Federal Office for the Environment FOEN

Climate Unit

National Greenhouse Gas Inventory of Switzerland

Review of the "waste sector"

Final report




7 October 2010

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Version Control	***Date***	***Intermediate Quality Check (☑☐)***	***Released (☑☐)***
Version 0.4	*30.11.09*	☑ UF	*(not released)*
Version 1.0	*09.08.10*	☑ UF, 1.7.10	☑ PF, ☑ SH, ☑ UF
Version 1.1 (language reviewed)	*07.10.10*	☑ UF, 1.10.10	☑ AR, 7.10.10

ABSTRACT

The review of the waste sector and the waste related emissions of the Swiss GHG inventory and NIR submitted 2009 concludes that the waste related emissions are calculated in a plausible way that yields reliable results.

The waste related emissions represent about 6% of total Swiss emissions. The categories in which waste related the reviewers suggest improving the estimation of emissions represent only about 1% of total Swiss emissions. If CO_2 emissions from municipal solid waste incineration were considered improvable, in total at most 5% of total Swiss emissions would need to be updated.

The methods used are considered as adequate. Activity data and emission factors are mostly country specific values, based on reliable data and only in few cases complemented by values found in literature. Only on rare occasions, default values for emission factors or model parameters from the IPCC guidelines had to be used. The use of the IPCC model for the estimation of CH_4 emissions from landfills and the N_2O emissions from domestic wastewater is considered to be adequate.

However, some observations in this review suggest corrections or a need for improvement (resp. investigation if an improvement is possible).

In cases when the default parameters from the IPCC guidelines have not been used but there is only spotty, potentially unreliable country specific data available, the reasons for this choice should be explained.

For several emission factors, this review recommends further research to determine values that are more specific. This applies mainly to N_2O emissions (especially from incineration of MSW and from wastewater treatment), as waste related N_2O emissions contribute about 12% to the total N_2O emissions. Only little information about these emission factors exists.

The CO_2 emissions from incineration of MSW and special waste with energy recovery contribute substantially to total Swiss emissions. In this area, the review suggests to undertake further research into specific emission factors.

The category “digestion of organic waste” (part of the “waste others” category) will become more and more relevant, as the trend towards renewable energy production will increase the quantity of organic waste digested. For this reason and because the reporting unit has only little information about this category at this time, it seems worthwhile to investigate into more specific data. An error in the calculation of CH_4 produced led to a considerable underestimation of all emissions calculated in proportion to that value.

The category “wastewater treatment” is evaluated as partially incomplete, as some gaps need to be closed:

- emissions from wastewater of the inhabitants not connected to public wastewater treatment,
- N_2O emissions from industrial wastewater
- emissions of the digestion process and biogas use (from the generation and use of biogas) from industrial wastewater treatment plants.

Of course, the general recommendation to improve the accuracy of the country specific values continuously to reduce existing uncertainties, applies also to the waste sector.

As guidance to the reader, the NIR could be improved in terms of a presentation of the overall reporting structure (what / where / why) and in providing more information on the source of certain values and on assumptions made in the calculation (cf. 3.3).

In conclusion, the findings of this review may be substantial in the waste sector but only apply to a small part of the total Swiss emissions. The reported waste related emissions are plausible and their contribution to the total Swiss emissions seems realistic.

ZUSAMMENFASSUNG

Der Review des „waste sector“ und der abfallstämmigen Emissionen des NIR und der CRF 2009 hat ergeben, dass die abfallstämmigen Emissionen mit einigen wenigen Ausnahmen gänzlich erfasst und plausibel berechnet wurden.

Die abfallstämmigen Emissionen stellen rund 6% der gesamten Schweizer Emissionen dar. Betrachtet man, für welche abfallstämmigen Kategorien die Abschätzung der Emissionen evtl. verbessert werden könnte, zeigt sich, dass dies nur rund 1% der gesamten Schweizer Emissionen betrifft. Wird die Abschätzung der CO_2-Emissionen aus der Kehrichtverbrennung ebenfalls als verbesserungsfähig betrachtet, sind insgesamt maximal 5% der gesamten Schweizer Emissionen betroffen.

Die verwendeten Berechnungsmethoden werden als geeignet beurteilt. So gut wie alle Aktivitätsdaten und Emissionsfaktoren wurden aus länderspezifischen Daten ermittelt und nur in wenigen Fällen durch Literaturdaten ergänzt. Nur in Einzelfällen mussten für Emissionsfaktoren oder Modellparameter Standardwerte aus den IPCC Richtlinien verwendet werden. Die Verwendung der IPCC Modelle zur Berechnung der Methanemissionen aus Deponien sowie der Lachgasemissionen aus der Behandlung häuslicher Abwässer wird als geeignet betrachtet.

Trotzdem gibt es einige wenige Punkte, die einer Korrektur oder Untersuchung auf evtl. Verbesserungsmöglichkeiten bedürfen.

In Fällen, in denen nicht die Standardwerte der IPCC Richtlinien verwendet werden obwohl nur wenig länderspezifische Daten verfügbar sind, sollten die Gründe hierfür erläutert werden.

Für einige wenige Emissionsfaktoren wird empfohlen, durch weitergehende Studien differenziertere Emissionsfaktoren zu bestimmen. Dies betrifft vor allem Lachgasemissionen aus der Abfallverbrennung und Abwasserbehandlung, da diese einen hohen Anteil der Gesamt-N_2O-Emissionen der Schweiz ausmachen (rund 12% der Gesamt-N_2O-Emissionen) und bisher relativ wenige Informationen zu diesen Emissionen vorliegen.

Die CO_2-Emissionen aus der Abfallverbrennung mit Energienutzung (Kehricht und Sonderabfall) haben ebenfalls eine grosse Bedeutung für die Gesamtemissionen. Auch hier wird empfohlen, durch weitere Untersuchungen differenziertere Emissionsfaktoren zu ermitteln.

Die Kategorie Vergärung (Teil der „waste other“) wird an Bedeutung weiter zunehmen, da die Menge an Abfällen in Vergärungsanlagen die nächsten Jahre weiter steigen wird. Aus diesem Grund und weil momentan noch nicht sehr viele Informationen vorliegen, wird empfohlen, für diese Kategorie spezifischere Emissionsfaktoren zu ermitteln. Ausserdem wurde durch einen Berechnungsfehler die Menge an produziertem Biogas bzw. Methan stark unterschätzt. Damit sind alle proportionalen Emissionen auch zu tief eingeschätzt worden.

Die Kategorie Abwasserbehandlung weist noch einige Lücken auf:

- Emissionen der nicht an Abwasserreinigungsanlagen angeschlossenen Bevölkerung
- Lachgasemissionen aus Industrieabwässern
- Emissionen aus Biogasanlagen für Industrieabwässer

Grundsätzlich gilt die Empfehlung auch für den „waste sector“, die Genauigkeit der länderspezifischen Daten kontinuierlich zu verbessern und somit die bestehenden Unsicherheiten zu verringern.

Um den Leser besser zu führen, könnte der NIR um eine übergeordnete Darstellung der Reporting-Strukturen (was / wo / warum) ergänzt werden. Auch die für die Berechnungen getroffenen Annahmen sollten beschrieben werden.

Es kann insgesamt festgestellt werden, dass diese Anmerkungen nur einen geringen Teil der gesamten Schweizer Emissionen betreffen und dass die Höhe der abfallstämmigen Emissionen und ihr Anteil an den Gesamtemissionen gut wiedergegeben sind.

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1. Introduction and objectives

1.1. Introduction

In 1993 Switzerland ratified the United Nations Framework Convention on Climate Change (UNFCCC). Since 1996, the submission of its national greenhouse gas inventory has been based on IPCC guidelines. Starting in 1998, the inventories have been submitted using the Common Reporting Format (CRF). In 2004, Switzerland started submitting a yearly National Inventory Report (NIR) under the UNFCCC.

In 2003 Switzerland ratified the Kyoto Protocol. In November 2006 Switzerland submitted its Initial Report under Article 7, paragraph 4 of the Kyoto Protocol. The submission of the Swiss GHG inventory in April 2008 has been Switzerland's first submission under both the UNFCCC and the Kyoto Protocol.

The Federal Office for the Environment (FOEN) is responsible to provide the emission data as well as for compiling both the national GHG inventory and the NIR.

In April 2009 the current inventory containing the years 1990 to 2007 and the associated NIR have been submitted.

As a quality assurance element, requested by the IPCC guidelines, a domestic review (by independent national experts) is conducted episodically.

FOEN mandated Rytec to review all waste-related sectors of the NIR (April 2009 submission) and GHG inventory.

1.2. Objectives

Some of the sectors of the inventory have already been reviewed in earlier years. This project reviews the waste sector of the current GHG inventory and NIR. Rytec qualifies as independent national experts as they have a good overview of the national waste sector but have – so far – not been providing information for the greenhouse gas inventory.

The main objective of the mandate was to review data and documents of the waste sector as well as all other waste-related domains in the NIR regarding

- completeness
- plausibility
- consistency
- transparency and
- presentation

Potential discrepancies should be highlighted and discussed with the party generating and submitting the inventory. Whenever possible, suggestions for improvement should be given.

2. Proceeding

2.1. General proceeding

After a familiarisation with all pertinent information, especially the IPCC guidelines as well as the documentation in the EMIS commentaries, the methods used and the assumptions made, the following points have been reviewed:

- Are all waste-related categories complete? Have all elements of the Swiss waste management system been considered?
- Are the waste-related categories correctly allocated to the sectors of the inventory?
- What emissions have been considered to be key sources?
- Are the methods chosen and their application correct, as well as the assumptions on which the calculations are based?
- the results (calculated emissions)
- the documentation and transparency of the inventory and the NIR in general

In addition, the recommendations as suggested in the current submission by the last central review of the UN have been verified.

2.2. Focal points of this review

The main focus was on the most relevant waste-related categories

- incineration of municipal solid waste (MSW), special waste included, in the energy sector,
- solid waste disposal on land,
- wastewater handling as well as
- other waste (composting and digestion of organic waste) and
- waste incineration in the waste sector.

Within these categories, the key categories have been thoroughly reviewed. They are

- CO_2 and N_2O from MSW (and special waste) incineration,
- CO_2 emissions from waste derived fuels in the cement industry,
- CH_4 emissions from solid waste disposal on land,
- N_2O emissions from wastewater handling and
- CH_4 emissions from other waste (composting and digestion of organic waste).

All relevant emissions from these categories have been reviewed with a focus on verifying the underlying sources for activity data and emission factors.

All other waste-related categories have been checked for completeness.

Only random checks on the basic multiplication of activity data x emission factor = net emissions were performed as it is a standard operation of the reporting tool itself.

More sophisticated calculations such as the model for CH_4 emissions from landfills were reviewed more thoroughly.

2.3. Underlying information and documents

This review is based on the documents submitted in 2009, i.e. the NIR and the tables in the Common Reporting Format (CRF) as well as the “EMIS commentaries”, the documentation of the Swiss national air pollution database (EMIS), which explains the activity data and the emission factors with all their sources and assumptions.

As in some cases FOEN has adapted and improved the calculations in the EMIS commentaries, but the submission 2009 of the NIR and CRF tables are still based on the previous commentary, certain observations in this report may be explained with this time-shift and will automatically be resolved simply by updating the NIR for the next submission.

2.4. Note about references to the 2006 IPCC guidelines

The UNFCCC was – at the time of this review – considering the new 2006 guidelines and guidance. They are not yet mandatory for the 2009 submission.

During this review, the 2006 IPCC guidelines have been consulted and any information found is quoted. Such remarks have to be considered purely informational.

3. Review & Results

3.1. Allocation of the waste-related categories to the sectors of the inventory

The following table shows the waste-related categories and where to find them in the inventory as part of a bigger sector:

Category	Reported in
MSW incineration	1 A 1 a Other Fuels
special waste incineration	1 A 1 a Other Fuels
solid waste disposal on land	6 A use of landfill gas in engines in 1 A 1 a Biomass
wastewater handling (domestic and industrial wastewater)	6 B
composting and digestion of organic waste	6 D use of biogas in engines in 1 A 1 a Biomass
shredder plants	6 D
waste incineration including • hospital waste incineration • illegal waste incineration • incineration of insulation material from cables • sewage sludge incineration • crematoria	6 C
waste derived fuels in cement industry	1 A 2 f
waste derived fuels in paper industry and cellulose production	1 A 2 d
recycling of batteries	2 C 5 e
recycling of refrigerators	2 F 1

3.1.1. Conclusion

All waste-related emission sources can be found in the Swiss National Greenhouse Gas Inventory.

The allocation to the sectors is conclusive and complete.

Some partial emissions from several categories seem to be missing or not conclusively assigned. For the corresponding remarks about such emissions and their allocation cf. chapter 3.2. containing the detailed commentaries.

In the review process, the following points have been discussed and clarified between the FOEN and Rytec. The main question was to determine whether any categories are missing or double counted in different sectors of the inventory:

- Agricultural residues / co-substrates treated in fermentation plants: They are not reported in the agriculture sector. This would have led to a double counting as they are already taken into account in the waste sector 6 D → no action required
- Emissions from purely agricultural digestion plants: They are not reported in the agriculture sector but under the energy sector 1 A 1 a and so they aren't missing. The emissions could be differentiated between emissions from the digestion process (which could be attributed to the agricultural sector) and from the energetic use of the biogas (remains in the energy sector) → future action recommended
- Emissions from industrial wastewater digestion plants: They seem to be missing in the inventory, as only emissions from the use of "human" sewage gas are reported under 6 B. As the FOEN informs, they will be taken into account in the submission 2010. → immediate action for 2010 submission
- Biogas from digestion plants used in engines: EMIS indicates that it is reported under 1 A 1. In the NIR biogas is also mentioned for different other categories in the energy sector (1 A 2f, 1 A 3b, 1 A 4a). The sum of all biogas quantities distributed over these different categories must be equal to the net total of biogas produced and no parts of it double counted. The FOEN confirms that they use a crosscheck process for the energy file to avoid double counting.

3.2. Verification of emission calculations

3.2.1. Municipal solid waste incineration

3.2.1.1 General observations

As all Swiss incineration plants for MSW are equipped with energy recovery systems, all emissions from incineration are assigned to the energy sector, under 1 A 1 a Public Electricity and Heating Production – Other Fuels – which is correct.

The activity data and the emission factors are country specific data. The chosen method is adequate.

The results given in the CRF tables, randomly checked for several years in this review, are generally correct. The recalculation of CO_2 emissions from MSW and special waste incineration shows differences of less than 1 Gg, with the exception of 47 Gg in 1999. The FOEN confirms that there were still discrepancies between the database for the inventory and the EMIS commentaries (update in process). FOEN assures this will be eliminated for further submissions.

3.2.1.2 Activity data

The activity data are provided as tons of waste incinerated per year. They originate in the national waste statistics, which is a reliable source.

3.2.1.3 Emission factor for CO_2

The CO_2 emissions from MSW and special waste incineration represent 3.6% (1990) resp. 5.0% (2007) of the total CO_2 emissions and 71.7% (1990) resp. 88.1% (2007) of the CO_2 emissions from Public Electricity and Heat Production. The CO_2 emissions from MSW and special waste incineration qualify as a key category.

The emission factor in kg CO_2 per t of waste incinerated is determined for two years (1990 and 2004) by measurements and assumptions and then interpolated for the years in between. The EMIS commentary mentions the value for 1990 too high, therefore the non-realistic decrease of the emissions between 1990 and 2004 is an artefact. After an internal discussion, the FOEN decided to retain this value, as there are no adequate means available to correct this value retrospectively. In 1990 this value was estimated by FOEN experts with best available information at that time.

A constant fraction of organic and fossil C in waste being 60% to 40% is used for the entire observation period. It is recommended to do more research into this value. As the FOEN informs, a pilot study on this value started in 2006 and the results of the main study will be taken into account as soon as available.

The value of about 0.5 t CO_2 / t of waste is high in comparison to one found in literature. In [12] the emission factor of 0.293 t fossil CO_2 / t of waste is derivided using a fraction of 240 kg C / t of waste (resulting in 862.4 kg CO_2 / t of waste), a fossil/total C fraction of 34% and a 0.98 transfer coefficient to the flue gas. The documentation in the Austrian NIR submitted 2009 mentions a value of 261 kg C / t of waste and a fraction of 45 % of fossil carbon.

Further research could lead to more exact values for this emission factor.

N.B.: It is a fact that the heating value of waste incinerated is very difficult to determine and there is no uniform method used by the different incineration plants. Energy content of waste or waste derived fuels should be regarded with reticence. But as the same heating value is used for one year to transform tons of waste in GJ and to transform kg CO2 / t of waste to kg CO2 / GJ, the uncertainty of this value cancels out in the calculation of emissions.

3.2.1.4 Emission factor for N2O

The N_2O emissions from MSW and special waste incineration represent 1.4% (1990) resp. 3.4% (2007) of the total Swiss N_2O emissions and nearly 100% (1990 and 2007) of the N_2O emissions from Public Electricity and Heat Production. N_2O emissions from MSW and special waste incineration are a key category.

Only little data for N_2O emissions are available and large variations in reported emission values exist. N_2O emissions depend mainly on the type of incineration plant, the mode of operation and the waste incinerated.

For 1990 the CORINAR emission factor was used for installations without DeNox. Further the assumption is used that the value doubles for incineration plants with DeNox installations and that all Swiss plants dispose of one from 2003 onwards. The values between 1990 and 2003 have been interpolated, the values after 2003 have been interpolated based upon a projection for 2020, which assumes a reduction of the emissions of nearly 90%.

This estimation seems to be very low. A higher projection for 2020 would lead to higher emissions for the years 2003 - 2020. Such a reduction of the emission factor could be explained with a technology breakthrough or big efficiency gains in the plant operation, to be confirmed by measurements.

As no limit value exists, N_2O emissions are generally not measured on Swiss waste incineration plants. It could be interesting and recommended to launch a measurement project to obtain reliable data.

More research into N_2O emissions is required for different incineration plants and different kinds of waste composition to specify more exact emission factors in this category.

Various information found for emission factors for N_2O emissions are listed in Annex 1 to indicate the big variety of values existing.

3.2.1.5 CH_4

There is no CH_4 occurring from MSW incineration, as the combustion is complete.

3.2.1.6 Further emissions

The NO_X, CO, SO_2 and NMVOC emissions from MSW incineration are calculated with plausible emission factors from country specific sources.

3.2.2. Special waste incineration

3.2.2.1 General observations

As all Swiss incineration plants for special waste are equipped with energy recovery systems, all emissions from incineration are assigned together with the emissions from MSW incineration plants under the energy sector, which is correct.

The results given in the CRF tables, randomly cross-checked for several years, are in principle correct (cf. remark under 3.2.1.1).

3.2.2.2 Activity data

The activity data are given in terms of tons of special waste incinerated per year. They originate from different statistics, for several years the values have been interpolated. Quantities of special waste incinerated in MSW incineration or cement plants are subtracted to avoid double counting. They are reliable.

3.2.2.3 Emission factor for CO_2

The emission factor in kg CO_2 per t of special waste incinerated is a constant average value for all years. The composition of the special waste is known for the years from 1992 to 2002, the emission factors are assumptions for the different fractions. In comparison to other values found in literature, the average value 1.45 t fossil CO_2 / t is rather high. In [12] a value of 0.636 t CO_2 / t is found, in [9] 0.48 t CO_2 / t was found for an Austrian special waste incineration plant. It is suggested to revaluate this emission factor. As special waste is only 5% of all waste incinerated no big influence on the calculated emissions is expected.

3.2.2.4 Emission factor for N_2O

The same emission factor as for MSW incineration is used, because of lack of data. Cf. remarks in 3.2.1.4. As special waste is only 5% of all waste incinerated no big influence on the calculated emissions is expected.

3.2.2.5 CH_4

There is no CH_4 originating from special waste incineration.

3.2.2.6 Further emissions

The NO_X, CO, SO_2 and NMVOC emissions from special waste incineration are calculated with the same emission factors as for MSW incineration from country specific sources.

3.2.3. Waste derived fuels in the cement industry

3.2.3.1 General observations

The emissions from the use of waste derived fuels in the cement industry are reported under 1 A 2f which is a correct allocation.

The emission factors given in the NIR (Table 3-15) do not correspond to the values given in the CRF tables. The CO_2 emissions from waste derived fuels in the cement industry, reported in the CRF tables, only match with the values given in the EMIS commentary for the years 1990 to 1993. The FOEN informs that it has corrected these discrepancies for the 2010 submission.

3.2.3.2 Activity data

The amounts and types of waste derived fuels used in the cement industry stem from reliable statistics provided by the Swiss cement industry.

3.2.3.3 Emission factor for CO_2

The emission factors for waste derived fuels are used to calculate a specific emission factor per year, using the fraction of every type of waste derived fuel of the total amount. This leads to reliable emission factors. The emission factors given in the NIR differ from the values in the CRF tables and have to be verified. From 1994 onwards the results of total CO_2 emissions, reported in the CRF tables, differ from the EMIS commentary. The FOEN informs that it has corrected these discrepancies for the 2010 submission.

3.2.3.4 Emission factor for N_2O

The average default value from the EMEP Emission Inventory Guidebook 2002 is used, because no country specific value is available. This is adequate. Further studies on the emission factor for N_2O emissions from different incineration plants and kinds of waste could also be used for a more specific determination of this emission factor.

3.2.3.5 CH_4

There is no CH_4 originating from waste derived fuels.

3.2.3.6 Further emissions

The NO_X, CO, SO_2 and NMVOC emissions from waste derived fuels in the cement industry are calculated with plausible emission factors from country specific sources.

3.2.4. Solid waste disposal on land

3.2.4.1 General observations

The emissions from solid waste disposal on land are documented in the waste sector. Only emissions from energetic use of landfill gas in engines are documented in the energy sector. This allocation is correct.

The activity data and emission factors are country specific data. Methane emissions from solid waste disposal are calculated using the IPCC guideline model. The chosen methods are adequate.

N_2O emissions from solid waste disposal are not requested in the CRF tables. In order to report N_2O emissions from the open burning on landfills we suggest using the CRF column under 6 C “waste incineration”.

3.2.4.2 Activity data

Reliable statistics for tons of waste disposed are available since 1992. For the years 1950 to 1992 the statistics are good approximations. The influence of “old waste”, especially from the early years, on the calculated emissions for the years after 1990 are expected to be small.

3.2.4.3 CH_4 emissions

CH_4 emissions from solid waste disposal represent 15.9% (1990) resp. 8.0% (2007) of the total Swiss CH_4 emissions and 94.7% (1990) resp. 70.6% (2007) of the CH_4 emissions of the waste sector. The CH_4 emissions from solid waste disposal are a key category.

For the calculation of the CH_4 emissions from solid waste disposal, the model from the IPCC guidelines is used. It is applied in a consistent way.

The result that about 30 % of the landfill gas is recovered (used or flared) is realistic.

The following directive can be found in the 1996 IPCC guidelines and must be applied: “It is important that the oxidation factor be applied after subtraction of CH4 recovered, as this CH4 is generally pulled from well below the surface of the SWDS, before oxidation can occur.” [1996 IPCC guidelines – chapter 6 Waste p. 6.10]

Rounding of intermediate and final results creates errors of up to 7%. For 2007 e.g. the exact result is 12’378 t CH_4 and because of rounding three intermediate results there are 13’300 t carried over to the CRF tables. It is strongly recommended to keep exact results until the transfer to the CRF tables.

The composition of municipal solid waste, known for the years 1991 and 2001, is interpolated between those two years and supposed to be constant before and after. If this change within 10 years was judged possible, it is rather improbable that this value would remain constant before and after. At least for 1984/1987 data should be available (cf. Schriftenreihe Umweltschutz Nr. 27) and could be taken into account to see a tendency (DOC for the waste disposed in the early years from 1950 onwards would differ from that in 1993.). The composition of the MSW before 1990 (from 1950 onwards) also has an influence on emissions after 1990, as the MSW degenerates slowly and methane is generated over many years. Applying a constant average (of the 1991 and the 2001 value) for the DOC would reduce the calculated emissions between 2% (2007) and 8% (1990).

For sewage sludge the same DOC value as for non-food garden waste is used (0.17). The 2006 IPCC guidelines give for domestic sludge a default DOC value of 5 % (range 4 – 5 %) (as percentage of wet waste assuming a default dry matter content of 10 %) and for industrial sludge a raw default DOC value of 9 % (assuming a dry matter content of 35 %). This could be used to get a more specific value but would not lead to very different results (e.g. to a decrease of about 2 to 3 % for a DOC of 0.1).

For the following parameters, taken as default parameters from the IPCC guidelines, it could be interesting to determine for country specific values:

- fraction of methane in the landfill gas (default 0.5)
- fraction of degradable organic carbon dissimilated (default 0.6 from the 1996 IPCC guidelines is taken, in the 2006 IPCC guidelines already 0.5 is given as default value)

If one of them changes e.g. by 0.1, the yearly emissions from solid waste disposal on land change by 17% - 20%.

Not all values for “landfill gas used in engines” correlate between the EMIS commentary and the excel-sheet “deponie-model” (provided by the FOEN) and should be verified against the original statistic. This has already been corrected by the FOEN for the 2010 submission.

The assumption that 10 % of the methane is flared is not explained and no source is specified. The FOEN informs that it is an internal evaluation (waste division of the FOEN).

In the EMIS commentary no CH_4 emissions occurring from the use of landfill gas in engines are mentioned. Emissions from leakage in the piping to the engine and methane slip in the combustion process must be taken into account. Leakage emissions are most likely reported with direct emissions and would be correct if the quantity of gas recovered and subtracted was measured directly before the engine (and thus measured behind eventual leakage). In the NIR an emission factor for CH_4 from co-generation from landfills is mentioned (Table 3-9), but nowhere in the EMIS commentary. Recalculations show that CH_4 emissions from the use of landfill gas in engines are taken into account.

The CH_4 emissions from open burning are correctly reported under 6 A.

3.2.4.4 NO_X emissions

NO_X emissions from open burning and landfill gas flared are reported correctly under 6 A.

It cannot be seen whether NO_X emissions from the use of landfill gas in engines are reported in Table 1 of the CRF tables as emissions are reported for Public Electricity and Heat Production in general and not per fuel type. The FOEN confirms that they are reported under 1 A 4, CRF-table 1.

3.2.4.5 CO emissions

CO emissions from open burning and landfill gas flared are reported correctly under 6 A.

It cannot be seen whether CO emissions from the use of landfill gas in engines are reported in Table 1 of the CRF tables as emissions are reported for Public Electricity and Heat Production in general and not per fuel type. The FOEN confirms that they are reported under 1 A 1 A.

3.2.4.6 NMVOC emissions

The NMVOC emissions from open burning are reported correctly under 6 A.

3.2.4.7 SO_2 emissions

The SO_2 emissions from open burning are not requested under 6 A. It should be mentioned in the report, where they are reported (as the FOEN informs under 6D).

It cannot be seen whether SO_2 emissions from the use of landfill gas in engines are reported in Table 1 of the CRF tables as the emissions are reported for Public Electricity and Heat Production in general and not per fuel type. The FOEN confirms that they are reported under 1 A 1 a.

3.2.4.8 CO_2 emissions

Fossil CO_2 emissions from open burning are reported correctly under 6 A. In the CRF table for 2007 CO_2 emissions of 0.06 Gg CO_2 from solid waste disposal on land are reported. Fossil CO_2 emissions from waste disposal only occur from open burning and activity data amount to 0 for this category in 2007. This point must be corrected. The FOEN informs that this was a technical problem of the database with “0”-values, which has already been resolved for the 2010 submission. The recalculation of the CO_2 emissions from waste disposal on land (i.e. from open burning as the only source of fossil CO_2) leads to differences of about 0.1 Gg. The FOEN explains this small difference with remaining discrepancies between the database for the inventory and the EMIS commentaries (update in process), which will be eliminated for further submissions.

3.2.4.9 N_2O emissions

N_2O emissions from open burning on disposal sites are not reported. In the 2006 IPCC Guidelines a default value of 150 g N_2O/t waste is given. These emissions could be reported under 6 C waste incineration as they are not requested under 6 A in the CRF tables.

3.2.5. Wastewater handling

3.2.5.1 General observations

The emission calculations are based on the energy content of the sewage gas used or flared. Emissions from sewage sludge treated in water treatment plants (incl. direct emissions from digestion, storage and distribution of the gas) have been taken into account[1].

Direct CH_4 emissions from sewage sludge drying are mentioned in the report but not quantified in the CRF tables.

Emissions from industrial wastewater treatment plants with pre-treatment are missing in the inventory.

The use of biogas from industrial wastewater digestion plants is mentioned in the Swiss statistics of renewable energies [15]. These quantities will be reported starting 2010 as an emission source in sector 1 A 1 a in the inventory.

No emissions from wastewater of inhabitants not connected to the public wastewater treatment system can be found reported. As the FOEN informs they have been excluded because their contribution seems very small. This should be mentioned in the NIR. (This review suggests not to exclude these emission sources for completeness)

A random check of the values reported in the CRF shows the consistency of the calculation. Of course, uncertainties in the Swiss assumptions and emission factors remain.

The NIR could inform that several wastewater treatment plants also accept co-substrates (e.g. slaughterhouse waste) and add them to the digestion process. As they are rich in energy content a considerable part of the sewage gas / biogas stems therefrom.

3.2.5.2 Activity data

The activity data are conclusive and stem from a reliable source.

[1] information provided by email from Ernst Basler + Partner AG

3.2.5.3 CH_4 emissions

CH_4 emissions are not calculated by the total methane occurring and then subtracting the CH_4 recovered but as CH_4 emissions occurring from the use (recovered or flared) of the total quantity of the methane. That leads to the fact that no CH_4 is reported as recovered what should be explained in the CRF tables.

Direct CH_4 emissions from sewage sludge drying are mentioned in the report but cannot be found in the EMIS commentary or the CRF tables. If their amount is negligible, this should be mentioned in the NIR.

In the footnote under Table 6 of the CRF tables a raw emission factor of 0.22 kg CH_4 per inhabitant is mentioned. It seems to date back to an older version of the inventory. The FOEN informs that this notation has been removed.

3.2.5.4 N_2O emissions

N_2O emissions from wastewater treatment represent 5.0% (1990) resp. 6.2% (2007) of total Swiss N_2O emissions and 89.2% (1990) resp. 80.2% (2007) of the N_2O emissions from the waste sector. The N_2O emissions from wastewater treatment are a key category.

The N_2O emissions from human sewage of all habitants are calculated using the method and default parameters given in the 1996 IPCC guidelines, the activity data are country specific. The results are correct.

Actually a study is being carried out in Switzerland [14] on how N_2O emissions depend on the mode of operation of the wastewater treatment, specifically the nitrification and denitrification processes. The actual state of the study suggests that N_2O emissions from wastewater treatment have been underestimated so far. As soon as they become available, the results should be looked at and further research should be undertaken to get more specific emission factors for further calculations, as N_2O emissions from wastewater treatment are a key category.

N_2O emissions from industrial wastewater are not considered. The FOEN informs that an EMIS commentary for industrial wastewater treatment and the declaration of the emissions in the NIR are planned for the next submission.

3.2.5.5 CO_2 emissions

There are only biogenic CO_2 emissions occurring from the use of sewage gas. The part from the energetic use of sewage gas is not mentioned as reported under 1 A 1 (Biomass), which would be consistent (comparable to the use of landfill gas and biogas). The FOEN explains this with the fact that the gas is only used on-site for the processes of treatment plant themselves.

3.2.5.6 Further emissions

Further emissions from the use of the sewage gas (NO_X, CO and NMVOC) were calculated using specific emission factors for the different kinds of use and their fraction of total use. The results are correct. The emissions from the energetic use of sewage gas are not mentioned as reported under 1 A 1, which would be consistent (see comment 3.2.5.5). The FOEN explains this with the fact that the gas is only used on-site for the processes of treatment plant themselves.

3.2.6. Digestion of organic waste (Waste others)

3.2.6.1 General observations

Emissions from digestion plants are documented in the waste sector; only emissions from using biogas in engines are documented in the energy sector (1 A 1). The 2006 IPCC Guidelines suggest that emissions from biogas facilities (anaerobic digestion) with energy production should be reported in the energy sector (1 A 4).

The allocation chosen for the Swiss NIR should be explained. In the NIR biogas is also mentioned for different other categories in the energy sector:

- 1 A 2 f Other (combustion installations in industries) biogas boilers and engines that do not provide heat or electricity to the public, Table 3-5;
- 1 A 3 b Road transportation, Table 3-25;
- 1 A 4 a Other Sectors: Commercial / Institutional Table 3-32).

It should be verified that the sum of biogas distributed to the different categories is equal to the net total and no parts of it are double counted. The FOEN informs that it uses a crosscheck process on the energy file to avoid double counting.

An error in the activity data (see 3.2.6.2) for the energetic use of biogas in the energy sector has been found. This has been corrected by the FOEN for the 2010 submission. The emissions from the digestion process calculated with the given emission factors are correct in the CRF tables.

SO_2 emissions are reported under “6D Other non-specified (composting and digestion)”, but no emission factor is given for SO_2 neither in the NIR nor in the EMIS commentary. This must be corrected. The FOEN informs that SO_2 emissions reported under 6D originate from open burning (on disposal sites) and wastewater treatment. This should be mentioned in the NIR.

As digestion of organic waste will remain an important and increasing activity, further studies should provide more specific emission factors for this category.

It would be recommended to split up the categories digestion and composting and to list emissions separately in the CRF tables, but as the FOEN informs, this is defined by the CRF and cannot be changed.

3.2.6.2 Activity data

Starting in the year 2002 the number of tons of biogenic waste digested is provided by the national waste statistic. Annual values from the statistic could be used for the years since 2002 instead of an assumption. This will be considered by the FOEN in the 2010 submission.

Erroneously the tons digested in 2006, provided by the national waste statistics, have been copied to the EMIS commentary as the 2007 value. Due to this “time-shift” the interpolated values for the years from 2003 to 2005 (and 2006) are wrong. In addition to that observation, it remains unclear where the (again differring) activity data for the years from 2003 onwards shown in the NIR (Table 8-17) come from. The FOEN informs that this has already been corrected for the 2010 submission.

A national statistic of materials digested in digestion plants could verify the amount of agricultural co-substrate (actually 10% co-substrates in addition to the quanitity digested are considered).

3.2.6.3 Quantity of CH_4 / biogas used in engines

The calculation of CH_4 per ton of waste digested is wrong, it doesn't take the transformation from C to CH_4 (12/16) into account. Furthermore only a fraction of 35% CH_4 in the biogas instead of 65% is used. This error has been corrected for the 2010 submission.

This leads to an underestimation of CH_4 used in engines of about 60%. All consecutive calculations are based on emission factors relative to this value of "CH_4 used" and needed to be updated.

The transformation from [t CH_4] to [TJ] (activity data in the EMIS commentary and the NIR) and of the emissions factors from [x / t CH_4] to [x / TJ] do not use the same energy content (0.047 and 0.05 TJ/t CH_4). The transformation must be calculated with the same conversion factor.

3.2.6.4 CH_4 emissions

CH_4 emissions from the category "waste others" (digestion and composting of organic waste) represent 0.7% (1990) resp. 2.8% (2007) of total Swiss CH_4 emissions and 4.1% (1990) resp. 25.3% (2007) of CH_4 emissions from the waste sector. CH_4 emissions from the category "waste others" (digestion and composting of organic waste) are a key category.

There is no emission factor for CH_4 as direct emission from the digestion plant given in the EMIS commentary and the NIR apart from emissions from the stock of digestion residues. Emissions from leakage, as well as diffuse methane emissions and methane slip must be taken into account. The 2006 IPCC Guidelines give a default value of 5 percent of the amount of CH_4 generated for these CH_4 emissions.

In the NIR (Table 3-9) an emission factor for CH_4 from fermentation engines is mentioned, but nowhere in the EMIS commentary. Recalculations could show that CH_4 emissions from the use of biogas in engines are taken into account. The FOEN confirms that they are considered in the energy chapter.

Emissions from the digestion residues could be looked at more precisely by measurements and the distinction whether the residue stocks are gas proof or not.

3.2.6.5 N_2O emissions

The same emission factor as for composting of organic waste is used. In the 2006 IPCC Guidelines the N_2O emissions from digestion are assumed to be negligible, while the emissions from composting could range from 0.5 to 5 percent of the initial nitrogen of the material. An adequate factor should be sought for N_2O emissions from the digestion of organic waste, as digestion of organic waste will stay an important category.

In the NIR (Table 3-9) an emission factor for N_2O from fermentation engines is mentioned, but no information is provided in the EMIS commentary. The FOEN affirms that they are considered in the energy chapter.

3.2.6.6 CO_2 emissions

The CO_2 emissions from digestion of organic waste and from the combustion of the biogas are purely biogenic CO_2 emissions.

The same emission factor as for landfill gas engines is taken, which is conclusive.

3.2.6.7 NO_X emissions

The same emission factor as for landfill gas engines is used. However, combustion characteristics could differ and the emission factor should be verified with further studies.

3.2.6.8 CO emissions

The same emission factor as for landfill gas engines is used, which is conclusive.

The CO emissions from the use of biogas in engines cannot be found reported.

3.2.6.9 NMVOC emissions

Cf. composting 3.2.7.6. The same value as for composting is used. As digestion of organic waste will stay an important category, a specific value should be sought.

3.2.6.10 SO_2 emissions

There are SO_2 emissions occurring from the combustion of biogas. They have neither been mentioned in the EMIS commentary nor can they be found reported in the NIR. As the FOEN informs, they have not been calculated so far and will be included in the next submission.

3.2.7. Composting of organic waste (Waste others)

3.2.7.1 General observations

The emissions from composting of organic waste are reported under the waste sector, which is correct.

With the given activity data and the emission factors the results given in the CRF tables (checked randomly) are correct.

There are SO_2 emissions reported under 6 D “other non-specified (composting and digestion)”, but no emission factor is given for SO_2 neither in the NIR nor in the EMIS commentary. This must be corrected. The FOEN informs that SO_2 emissions reported in 6 D summarize open burning (on disposal sites) and wastewater treatment. This should be mentioned in the NIR.

3.2.7.2 Activity data

As in the category “digestion” the EMIS commentary reports a wrong amount of organic waste composted for 2007 – the value for 2006 is taken. As a consequence the interpolated values for the years from 2003 to 2005 (2006) aren’t correct. It remains unclear, where the (again differing) activity data for the years 2003 onwards given in the NIR (Table 8-17) come from. The FOEN informs that this has already been corrected for the 2010 submission.

Starting in 2006, separate values for composting and digestion are available. Whereas up to 2006 the -10% going into digestion plants equalled the +10% supposed backyard composting (allowing the full composting value to be regarded as the sum of composted material), a separate estimate for backyard composting should be introduced after 2006. In general terms an amount of 10% for backyard composting seems to be low and should be verified. The actual submission mentions that more reliable data will be sought for future submissions.

3.2.7.3 CH_4 emissions

The CH_4 emissions from the category “waste others” (digestion and composting of organic waste) represent 0.7% (1990) resp. 2.8% (2007) of the total CH_4 emissions and 4.1% (1990) resp. 25.3% (2007) of the CH_4 emissions from the waste sector. The CH_4 emissions from the category “waste others” (digestion and composting of organic waste) are a key category.

The CH_4 emissions are calculated with a constant emission factor based on a detailed study. It corresponds to the value range given in the 2006 IPCC Guidelines.

3.2.7.4 N_2O emissions

The N_2O emissions are calculated with a constant emission factor based on a detailed study. It corresponds to the value range given in the 2006 IPCC Guidelines.

3.2.7.5 CO_2 emissions

CO_2 emissions from composting are purely biogenic.

3.2.7.6 NMVOC emissions

The VOC emission factor is carried over as emission factor for NMVOC. It should be verified that the definition of NMVOC for the inventory and the “VOC emission reference” correlate.

3.2.7.7 CO emissions

A recent study found small CO emissions from composting [10]. It could be used to estimate an emission factor for CO emissions from composting.

3.2.7.8 NO_X emissions

No NO_X is emitted during composting.

3.2.7.9 SO_2 emissions

SO_2 is not occurring from composting.

3.2.8. Other categories (Waste others)

3.2.8.1 General observations

In addition to composting and digestion of organic waste, the category “shredder plants” is reported under “waste others”.

3.2.8.2 Emissions from shredder plants

The activity data could be specified more exactly. Emissions from shredder plants have no influence on total emissions, their contribution is minimal.

An emission factor of 5 g/t for CO emissions based on one measurement (2.4 g/t) was used. It has effectively no influence on the total emissions, as their contribution to the total emissions is minimal, amouting to zero in the CRF tables.

Measurements of VOC are taken to determine the emission factor for NMVOC. It should be verified that the definition of NMVOC for the inventory and the VOC from the reference correlate.

3.2.9. Waste incineration

3.2.9.1 General observations

In the category waste incineration the following categories are reported:

- Sewage sludge incineration
- Incineration of hospital waste (until 2002)
- Illegal waste incineration
- Incineration of insulate material from cables (until 1995)
- Crematories

These categories contribute only very small emissions in comparison to total emissions.

The used activity data and emission factors are country specific values (with the exception of the N_2O emission factor for sewage sludge incineration, where a default value is used) and are adequate for these categories.

The results given in the CRF tables, checked randomly, are correct.

3.2.9.2 Remarks

Illegal waste incineration: There are no N_2O emissions reported from illegal waste incineration (emission factor “0”). At least a default value should be taken into account. In the 2006 IPCC guidelines a default value of 150 g N_2O / t waste for open burning of MSW is given.

3.3. Documentation and Transparency

3.3.1. General observations

It is difficult to retrace the allocation of waste related emissions to the different sectors of the NIR. For a better understanding of the logic behind, it could be helpful to show a schematic overview (cf. NIR Figure 8-4 for wastewater treatment) to explain what waste related activities lead to what kind of emissions and where they get reported.

In several categories the information on emission factors provided in the EMIS commentaries are not complete, sometimes they differ from the data reported in the NIR. It was difficult to find out by recalculations of partial emissions whether they were effectively missing in the inventory or just not mentioned in the commentary as for example CH_4 emissions from the use of biogas in engines. The commentaries should be improved to be accurate, complete and correlating with the inventory and the NIR.

The NIR itself does not always provide sufficient explanations and information about emission factors considered, activity data used and assumptions made. It is often necessary to consult the EMIS commentaries, which sometimes lack clarity or even lead to confusion in the current context (see paragraph above). It is recommended to improve the NIR to transparently provide all the information needed to understand the logic behind the report.

This also applies to unit conversions between the NIR, the CRF and the EMIS commentaries for activity data and emission factors. As sometimes differing units are used, an additional transformation of the units is necessary. This makes it difficult to verify the results, as e.g. the transformation to energy units using heating values is not a physical constant but a result of the respective composition of the waste. For example, the emissions from MSW incineration are mentioned in the NIR to be calculated based on the quantity (tons) of waste incinerated. Activity data are given in tons, the emission factor in e.g. t CO_2/t. But the CRF tables allow only TJ (activity data) and t/TJ (Emission factor) for the energy sector. The transformation from one to the other is not explained.

3.4. Check of the recommendations from the review of the ERT of the UN

As the ”Report of the individual review of the greenhouse gas inventories of Switzerland submitted in 2007 and 2008” was published after the submission of the inventory and NIR 2009, it was not possible for the compiling party to implement all the suggestions given in the review report.

The recommendation under § 89 (wastewater handling) has been implemented.

The recommendations under §§ 7., 11., 16. and 20. are general recommendations, which remain valid.

The specific recommendations under §§ 29., 30., 43., 87. and 88. as well as 91. – 94. have not yet been implemented by the compiling party.

4. Conclusion of the Review and recommendations

4.1. Remarks and recommendations

The review of the waste related emissions of the Swiss GHG inventory and NIR submitted 2009 has shown some discrepancies. The following list is not complete, for details cf. chapter 3. Some of the points will already be corrected for the 2010 submission (also cf. chapter 3).

1. For the digestion of organic waste the amount of CH_4 produced and used in engines is largely underestimated due to calculation errors. Direct emissions from this category seem to be missing completely. There is a general need of improvement of the different emission calculations for this category, as energy production from organic waste will increase.
2. Discrepancies have been detected for the emission factors and emissions from the use of waste derived fuels in the cement industry between the EMIS commentary, the NIR and the CRF tables.
3. Not all values for landfill gas used in engines correlate between the EMIS commentary and the excel-sheet “deponie model” and should be verified against the underlying statistics.
4. It should be double-checked if direct methane emissions from the use of biogas and landfill gas are taken into account in a correct and complete manner.
5. The CRF tables of 2007 report CO_2 emissions from open burning, but the activity data amount to 0. This is inconsistent and must be corrected.
6. Emissions from wastewater from inhabitants not connected to public wastewater treatment cannot be found reported.
7. N_2O emissions from industrial wastewater are not considered.
8. Emissions from industrial wastewater digestion plants do not appear in the inventory.
9. It should be mentioned in the NIR why direct emissions occurring from sewage sludge drying have not been quantified and reported in the CRF tables.

Acknowledging that the waste related emissions are realistically reported and that their contribution to the total emissions is reflected, the following recommendations could still be given to the compiling party:

1. The allocation of waste related emissions to the different categories in the NIR should be explained more clearly (e.g. with an graphic overview).
2. More research is required into N_2O emissions from different kinds of incineration, incineration plants and waste composition to specify more exact emission factors for this category.
3. It is recommended to research N_2O emissions from wastewater treatment to get more specific and exact values.
4. The accuracy of the emission factor for CO_2 emissions from incineration of MSW and special waste could be improved by further studies.
5. For the use in the model parameters, country specific values should be used with a high priority, provided they are realistic, accurate and refer to a sensibly broad data base.

6. It is recommended to use – whenever possible – unrounded country specific values for the model parameters to get the best possible results (some discrepancies have their origin in multiple rounding exercises).
7. The allocation of biogas to the different sectors of the inventory is unclear and explanations should be improved.
8. The amount of sewage gas recovered could be mentioned in the CRF tables.

4.2. Overview of the emissions' fraction of total emissions and their possibility of improvement

The following table gives an overview of the relevant emissions and highlights the categories which are most important:

waste sector 2007	CO2 in Gg	CH4 in Gg CO2 eq (*21)	N2O in Gg CO2 eq. (*310)
MSW+spec. w. inc. total	**2'162**	**NO**	**112**
MSW inc.	1'819	NO	105
spec. w. inc.	342	NO	7
waste derived fuels in cement ind. total	**295**	**NO**	**26**
waste disposal total	**0**	**279**	**-**
disposal	biog.	279	-
open burning	0	0	0
engines	biog.	0	0
flared	biog.	-	-
wastewater treatment	**-**	**13**	**201**
waste incineration	**15**	**4**	**31**
waste other total	**NO**	**100**	**20**
digestion	-	15	3
composting	-	85	17
shredder	-	-	-
sub - totals	**2'471**	**396**	**390**
total		**3'257**	
Total emissions Switzerland 2007	[Gg CO2 eq.]	50'617	

Table 1: Overview of reviewed waste related emissions (in CO_2eq.), highlighted values have the largest influence on total emissions

category	emission and	its fraction of the total emissions of Switzerland 2007	its fraction of the reviewed emissions	improvements possible on
solid waste disposal on land	CH4 landfills 13.3 Gg 279 Gg CO2 eq. 0.55% of total CO2 eq.	8% of total CH4	8.6%	parameters for the model: waste composition -> DOC fraction of methane in landfill gas fraction of degradable organic carbon dissimilated
wastewater treatment	N2O 0.65 Gg 201 Gg CO2 eq. 0.40% of total CO2 eq.	6.2% of total N2O	6.2%	method further studies on EF
MSW incineration	CO2 1'818.6 Gg 3.60% of total CO2 eq	4.2% of total CO2	55.8%	study on waste composition (already going on)
	N2O 0.34 Gg 105 Gg CO2 eq. 0.20% of total CO2 eq.	3.25% of total N2O	3.2%	further studies on emission factor for different kinds of installation, mode of operation, ..
digestion of organic waste	CH4 0.7 Gg 15 Gg CO2 eq. 0.03% of total CO2 eq.	0.4% of total CH4	0.5%	emission factors, as it was underestimated and generally as digestion of organic waste is an increasing category
for information composting	4.0 Gg 85 Gg CO2 eq. 0.17% of total CO2 eq.	2,4% of total CH4	2.6%	
	4.78% of the total CO2 eq. and 1.18% if CO2 from MSW incineration is not regarded as improvable		74.3% of the reviewed emissions could be looked at with further research 18.5% if CO2 from MSW incineration is not regarded as improvable	

Table 2: Overview of areas of improvement regarding waste related emissions and their respective fraction on the total reviewed emissions and the total Swiss emissions

To consider the possibility and the need of improvement of the waste related emission data, the fractions of the emissions have been looked at and whether they are good estimates or could be improved.

In a first analysis the estimation of the CO_2 emissions from MSW incineration is considered as good, as no significant error was found.

Regarding the fact that:

- The estimation of the emissions is good (highlighted green) for
  - CO_2 emissions from MSW and special waste incineration
  - CO_2 emissions from waste derived fuels in the cement industry
  - CO_2 emissions from waste disposal
  - CH_4 emissions from waste disposal
  - CH_4 emissions from waste incineration
  - N_2O emissions from waste disposal
  - N_2O emissions from waste incineration
  - N_2O emissions from composting

- improvement is possible (highlighted yellow) for
  - CH_4 emissions from wastewater treatment
  - CH_4 emissions from composting
  - N_2O emissions from special waste incineration
  - N_2O emissions from waste derived fuels in the cement industry
  - N_2O emissions from digestion of organic waste

and

- improvement is recommended (highlighted orange) for
  - N_2O emissions from MSW incineration
  - N_2O emissions from wastewater treatment (especially industrial wastewater)
  - CH_4 emissions from digestion of organic waste

the following overview can be given:

2007	CO2	CH4 in CO2 eq (*21)	N2O in CO2 eq. (*310)	good	improvement possible	improvement necessary
MSW+spec. w. inc. total	**2'162**	**NO**	**112**			
MSW inc.	1'819	NO	105	1'819		105
spec. w. inc.	342	NO	7	342	7	
waste derived fuels cement ind. total	**295**	**NO**	**26**	295	26	
waste disposal total	**0**	**279**	**-**			
disposal	biog.	279	-	279		
open burning	0	0	0	0		
engines	biog.	0	0	0		
flared	biog.	-	-			
wastewater treatment	**-**	**13**	**201**		13	201
waste incineration	**15**	**4**	**31**	50		
waste other total	**NO**	**100**	**20**			
digestion	-	15	3		3	15
composting	-	85	17	17	85	
shredder	-	-	-			
sub - totals	**2'471**	**396**	**390**	2'803	133	322
total	**3'257**			86%	4%	10%

Table 3: The main waste related emissions in [CO2 eq.] and their possibility of improvement
Highlighted green: good estimates
Highlighted yellow: improvement possible
Highlighted orange: improvement recommended

The following graphs indicate for each emission [CO_2, CH_4 (in CO_2 eq.) and N_2O (in CO_2 eq)] the percentage of good estimates and of reported emissions for which the data or calculation could/must be improved:

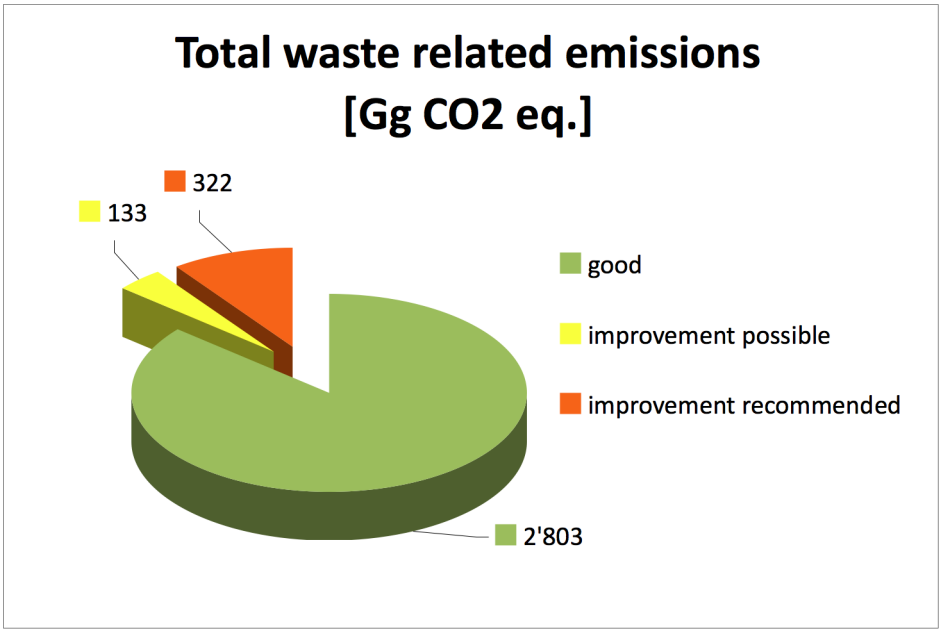

Illustration 1: The main waste related emissions [Gg CO_2 eq.] and their possibility of improvement

CO2 [Gg CO2 eq.] [%]	CH4 [Gg CO2 eq.] [%]	N2O [Gg CO2 eq.] [%]
2'471	283	48
100%	72%	12%
0	97	35
0%	25%	9%
0	15	306
0%	4%	79%

Table 4: Overview over the different emissions in Gg and percent

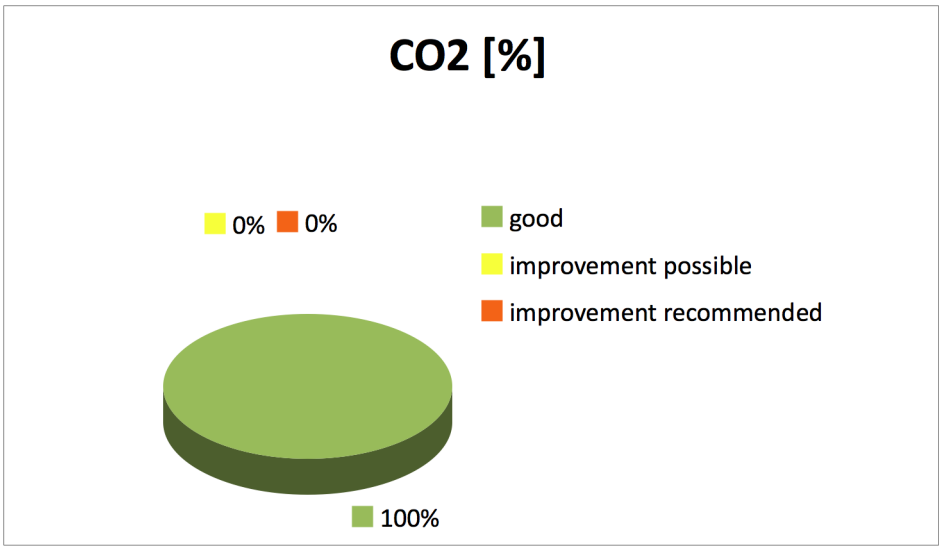

Illustration 2: Waste related CO_2 emissions and their possibility of improvement (quantities see Table 4)

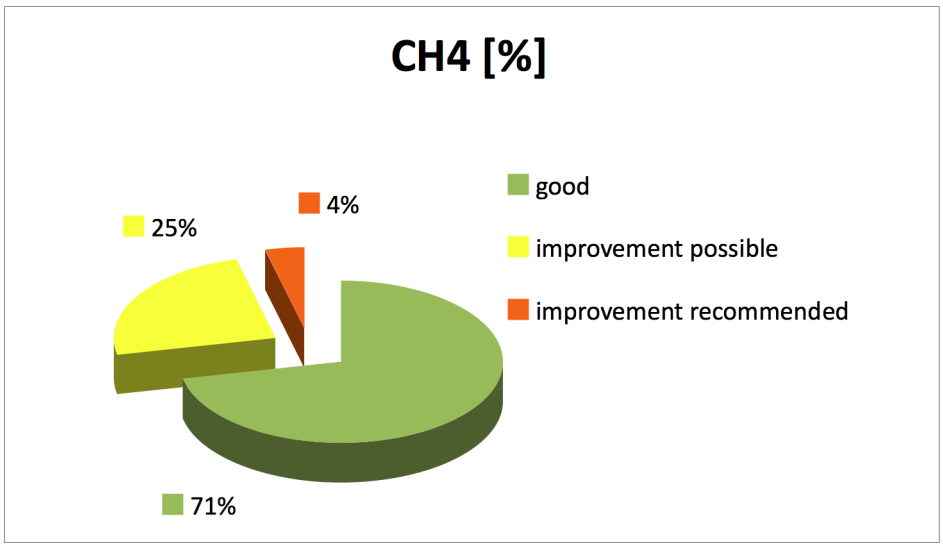

Illustration 3: Waste related CH_4 emissions and their possibility of improvement (quantities see Table 4)

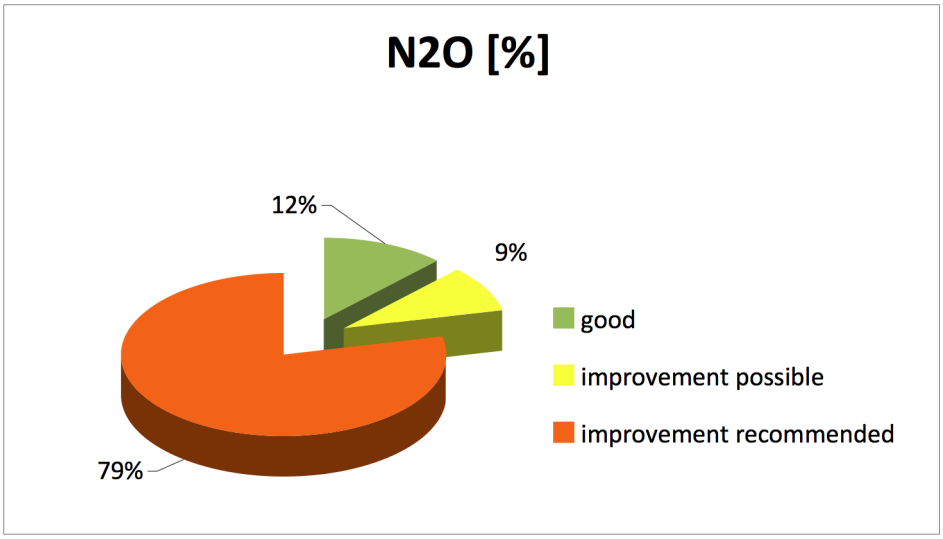

Illustration 4: Waste related N_2O emissions and their possibility of improvement (quantities see Table 4)

Overall, it is obvious that the largest proportion of waste related emissions in the GHG inventory is reported correctly, consistently and needs no improvement.

Looking closer, a big interest to improve the data about N_2O emissions should exist.

The importance to enhance information concerning the digestion of organic waste has been highlighted earlier in this review.

Improving the calculation of CO_2 emissions from MSW incineration would have the biggest effect on the total waste related emissions. It seems reasonable to have a closer look at the relevant emission factor. If done so, the following table highlights the room for improvement in the very important domain of CO_2 emissions from waste incineration (especially in comparison to Table 4):

CO2 [Gg CO2 eq.] [%]	CH4 [Gg CO2 eq.] [%]	N2O [Gg CO2 eq.] [%]
653	283	48
26%	72%	12%
1'819	97	35
74%	25%	9%
0	15	306
0%	4%	79%

Table 5: Overview in Gg and percent, CO_2 from MSW incineration as improvable

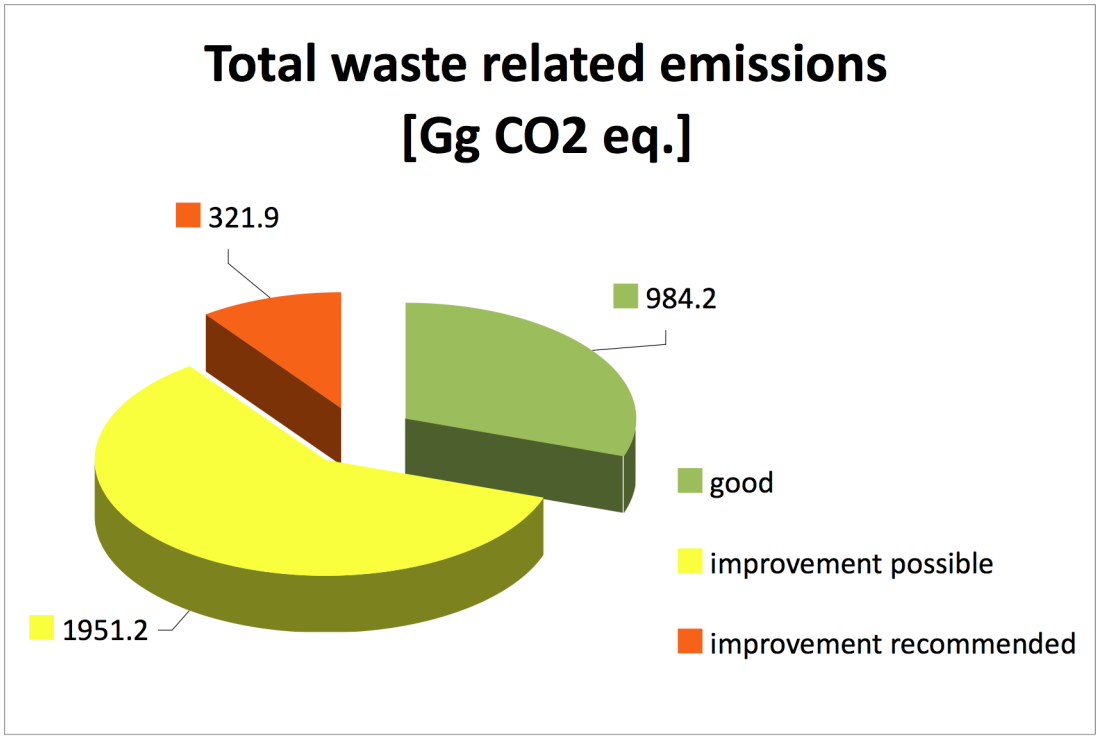

Illustration 5: Updated status chart for the main waste related emissions [CO_2 eq.] if CO_2 from MSW incineration is regarded as improvable

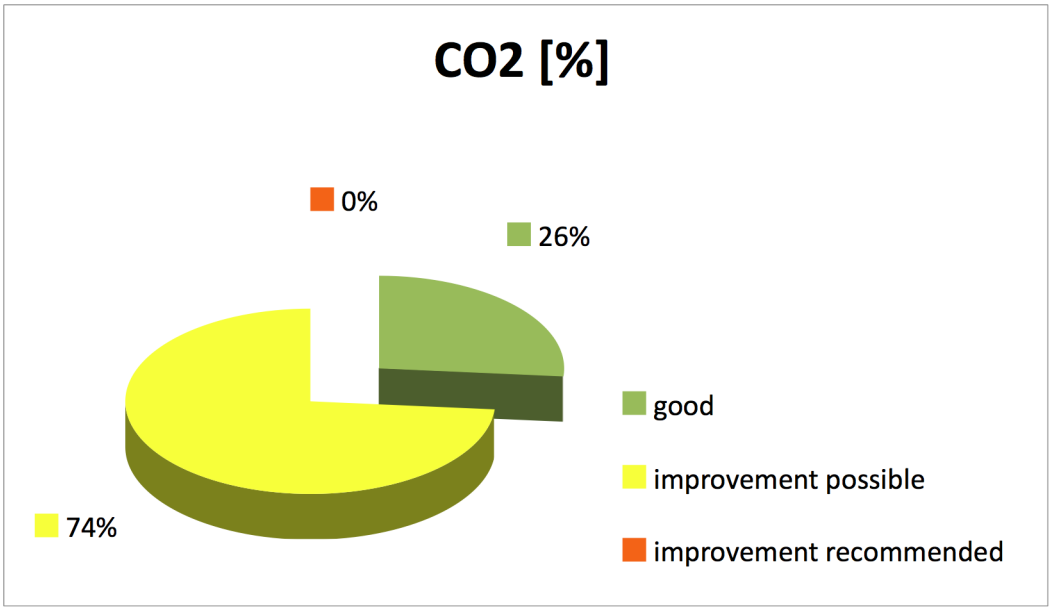

Illustration 6: Updated status chart for the waste related CO_2 emissions if CO_2 from MSW incineration is regarded as improvable (quantities see Table 5)

This illustrates again the big influence of MSW incineration on the waste related emissions and of one dominating emission factor in an important category.

These analyses should underline the recommendation to improve information about CO_2 emissions from MSW incineration and about NO_2 emissions in general, parallel to the elimination of the particular discrepancies found within this review.

4.3. Summary of the review

The review of the waste sector and the waste related emissions of the Swiss GHG inventory and NIR submitted 2009 concludes that the waste related emissions are calculated in a plausible way that yields reliable results.

The waste related emissions represent about 6% of total Swiss emissions. The categories in which waste related the reviewers suggest improving the estimation of emissions represent only about 1% of total Swiss emissions. If CO_2 emissions from municipal solid waste incineration were considered improvable, in total at most 5% of total Swiss emissions would need to be updated.

The methods used are considered as adequate. Activity data and emission factors are mostly country specific values, based on reliable data and only in few cases complemented by values found in literature. Only on rare occasions, default values for emission factors or model parameters from the IPCC guidelines had to be used. The use of the IPCC model for the estimation of CH_4 emissions from landfills and the N_2O emissions from domestic wastewater is considered to be adequate.

However, some observations in this review suggest corrections or a need for improvement (resp. investigation if an improvement is possible).

In cases when the default parameters from the IPCC guidelines have not been used but there is only spotty, potentially unreliable country specific data available, the reasons for this choice should be explained.

For several emission factors, this review recommends further research to determine values that are more specific. This applies mainly to N_2O emissions (especially from incineration of MSW and from wastewater treatment), as waste related N_2O emissions contribute about 12% to the total N_2O emissions. Only little information about these emission factors exists.

The CO_2 emissions from incineration of MSW and special waste with energy recovery contribute substantially to total Swiss emissions. In this area, the review suggests to undertake further research into specific emission factors.

The category “digestion of organic waste” (part of the “waste others” category) will become more and more relevant, as the trend towards renewable energy production will increase the quantity of organic waste digested. For this reason and because the reporting unit has only little information about this category at this time, it seems worthwhile to investigate into more specific data. An error in the calculation of CH_4 produced led to a considerable underestimation of all emissions calculated in proportion to that value.

The category “wastewater treatment” is evaluated as partially incomplete, as some gaps need to be closed:

- emissions from wastewater of the inhabitants not connected to public wastewater treatment,
- N_2O emissions from industrial wastewater
- emissions of the digestion process and biogas use (from the generation and use of biogas) from industrial wastewater treatment plants.

Of course, the general recommendation to improve the accuracy of the country specific values continuously to reduce existing uncertainties, applies also to the waste sector.

As guidance to the reader, the NIR could be improved in terms of a presentation of the overall reporting structure (what / where / why) and in providing more information on the source of certain values and on assumptions made in the calculation (cf. 3.3).

In conclusion, the findings of this review may be substantial in the waste sector but only apply to a small part of the total Swiss emissions. The reported waste related emissions are plausible and their contribution to the total Swiss emissions seems realistic.

5. References

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6. ANNEXES

6.1. Annexe 1: List of data found about N_2O emissions from waste incineration

6.1.1. Values used

Emission factor for the N_2O emissions from waste incineration plants not equipped with a DeNox installation (NO_X abatement technology) for the GHG inventory 2009: 0.06 g N_2O / kg (moist matter), taken from [13], stems from Commission of the European Community, CORINAIR Inventory, Default emission Factors, 2nd ed. Jan. 1992.

Emission factor for the N_2O emissions from waste incineration plants equipped with a DeNox installation for the actual GHG inventory: 0.12 g N_2O / kg (moist matter): assumption that it is twice the one for plants without DeNox.

For sewage sludge incineration, an emission factor of 0.8 kg N2O / t dry matter is used.

6.1.2. Other available literature data

The following values and conclusions have been found in [8]:

- 6.4 g/GJ (→ 0.078 g N_2O / kg for 12.24 GJ/t) (for conventional MSW incineration plants, BUWAL 1995)
- 0.2 g/GJ (→ 0.0025 g N_2O / kg for 12.24 GJ/t) (for conventional MSW incineration plants, Austrian measurements)
- 3.7 g/GJ (→ 0.015 g N_2O / kg for 4 GJ/t) (for fluidised bed combustion of sewage sludge, BUWAL 1995)
- 25 g/GJ (→ 0.1 g N_2O / kg for 4 GJ/t) (for fluidised bed combustion of sewage sludge, Austrian measurements)
- The N_2O emissions increase for plants with a DeNox installation, especially for DeNox with SNCR technique and for those especially if urea is used.

6.1.3. EU – Best reference

In the BREF - waste incineration - a value of 10 mg N_2O / Nm3 for sewage sludge incineration with fluidised bed combustion is mentioned, which means an emission factor of 0.09 g N_2O / kg (with a volume flow of 9’000 Nm3/t).

6.1.4. 2006 IPCC guidelines

The default values in the 2006 IPCC Guidelines range from 0.05 g N2O / kg for MSW incineration up to 0.9 g N2O / kg for sewage sludge incineration.

6.1.5. Annotation

The transformation of the units depends a lot on the heating value or volume flow used and should be regarded with reticence as they can differ a lot between different kinds of waste (heating value) and different incineration installations (volume flow).

6.1.6. Conclusion

More research is required into N_2O emissions from different incineration plants and different kinds of waste composition to specify more exact emission factors for this category.

It could be interesting and recommended to launch a measurement project to obtain reliable data.