composition of waste over time. Emmanuel Gentil finalized his presentation with the question “how GHG mitigation of waste management should be communicated outside the waste sector?” According to IPCC, GHG mitigation cannot be expressed with benefits or negative numbers but only as (reduced) direct emissions as reported in the sectors of the common reporting format.

The suggestion by Emmanuel Gentil was to relate reduced GHG emissions from waste management to the other sectors (energy, industry) by comparing the IPCC emissions of the other sectors with and without the contribution from waste management (in order to quantify the mitigation potential attributed to waste management (provision of energy and recycling of

[2] With the attributional approach the electricity mix e.g. in a country (national grid) is taken as credit in case of produced electricity, with the marginal approach the most likely substituted energy carrier/s (usually one or several fossil energy carriers) is/are taken as credit.

[3] With the political goal 0% fossil energy in 2050 in Denmark the marginal would be coal which has a share of 50% in the grid. (editorial addendum: from economics the marginal would be gas as gas power plants are usually more expensive than coal power plants).

materials)). The recommendation from the participants was not to try to compare or transfer the results at all. Apart from the problem that several sectors / interest groups will claim to take the credit as their own, there is the main problem of identifying the avoided processes ("what is substituted"). This leaves such an attempt with a level of uncertainty which will be not accepted. None the less, the problem of communicating the mitigation potential of waste management to wider audience remains to be addressed.

Susan Thorneloe from the US EPA Office of Research and Development presented U.S. trends in SWM and GHG emissions. She briefly introduced the U.S. Municipal Solid Waste Decision Support Tool (MSW-DST) which was developed over the last two decades, and where an updated version with an improved interface will be available in a couple of months. Susan's presented U.S. trends in MSW generation and recycling rates since the 1960s along with recycling rates of selected products. Preliminary results to update a 2002 publication in Air & Waste Management Associations journal compare trends in net life-cycle GHG emissions since the 1970s from MSW management. The results show considerable reductions from the actual technology mix compared to the 1970 technology mix even though U.S. MSW generation has more than doubled since the 1970s. Like Thomas Christensen described for Denmark the calculations for the U.S. also consider coal as marginal for produced electricity (also share of approx. 50% in the grid). Susan Thorneloe also presented data from recent field measurements using optical remote sensing at three sites to evaluate landfill gas collection which can be major uncertainty[4]. To assure the comparability of the results (gas generation depends on the waste composition, moisture content and time of initial disposal), sites were chosen with similar MSW composition and similar design and operational histories. Two of the sites showed methane collection efficiencies that confirmed the previous assumption of an average efficiency of about 75%, ranging from 70 to 90%. For the third site, a 40% collection efficiency was found although it is expected that the collection efficiency is improved since the site upgraded the gas collection system a few months after testing.

In the following discussion it was explained that the measured collection efficiency is to be understood as a "snapshot" of real emissions during the gas collection phase and not to be confused with the collection efficiency for the overall methane emissions related to one ton of MSW. For the overall emissions remains the uncertainty of the total amount and share of methane emitted to the air because of the lack of data for landfills – short term or longer term. Thomas Christensen already mentioned in his presentation that empirical data for landfilling only exist for a few sites and at most for a time period of 30 years, whereas MSW landfilled generates emissions for many decades. Therefore, landfill gas collection efficiency remains to be an uncertainty and sensitivity analysis incorporating the range of potential uncertainty is recommended. In a paper for ES & T in 2009[5], discards management approaches were compared incorporating a sensitivity analysis to understand whether it is better to burn or bury waste discards. Susan reported that they found that burning waste tends to be more efficient in terms of energy efficiency and carbon emissions than landfilling waste even when assuming the most optimistic values for landfill gas collection efficiency.

[4] Quantifying Methane Abatement Efficiency at Three Municipal Solid Waste Landfills, EPA/600/R-12/003, Jan 2012

[5] Ozge Kaplan, P., Decarolis, J., Thorneloe, S.: Is it better to burn or bury waste for clean electricity generation, In: Environmental Science & Technology, Vol. 43, NO 6, 2009

Adam Brundage from ICF International presented the OECD study "Greenhouse gas emissions and the potential for mitigation from materials management within OECD countries" published in March 2012. In the study five regional groups are differentiated. For these the current MSW composition and management practices were established and used for the projection to a future baseline in 2030. The total MSW generation for 2030 was taken from OECD Environmental Outlook for waste development. Alternative scenarios for 2030 were specified taking into account technically-achievable rates like e.g. an increased landfill gas capture efficiency of 87% or source reduction of 30% of MSW. The mitigation potential of these alternative scenarios was compared to the baseline in year 2030. The scenario targets (i.e., technically-achievable rates in each scenario) are equal for all five regions. The results show that source reduction and recycling provide the highest reduction in GHG emissions per ton of MSW (i.e., the effectiveness of reduction GHG emissions on a per ton MSW basis). The absolute GHG emissions reductions, however, vary by scenario and region. This is due to the fact that first, different regions have varying amounts and compositions of MSW and second, the scenarios have varying "technically potential" rates with some scenarios having much more aggressive rates than others.

In the following discussion it was pointed out that a 87% capture efficiency is not realistic, even if only the gas collection phase is regarded. For source reduction Adam Brundage explained that this is calculated as if the respective materials (plastic, metal, etc.) were not produced, and these avoided emissions are credited to waste management. The definition of the respective (avoided) materials is very difficult for mixed waste especially food waste. This is because food waste is a relatively complicated mixture of many different products and materials from beef to vegetables; all which have completely different life-cycle GHG emissions profiles. Unfortunately, sensitivity analyses could not be done in line with the budget of the project.

In the final presentation **Cornelia Merz from Öko-Institut** presented a comparison of the studies prepared by the project team IFEU and Öko-Institut. Apart from the EEA and the OECD study (only results for Europe) two further studies were compared: (UBA 2010) and (Prognos 2008, only the results for MSW). All studies follow a lifecycle approach. Differences in the overall results for the EU (2005 … 2010) derive e.g. from different shares of MSW treatment options (recycling, incineration, landfill). Additionally, (EEA 2011) shows different (lower) direct emissions from landfilling mainly due to the different accounting method (first order decay according to IPCC). Furthermore, some of the emission factors vary significantly: For wood, in (Prognos 2008, UBA 2010) energy recovery and material recycling is taken into account whereas (EEA 2011) and (OECD 2012) assume material recycling only. Moreover, (UBA 2010) credits the benefit of an alternative energetic use of primary wood spared by material recycling. Differences also derive when the substitution factor is based on the market share of primary material input instead of taking into account the physical/technical substitution potential (glass), and in case of necessary assumptions for data available from other studies[6]. Further important differences arise from different parameter values used for the calculation of incineration and landfilling. (EEA 2011) used high energy efficiencies for incineration, (OECD 2012) a high landfill gas collection efficiency

[6] E.g. the share of recycled plastic types (PET, PS, PO) is not published in (Prognos 2008) and was estimated as uniformly distributed in (OECD 2012).

of 75%, while (EEA 2011) used the National Inventory Reports as data base capping the landfill gas recovery rate at 45%. (Prognos 2008) and (UBA 2010) used 20% recovery rate in the baseline, but considered a 40% recovery rate in sensitivity analysis. Assumptions concerning the utilization of the recovered gas also differ. The presentation finished with a few conclusions and questions addressing the aspects changes in waste volume, GHG emissions from landfill, avoided processes and different data (emission factors, parameters).

In the discussion on the presentation Thomas Christensen recommends to generally use the technical substitution potential. This aspect was also mentioned in the presentation of Emmanuel Gentil who pointed out that the market-related substitution potential is inconvenient because when taking into account the market share "the more you substitute the less credit you get" which gives a conflicting message. Regine Vogt approves the recommendation and explains that the only difference in the emission factor for glass (based on IFEU) in (Prognos 2008) and (UBA 2010) results from the change from market-related substitution to using the technical substitution potential.

In the following **discussion session moderated by Marlene Sieck from UBA Germany and Jürgen Giegrich from IFEU Heidelberg** some of the aspects already discussed before were picked up especially data used, avoided processes and changes in waste volume. Others like landfill gas emissions were not addressed again.

Concerning the total waste volume it was pointed out that data are sometimes uncertain. E.g. in the UK data on MSW volume changed significantly from 2009 to 2011 due to a change in statistical definition of MSW. For consistency reasons the former classification is still used in addition to reporting to Eurostat the "local authority controlled MSW". Another example is given with the US data where the US EPA takes a top down approach to calculate the total waste volume while a study done by BioCycle and the Columbia University takes a bottom up approach and sums up data collected from the federal states on waste volume generated. The latter results in a total waste volume twice as high as that of the EPA approach. It is suggested that official data sources be used and an effort be made to push official data providers to improve their quality. Nevertheless, for studies doing system comparisons it was agreed that changes in waste volume are not critical for decisions because different technologies or management systems can be compared based on one ton waste. In case changes in total waste volume shall be considered (e.g. overall results on national scope) it is possible to do two separate system comparisons, one based on the current waste volume and one based on a forecast waste generation.

Waste composition is of higher importance than waste volumes. It determines parameters like heating value, content of organics, readily degradable organics, fossil and regenerative carbon content, which are relevant for the calculation of incineration and landfilling. As mentioned before there is no investment by governments into compositional studies. Some ideas to derive or predict data on waste composition were:

- get access to data on waste composition from waste management companies and aggregate these
- use IPCC degradation rates for different waste fractions for different countries as defaults for status quo

- predict changes in waste composition based on economic data on private consumption (same as for forecast of waste generation); this prediction will not be largely affected by economic crises because the consumption of basic goods (e.g. clothes, food) does not change significantly.

In the context of data and data quality also statistical data were addressed like data of Eurostat on treatment options for MSW (recycling, composting). First of all, Eurostat gives no further detailed information for recycling (type and volume of materials recycled), and the amount reported for composting includes not only centralized composting, anaerobic digestion and home composting but also composting of municipal sewage sludge and of residual MSW. Here studies need additional information from the statistical agencies or have to rely on other data sources[7].

The question of standardized emission factors for direct emissions and for avoided processes was raised. It was pointed out that such standardized emission factors would be desirable as defaults especially for avoided processes (indirect downstream emissions) but not for direct emissions because the latter should be calculated based on available activity data. E.g. for MSW incineration plant-specific information on energy efficiency is available. Furthermore, it was objected that different stakeholders have different needs and/or availabilities concerning the degree of detail for data on recycling. Some only have information on the amount of certain recyclable fractions and prefer one emission factor per fraction whereas others ask for more detailed information e.g. for recycled PET which can be reused in bottles, used for the production of textiles, be exported to China etc. Nevertheless, it might be helpful to provide a set of standardized emission factors for the main/basic waste fractions. Such a set could be given as global average since most recyclables are traded internationally. A differentiation could be made for high and low carbon intensive electricity grids because the offsets for these differ significantly. The “one for all” approach could be used for all fractions except for compost or even organic waste fractions (wood, paper). For the latter the high difference in the results for energy recovery between high and low carbon intensive electricity grids should be shown transparently to avoid misunderstandings and incorrect decisions.

As a general problem the availability of data on avoided processes is identified. E.g. reliable data on paper production are hard to get. Also steel companies and/or associations only publish an overall net result for steel production which makes it impossible to assess the contribution of recycling. Here the question was raised if IPCC data may be used to derive “one for all” emission factors for production (avoided emissions) by dividing the reported total GHG emissions by the total amount of production. This would be a start to induce companies to deliver better data. Nevertheless, with this approach still the contribution of recycling cannot be assessed because the result will reflect the mix of secondary and primary materials in the market. Another possibility is to use the Ecoinvent database, a commercial database which provides good documentation. The handicap with Ecoinvent data is that they are (in many cases) old, an observation which also holds for JRC data available from the

[7] E.g. ORBIT Association and European Compost Network (ECN): Compost production and use in the EU. Final report to the European Commission, DG Joint Research Centre/ITPS, Feb, 2008 or Prognos AG: European Atlas of Secondary Raw Materials. 2004 Status Quo and Potentials, Jan 2008.

ELCD database. In order to address the uncertainties related to standardized emission factors it is proposed that ranges be given. Moreover, it is suggested to indicate the process energy demand separately, distinguishing between virgin and secondary production.

The aspect of standardized emission factors and how to derive them could not be answered within the discussion. But in summary it was emphasized that the comparison of the different studies showed good news. Although the studies use different approaches and partially different data the overall picture shows similar results for the baselines. Especially, the recommendations derived from the results lead into the same direction.

To face uncertainties it is recommended to use sensitivity analysis. Even though this makes messages more complicated sensitivity analysis is a good instrument to address weak data. To make sure the budget allows sensitivity analysis this should be already addressed in the costs projection.

Annex

AGENDA

10:00 - 10:30	**Address of welcome, routine of the day** Volker Weiss (UBA)
	Round of introductions

Presentations, Moderator: Marlene Sieck (UBA)

10:30 - 10:50	**Overview and background** Regine Vogt (IFEU)
10:50 - 11:30	**Waste and GHG accounting: problems and possible solutions** Thomas Christensen (TU Denmark)
11:30 - 12:00	**MSW management and GHG modeling in Europe, EEA study 2011** Emmanuel Gentil (ETC/SCP)

12:00 - 13:00 Lunch

13:00 - 13:30	**SWM and GHG, study in the US (2006)** Susan Thorneloe (USEPA)
13:30 - 14:00	**GHG mitigation potential, OECD study (2012)** Adam Brundage (ICFI)
14:00 - 14:40	**Comparing studies on SWM and GHG for the EU** Cornelia Merz (Öko-Institut)

14:40 - 15:00 Coffee break

15:00 - 16:30 **Discussion**
Moderator: Marlene Sieck (UBA), Jürgen Giegrich (IFEU)

16:30 - 17:00 **Summary and leave-taking**

List of participants

	First name	Last name	Institution	Country
1	Ann	Ballinger	Eunomia Research & Consulting	United Kingdom
2	Flora	Berg	Veolia Environmental Services	France
3	Bärbel	Birnstengel	Prognos	Germany
4	Adam	Brundage	ICF International	United States
5	Thomas	Christensen	Techn. University of Denmark	Denmark
6	Terry	Coleman	ERM, Environm. Resources Management	United Kingdom
7	Günter	Dehoust	Öko-Institut	Germany
8	Konrad	Derschau, von	Farmatic Anlagenbau	Germany
9	Emmanuel	Gentil	Copenhagen Resource Institute	Denmark
10	Jürgen	Giegrich	IFEU Heidelberg	Germany
11	Janne	Kärki	VTT, Technical Research Centre of Finland	Finland
12	Hansjürgen	Krist	bifa Umweltinstitut	Germany
13	Cornelia	Merz	Öko-Institut	Germany
14	Wolfgang	Pfaff-Simoneit	KfW Entwicklungsbank	Germany
15	C.-André	Radde	BMU *(Federal Environment Ministry)*	Germany
16	Alexandra	Robinson	Öko-Institut	Germany
17	Marlene	Sieck	UBA *(Federal Environment Agency)*	Germany
18	Ella	Stengler	CEWEP	European Union
19	Susan	Thorneloe	US EPA	United States
20	Eemeli	Tsupari	VTT, Technical Research Centre of Finland	Finland
21	Regine	Vogt	IFEU Heidelberg	Germany
22	Volker	Weiss	UBA *(Federal Environment Agency)*	Germany