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Emissions of methane from solid waste disposal sites in the Czech Republic during 1990-2005

Application of first order decay model

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Abstract

Long term used method for estimation of methane emissions from solid waste disposal sites in the Czech Republic was total yield gas method (TYG). This method is simple and in case that SWDS sector is key emission sector inventory experts are encouraged to use more sophisticated methods.

More detailed methods include kinetics of waste decomposition. Author of this paper used IPCC tier 2 method called first order decay (FOD) for estimation of methane emission from solid waste disposal sites in the Czech Republic and compared results between two methods. Results show similarity in absolute value for year 1990. For Kyoto mechanisms year 1990 is crucial. Czech Republic has year 1990 set as a reference year for the first commitment period (2008-2012). Using TYG method emission for year 1990 was estimated 93 Gg CH_4. Using FOD method emission is estimated to 81 Gg of CH_4. While absolute value estimated by using two different methods is not significantly different, development of the emissions in period 1990-2005 is quite different. Using TYG method results shows more or less stable trend while FOD method shows steadily increasing emissions.

Method

First order decay (FOD) model assumes gradual decomposition of waste disposed to landfill. For calculation of GHG emissions from subsector "6. A solid waste disposal on land" of national greenhouse gas inventory author used "IPCC Spreadsheet for Estimating Methane emissions from Solid Waste Disposal Sites". This spreadsheet includes first order decay model. Equation is basically the one presented in IPCC, 2000 (Box 1) but it is modified to fit MS Excel sheet calculation options. Detailed description of the spreadsheet and equation behind it is in appendix[1] 1 of this paper.

Without getting in too much details TYG approach uses simplified assumption which is that emission of methane occurs in the year the waste is deposited into landfill. Detailed description of method is in IPCC, 2000 and results for the Czech Republic are in NIR, 2004. This approach might be useful when trying to quantify total emissions from one ton of waste. Reality is that methane generation is not constant over decomposition period. Methane leakages are dependent on various time dynamic factors inter alia outdoor temperature, humidity or way of compacting. Moreover, certain recovery technology or management practice might be introduced to the landfill in later stage of methane generation. Change in technology (e.g. flaring, bio-filters, capping) will likely result in change of methane emissions to atmosphere that obviously will affect emission parameters of landfill. Changes in technology parameters cannot be reflected in methane calculation by TYG method. Mathematical formulas used for FOD and TYG approaches shows box 1 and 2.

It is crucial to understand that both approaches TYG and FOD are top-down approaches and therefore there might be a problem with comparability of bottom-up approaches like summation of particular sites.

Box. 1: First Order Decay model (IPCC, 2000)

$$E_{(\text{Gg CH}_4/\text{rok})} = \left[\sum_X \left[\left(A \bullet k \bullet MSW_T(x) \bullet MSW_F(x) \bullet L_0(x)\right) \bullet \exp^{-k(t-x)}\right] - R_t\right] \bullet (1 - OX)$$

where

$$A = \left(1 - e^{-k}\right),$$

$$k = \ln 2 / t_{1/2} \ ,$$

and

$$L_0 = MCF \bullet DOC \bullet DOC_F \bullet F \bullet \frac{16}{12}$$

A is normalization factor correcting equation, *t* is an inventory year, *x* is a year of activity data input, *k* denotes to methane production constant (1/year), t1/2 is half time of decomposition, i.e. time for how long it takes to decompose half of decomposable waste, MSWT is total amount of municipal solid waste produced in the given year, and MSWF is its fraction disposed to landfill. MCF is methane correction factor specifying waste management practice (value 1 for managed SWDS), DOC a DOCF is degradable organic carbon respectively fraction that actually decomposes. F is methane fraction in LFG, R(t) is recovered methane, 16/12 is methane/carbon correction and OX is oxidation factor showing a fraction of methane that is oxidized in aerobic zone of the landfill.

[1] Appendixes contain also detailed parameters tables, detailed results tables and data tables for figures showed in this paper.

Box. 2: Total Yield Gas model (IPCC, 1996)

$$\text{Methane emissions (Gg } CH_4) = [(MSW_T \times MSW_F \times L_0) - R] \times (1 - OX)$$

where

$$L_0 \text{ (Gg } CH_4\text{/kg waste)} = MCF \times DOC \times DOC_F \times F \times 16 / 12$$

where MSW_T is the total amount of municipal waste generated in the given year, MSW_F is its fraction deposited in the landfill, MCF is the correction factor for methane (=1 for a managed landfill), DOC and DOC_F are the fraction of degradable carbon and the part thereof that is actually degraded, F is the CH_4 content in the landfill gas, R denotes the methane removed by targeted oxidation (recovered), 16/12 is the weight ratio of methane/carbon and OX is the oxidation factor.

Data

FOD model requires several parameters and several activity data to produce reasonable results. On following lines we will describe particular model variables. Summary of all model variables with their source is in the appendix 2.

Waste amount

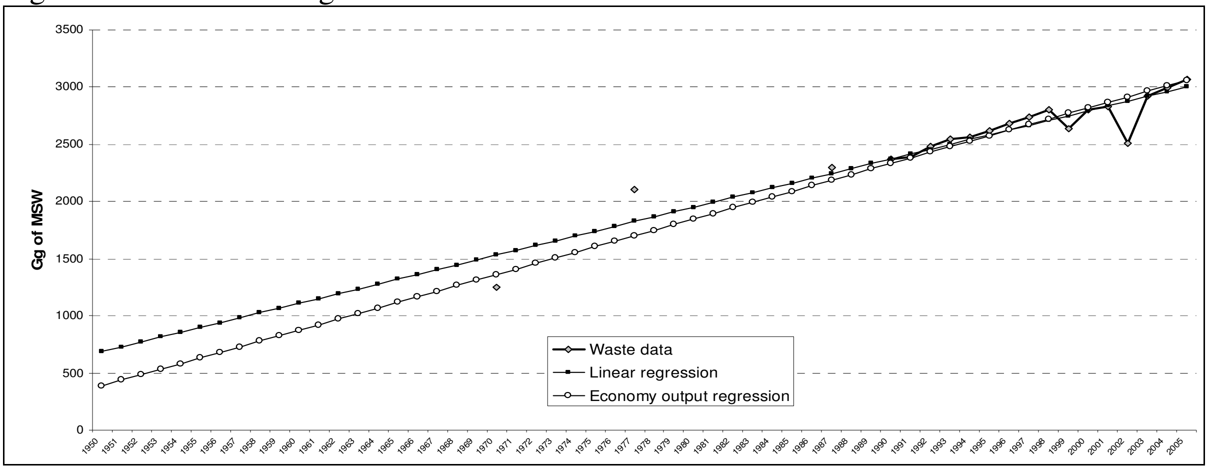
Key parameter in equation is amount of municipal solid waste (MSW) disposed to landfills in the country (alternatively total amount of MSW and landfilling ratio is used). Because we using FOD method we need long time series of amount of disposed MSW. Time line length is based on decay rate. Half-life of waste can be expressed as ln(2)/k where k is the decay rate constant. It differs between the categories of waste and also by geographical condition (main role is played by moisture, evapotranspiration and temperature). Author in this work take IPCC assumption (IPCC, 2000) that significant amount of methane is generated in the period 3-3.5times half-life of waste. Longest half-life we used for burnable waste (mainly wood/straw) – 23 years (Oonk and Boom 1995; IPCC 2000) which gives k rate 0.03. In this work we are using different k value for different waste stream but using half-life 14 years (k=0,05) we need 42-48 year long time line. It means for year 1990 we need data from year 1952. It is a major problem, because in the Czech Republic we lack even the data for year 1990. For TYG method there has been made assumption (Havránek, 2001) based on trend years 1993-2000. For method FOD we need same exercise but much longer.

Several time points were available and for non available years we used linear extrapolation. In study of Černík (Černík, 1985) is reported that amount of total waste production in ČSSR[2] is about 3.5 mil. tons of MSW from which is 3,2 mil. tons disposed to landfills. We assume that based on population ratio Czech Republic produced two thirds of the total (approximately 2.3 mil tons). Governmental council for the environment published (data for 1977) estimate that 2.1 mil tons of MSW is landfilled in the Czech Republic. Another source (Petrů, 1979) quotes report from data for 1970) that landfilled MSW reaches approximately 1.3 mil tons. Author was unable to identify more relevant studies to produce more points for timeline. As a first approach we used linear regression to prolong trend up to 1950. We came to regression $y = 42{,}112x + 645{,}61$ with $R^2 = 0{,}89$. Using this equation amount of waste disposed to SWDS in 1950 was 690 Gg. This value is taken as a reference value and used same function for period 1951-1989.

[2] ČSSR, known as Czechoslovakia or Czechoslovak Socialistic Republic is former state which consisted from the Czech Republic and Slovak Republic.

Author also tried different approach. We may assume hypothesis that production of waste is tied to economy output. In period 1970 - 1980 national statistics (Statistical yearbooks, var. years) used “social product” instead of nowadays used GDP. Exact definition and categories are not important basically it was main indicator of economy output. Looking on period 1970 to 1980 it has been found, that social product almost doubled here (went up 1.73 times). When we look on waste data, we see that amount of waste went up 1.76 times.
Using same scale we know that in periods 1950-1970 social product went up 3.7 times so we may assume waste production changed in same ratio. This would give us estimate less than 400 Gg of disposed MSW (or 40 kg of waste per capita/year) in year 1950. Rest points on graph (fig. 1) were calculated using regression (R^2=0,86). Using expert judgement and R^2 value author thinks that this value is underestimated for such industrialized country and therefore in following calculations used this value only for a sensitivity analysis (in equation we use 690 Gg from linear regression). In results and in sensitivity analysis one can see marginal difference for selected period (1990-2005). In 1990 difference is below 5% of the total emission and in 2005 difference is below 1%. Both of them are below sensitivity of the method.

Fig. 1: MSW data and regression back to 1950



Waste composition
Waste composition is also problematic because of the same reason as amount of waste is. There is no data about waste composition in 1950 and there is no data that can be quoted and taken as representative for the country in following years either. There has been some measurement done but seems to be rather local and general MSW composition can differ significantly. Therefore we assume that waste composition (waste streams percentages) are same as reference IPCC values for Eastern Europe. We also assume (due to lack of national data) that this composition was similar during entire time line. Composition distribution is shown in table 1.

Tab. 1: Default waste composition for the Eastern Europe (IPCC model, 2006)

Food	30 %	Textile	4,5 %
Garden	0 %	Nappies	0 %
Paper	22 %	Plastics, other inert	36 %
Wood	7,5 %		

Organic carbon

Waste composition is only useful if we know how much organic carbon particular waste stream includes. For this estimation author used default values suggested by IPCC. Default value was also used for fraction of DOC that actually decomposed (DOC_f = 0,5).

Tab. 2: Degradable organic carbon fraction – wet waste (IPCC model, 2006)

	Range	Default	Used values
Food waste	0.08-0.20	0,15	0,15
Garden	0.18-0.22	0,2	0,2
Paper	0.36-0.45	0,4	0,4
Wood and straw	0.39-0.46	0,43	0,43
Textiles	0.20-0.40	0,24	0,24
Disposable nappies	0.18-0.32	0,24	0,24

Methane generation rate

Methane generation rate (k) is closely tied with particular substance and available moisture. For FOD equation author used rates for particular waste streams (wood, paper etc.) based on default IPCC values for defined climate condition (see tab. 3).

Tab. 3: IPCC Climate Zone Definitions (IPCC model, 2006)

	Mean annual temperature	**Mean annual precipitation**	**Mean annual precipitation / Potential evapotranspiration**
Dry temperate	0 - 20°C		<1
Wet temperate	0 - 20°C		>1
Dry tropical	> 20°C	<1000 mm	
Moist and wet tropical	> 20°C	>1000 mm	

Average annual temperature in the Czech Republic is around 7 °C. Annual precipitation is higher than potential evapotranspiration. Therefore author used values for wet temperate climate which are shown in tab. 4.

Tab. 4: Methane generation rate constant (IPCC model, 2006)

	Range	**Used value**
Food waste	0.1–0.2	0,185
Garden	0.06–0.1	0,1
Paper	0.05–0.07	0,06
Wood and straw	0.02–0.04	0,03
Textiles	0.05–0.07	0,06
Disposable nappies	0.06–0.1	0,1
Sewage sludge	0.1–0.2	0,185

Methane correction factor

MCF is value that express overall management of the landfills in the country. The better managed landfill and deeper the biggest MCF. Shallow SWDS gets a lot more oxygen in to the landfill body to anaerobically decompose DOC. Values that IPCC suggest to use are shown in tab. 5. Because landfill management has been changing during estimated period tab.6 shows various assumptions around this factor. Data on MCF before 1993 are based on expert judgement. From 1993 there is no data about unmanaged SWDS so author assumes there are none.

Tab. 5: Methane correction values (IPCC, 1996)

	MFC
Unmanaged, shallow	0,4
Unmanaged, deep	0,8
Managed	1
Managed, semi-aerobic	0,5
Uncategorised	0,6

Tab. 6: Used MCF values

	MFC
1950 – 1959	0,6
1960 – 1969	0,6
1970 – 1979	0,8
1980 – 1989	0,9
1990 – 2005	1,0

Oxidation factor

As methane moves from anaerobic zone to aerobic and semi-aerobic zones close to landfill surface part of it becomes oxidised to CO_2. There is no conclusive agreement in scientific community how intensive oxidation of methane is. Oxidation is indeed site specific due to effects of local condition (including fissures and cracks, compacting, landfill cover etc.). There is no representative measurement or estimation of oxidation factor for the Czech Republic. There are some studies quoted in Straka, 2000 which mention non-zero oxidation factor, but those figures seems to be site specific and therefore cant be used as representative for whole country. Methodology (IPCC, 2000) however suggests not to use oxidation factor higher than 0.1 if no site measurements were available (higher magnitude adds uncertainty). Author also used the recommended oxidation factor of 0.1 in our assessment.

Delay time

When waste is disposed to SWDS decomposition (and methanogenesion) does not start immediately. The assumption included in the IPCC model is that the reaction starts on the first of January in the year after deposition, which is equivalent to an average delay time of six months before decay to methane commences. It is good practice to assume an average delay of from two to six months. If a value greater than six months is chosen, evidence to support this must be provided. The Czech Republic hasn't got representative country specific value for delay time so author used default value 6 months.

Fraction of methane

This parameter tells us share (mass) of methane on total amount of landfill gas (LFG). In previous calculation of methane emissions from SWDS (NIR, 2004) value 0,61 was used. This figure was based on measurement of limited amount of sites (Straka, 2000). This value is higher than IPCC suggested range between 0,5-0,6. In this work we revise this value based on new evidence (MTI, 2005). MTI gets annual reports from landfills capturing their LFG. SWDS report gross calorific value of their captured LFG. Author used this value for comparison with gross calorific value of pure methane. Doing this one gets value 0,55 which is the value that has been used in quantification.

Recovered methane
Methane that is collected by artificial system and incinerated (e.g. for energy purposes) is not considered as an emission of GHG (due to biogenic origin of carbon). In equation in appendix 1 shortcut R is used. There is no default value for R so author used country estimates based on Straka, 2000 and MPO, 2005[3]. Values for particular years are shown in table 7 column CH_4 recovery.

Results

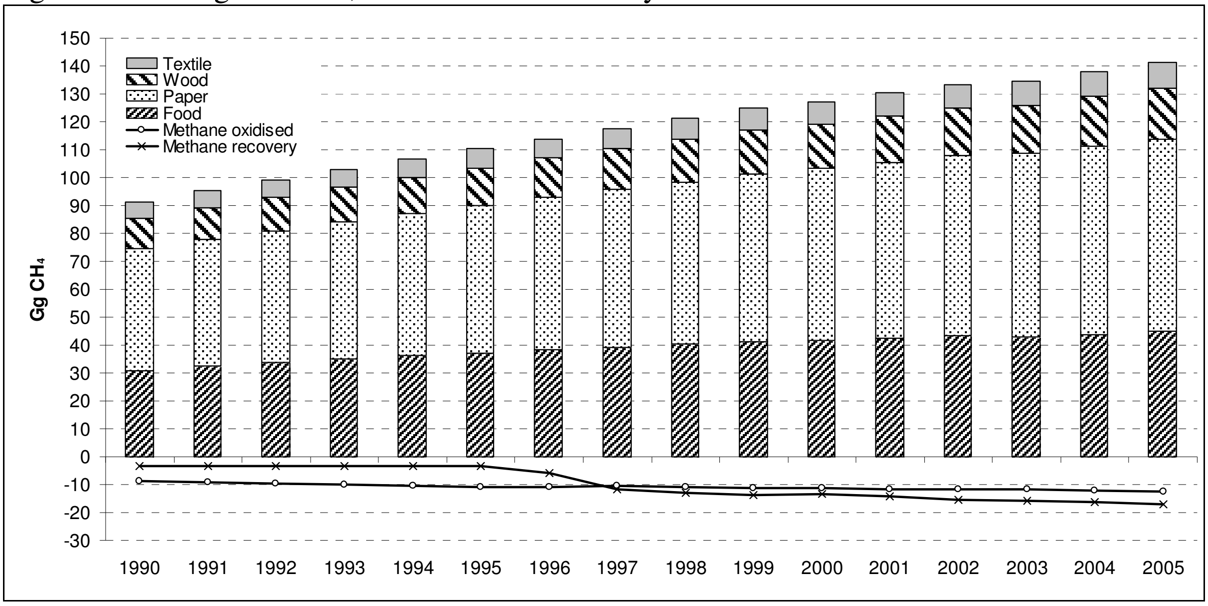
Total emissions of methane are based on equation 10 from appendix 1 - CH_4 emitted in year T = (ΣxCH4 generated (x,T) – R(T))×(1- OX(T)). Detailed time line from 1950 with breakdown on particular waste components is provided in appendix 3 together with other model outputs. Table 7 shows development of emissions of methane from SWDS and fig. 2 shows graphical overview of selected period. Please notify that categories of methane recovery and oxidised methane are not shown as cumulative on this graph.

Tab. 7: Emissions of methane from SWDS (Gg)

	CH_4 generation	CH_4 recovery	CH_4 oxidised	CH_4 emission
1990	91,2	-3,3	-8,8	**79**
1991	95,2	-3,3	-9,2	**83**
1992	99,0	-3,5	-9,6	**86**
1993	102,9	-3,5	-9,9	**89**
1994	106,7	-3,5	-10,3	**93**
1995	110,3	-3,5	-10,7	**96**
1996	113,9	-6,0	-10,8	**97**
1997	117,6	-11,8	-10,6	**95**
1998	121,2	-13,1	-10,8	**97**
1999	124,8	-13,7	-11,1	**100**
2000	127,2	-13,4	-11,4	**102**
2001	130,4	-14,1	-11,6	**105**
2002	133,4	-15,5	-11,8	**106**
2003	134,5	-16,0	-11,9	**107**
2004	137,8	-16,4	-12,1	**109**
2005	141,1	-17,0	-12,4	**112**

[3] Data up to 2002 are based on Straka, 2000, year 2002 is expert estimate based on trend and 2003 on is based on MPO 2005.

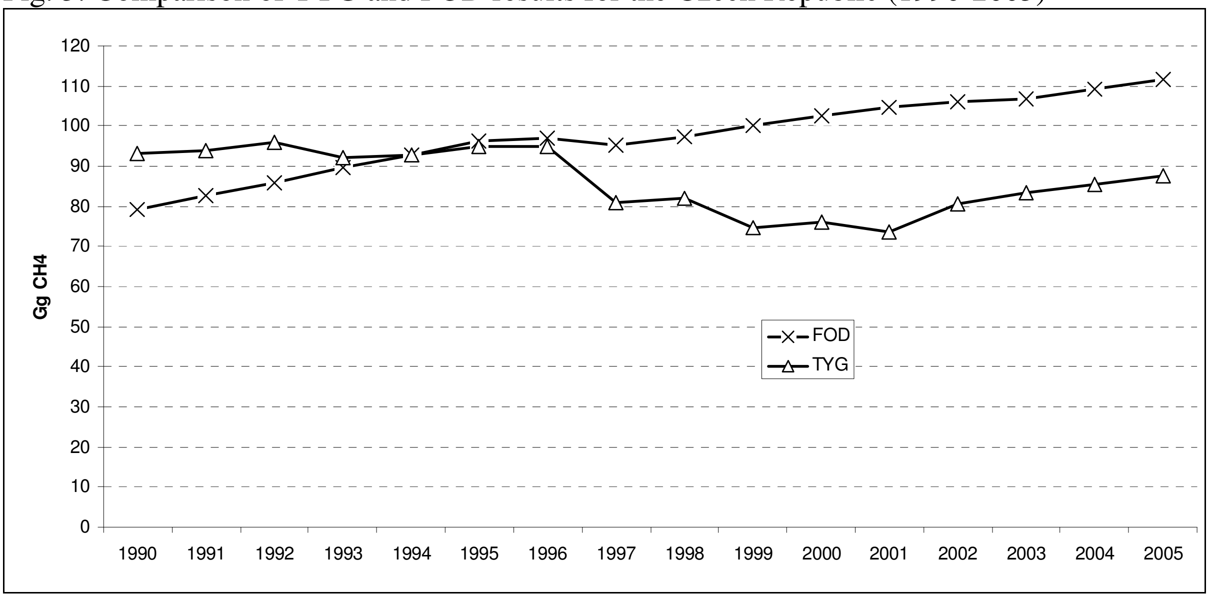
Fig. 2: Methane generation, oxidation and recovery in 1990-2005



Comparison of FOD and TYG

In figure 3 one can see difference between results of previously used TYG method and FOD model. Part of this difference can be accounted to changes in input factors and input data, but major difference is because of different mechanisms of calculation. TYG method also lack inner consistency because based on methodology (IPCC, 2000) from hypothetical emissions of entire lifespan of disposed waste subtracts actual recovery of LFG. This inconsistency leads to perversion of real trend in this sector – real emissions go up faster pace than reduction due to increasing LFG recovery.

Fig. 3: Comparison of TYG and FOD results for the Czech Republic (1990-2005)



Discussion

As was previously mentioned FOD model is more data demanding than TYG. Data gathering is expensive and in case of historical data sometimes even impossible. That's why calculation includes several assumptions. Author of this paper takes in reference scenario most robust assumptions based e.g. on IPCC defaults, national studies, national statistics and when such sources missing he uses expert judgement. In this subchapter one can look how results would change should we substitute some assumption for another. This substitution is done as a various sensitivity scenarios. Sensitivity scenario one (S1) is reference FOD scenario based on above mentioned assumptions (chapter data). Sensitivity scenario two is TYG method results. Other scenarios are in table 8.

Tab. 8: Sensitivity scenarios specifications

NAME	DESCRIPTION
S1 - FOD	**FOD method with assumption described in data chapter**
S2 - TYG	**TYG method results based on (NIR, 2004)**
S3 – 1950	**In this scenario we use different generation and disposal rate of MSW in to SWDS during 1950-1989, difference is based on change of social product (see subchapter on waste amount) in this period, all other parameters are same as in S1**
S4 – High DOC	**Methane generation is based on carbon content in the disposed waste. An IPCC default values come in certain range. For this scenario author chose high end of DOC value for particular MSW components. This range is shown in table 2.**
S5 – Low DOC	**Similar scenario as S4. An IPCC default values come in certain range. For this scenario author chose low end of DOC value for particular MSW components. This range is shown in table 2.**
S6 – Dry climate	**Methane generation rate (k) is based on type of waste and also on humidity of the waste. If annual precipitation is lower than potential evapotranspiration k rate might change. For this scenario author substituted k values of present wet temperate climate for dry temperate climate. Detailed values are in appendix 2 in k-rate table.**
S7 - Uncategorised waste management	**Methane correction factor for the Czech Republic is known from start of nineties. In period 1950-1990 author used gradual increase of MCF from 0,6 to 1,0 (see table 5). In this scenario is this gradual increase substituted by factor 0,6 (uncategorised SWDS) for entire 1950-1989 period.**
S8 - Bulk waste	**IPCC FOD model allows using either detailed waste composition approach or in case detailed composition is missing bulk waste approach. Bulk waste does not have specific k rates and DOC values for particular waste components. It uses DOC 0,18 and k 0,09 for total amount of disposed waste.**

Fig. 4: Development of methane emissions from SWDS in the Czech Republic under different sensitivity scenarios (1990-2005)

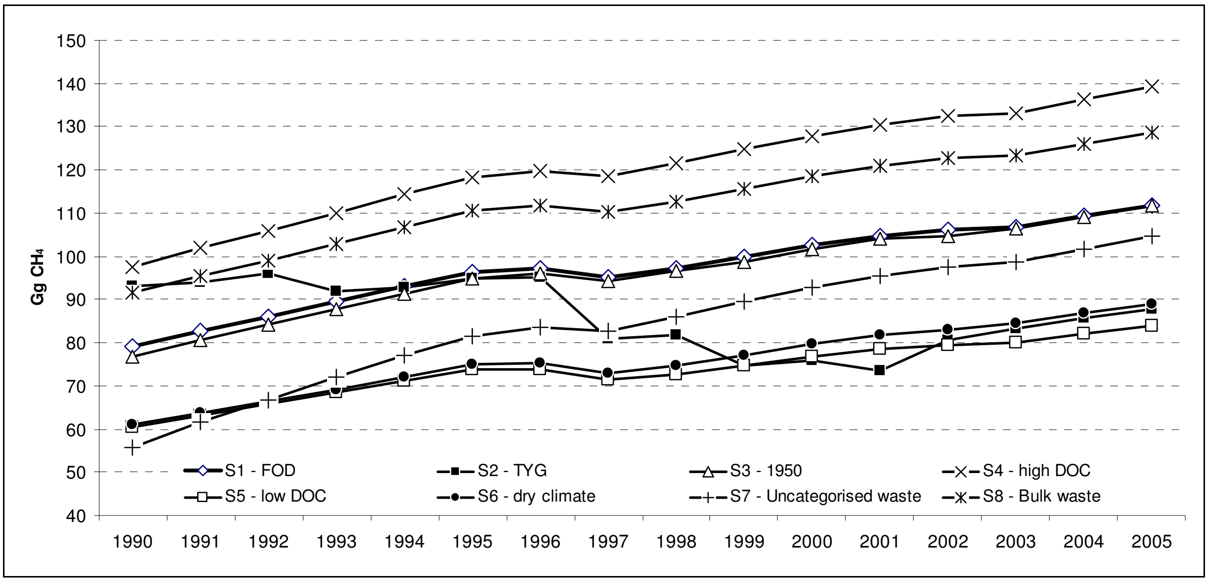


Figure 4 shows development of various sensitivity scenarios. As one can see all FOD based scenarios behaves in same manner - amount of waste is increasing so is increasing emissions from this sub sector. How much particular sensitivity scenarios differs from each other in year 1990 and year 2005 is shown in table 9 and table 10. Tables are composed as value of scenario in line divided by value of scenario in column minus one and result multiplied by 100 to get results in percentage.

While figure 4 shows all scenarios for sensitivity and for further uncertainty analysis seems to be important IPCC low and high scenarios which varies in +/- 25% from reference scenario. Scenario using different slower k-rate has also large difference (smaller by 20-23%) from reference sensitivity scenario but total amount of emissions doe not differ that much – only distribution through the time is altered. Sensitivity of scenario where year 1950 is calculated based on social product does not differ significantly – 3% in 1990 and less than 1% in 2005. Scenario TYG differs significantly but it is due to completely different approach to emissions calculation. Scenario without detailed composition of waste (S8) gives slightly higher results (+15%).

Tab. 9: Sensitivity scenarios difference in 1990

	S1 – FOD	S2 – TYG	S3 – 1950	S4 – high DOC	S5 - low DOC	S6 – dry climate	S7 – Unc. waste	S8 – Bulk
S1 - FOD	0%	-15%	3%	-19%	31%	30%	42%	-13%
S2 - TYG	18%	0%	22%	-4%	54%	53%	67%	2%
S3 - 1950	-3%	-18%	0%	-21%	27%	26%	38%	-16%
S4 - high DOC	23%	5%	27%	0%	61%	60%	75%	6%
S5 - low DOC	-24%	-35%	-21%	-38%	0%	-1%	8%	-34%
S6 - dry climate	-23%	-35%	-21%	-37%	1%	0%	9%	-33%
S7 - uncategorised waste	-30%	-40%	-27%	-43%	-8%	-9%	0%	-39%
S8 - bulk waste	16%	-2%	19%	-6%	51%	50%	64%	0%

Tab. 10: Sensitivity scenarios difference in 2005

	S1 – FOD	S2 – TYG	S3 – 1950	S4 – high DOC	S5 - low DOC	S6 – dry climate	S7 – Unc. waste	S8 – Bulk
S1 - FOD	0%	27%	0%	-20%	33%	26%	7%	-13%
S2 - TYG	-21%	0%	-21%	-37%	5%	-1%	-16%	-32%

S3 - 1950	0%	27%	0%	-20%	33%	26%	7%	-13%
S4 - high DOC	25%	59%	25%	0%	66%	57%	33%	8%
S5 - low DOC	-25%	-4%	-25%	-40%	0%	-6%	-20%	-35%
S6 - dry climate	-20%	1%	-20%	-36%	6%	0%	-15%	-31%
S7 - uncategorised waste	-6%	19%	-6%	-25%	25%	18%	0%	-19%
S8 - bulk waste	15%	47%	15%	-8%	54%	45%	23%	0%

Future steps

While sensitivity analysis can show some weak points or point out key some assumption of calculation, it cannot substitute uncertainty analysis. In following years author would like to run full uncertainty analysis to identify key elements and focus on improvement of their robustness (mainly in terms of data sources).

Literature and data sources

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[4] Because it is annual analysis years of yearbook relevant to the particular year are used.

Appendix 1

(IPCC model theory)

Following description of model theory was copied from IPCC Spreadsheet for Estimating Methane emissions from Solid Waste Disposal Sites

The basic equation for the first order decay model is:

(1) $DDOCm = DDOCm(0) * e^{-kt}$

where DDOCm(0) is the mass of decomposable degradable organic carbon (DOC) at the start of the reaction, when t=0 and $e^{-kt}=1$, k is the reaction constant and t is the time in years. DDOCm is the mass of DDOC at any time.
From equation (I) it is easy to see that at the end of year 1 (going from point 0 to point 1 on the time axis) the mass of DDOC left not decomposed in the SWDS is:

(2) $DDOCm(1) = DDOCm(0) * e^{-k}$

and the mass of DDOC decomposed into CH_4 and CO_2 will be:

(3) $DDOCmdecomp(1) = DDOCm(0) * (1 - e^{-k})$

In a first order reaction, the amount of product (here decomposed DDOCm) is always proportional to the amount of reactant (here DDOCm). This means that it does not matter when the DDOCm was deposited. This also means that when the amount of DDOCm accumulated in the SWDS, plus last year's deposit, is known, CH_4 production can be calculated as if every year is year number one in the time series. Then all calculations can be done by equations (2) and (3) in a simple spreadsheet.
The default assumption is that CH_4 generation from all the waste deposited each year begins on the 1st of January in the year after deposition. This is the same as an average six month delay until substantial CH_4 generation begins (the time it takes for anaerobic conditions to become well established). However, the worksheet includes the possibility of an earlier start to the reaction, in the year of deposition of the waste. This requires separate calculations for the deposition year. For longer delay times than 6 months, DDOCmd in the columns F and G cells in the CH_4 calculating sheets, have to be readdressed one cell down, and the number 13 in exp2 has to be changed to 25 (7 to 18 months delay time).
The equations used in these spreadsheets are: (As the mathematics of every waste fraction/category is the same, indexing for fraction/category is omitted for equations 4-9.)

To calculate mass of decomposable DOC (DDOCm) from amount of waste material (W):

(4) $DDOCmd(T), = W(T) \bullet DOC * DOCf \bullet MCF$

The amount of deposited DDOCm remaining not decomposed at the end of deposition year T:

(5) $DDOCmrem(T) = DDOCmd(T) \bullet e^{(-k \bullet ((13-M)/12)}$

The amount of deposited DDOCm decomposed during deposition year T:

(6) $DDOCmdec(T) = DDOCmd(T) \bullet (1 – e^{(-k \bullet ((13-M)/12))})$

The amount of DDOCm accumulated in the SWDS at the end of year T

$$(7)\ DDOCma(T) = DDOCmrem(T) + (DDOCma(T-1) \bullet e^{-k})$$

The total amount of DDOCm decomposed in year T

$$(8)\ DDOCmdecomp(T) = DDOCmdec(T) + (DDOCma(T-1) \bullet (1 - e^{-k}))$$

The amount of CH_4 generated from DOC decomposed

$$(9)\ CH_4\ generated(T) = DDOCmdecomp(T) \bullet F \bullet 16/12$$

The amount of CH_4 emitted

$$(10)\ CH_4\ emitted\ in\ year\ T = (\Sigma_x CH_4\ generated\ (x,T) – R(T)) \bullet (1- OX(T))$$

Where:

T = the year of inventory
x = material fraction/waste category
W(T) = amount deposited in year T
MCF = Methane Correction Factor
DOC = Degradable organic carbon (under aerobic conditions)
DOCf = Fraction of DOC decomposing under anaerobic conditions
DDOC = Decomposable Degradable Organic Carbon (under anaerobic conditions)
DDOCmd(T) = mass of DDOC deposited year T
DDOCmrem(T) = mass of DDOC deposited in inventory year T, remaining not decomposed at the end of year.
DDOCmdec(T) = mass of DDOC deposited in inventory year T, decomposed during the year.
DDOCma(T) = total mass of DDOC left not decomposed at end of year T.
DDOCma(T-1) = total mass of DDOC left not decomposed at end of year T-1.
DDOCmdecomp(T) = total mass of DDOC decomposed in year T.
CH_4 generated (T) = CH_4 generated in year T
F = Fraction of CH_4 by volume in generated landfill gas
16/12 = Molecular weight ratio CH_4/C
R(T) = Recovered CH_4 in year T
OX(T) = Oxidation factor in year T (fraction)
k = rate of reaction constant
M = Month of reaction start (= delay time + 7)

Appendix 2

(Parameters and activity data tables)

IPCC REGIONAL DEFAULT VALUES FOR WASTE COMPOSITION, WASTE GENERATION, AND FRACTION DISPOSED

Default DOC	0,4	0,24	0,15	0,43	0,2	0,24	0,05	0,39	0			
										MSW Generation Rate (tonnes/cap/yr)	**Fraction MSW disposed to SWDS**	**Regional Average DOC (wt fraction)**
	Percent Waste Composition Data											
	Paper/ card board	**Textiles**	**Food waste**	**Wood**	**Garden / park**	**Nappies / Diapers**	**Sewage sludge**	**Rubber / leather**	**All other, inerts**			
Asia: Eastern	18,8	3,5	26,2	3,5				1,0	47,0	0,55	0,55	0,14
Asia: South-central	11,3	2,5	40,3	7,9				0,8	37,2	0,21	0,74	0,15
Asia- Southeast	12,9	2,7	43,5	9,9				0,9	30,1	0,27	0,59	0,17
Asia- Western & Middle East	18,0	2,9	41,1	9,8				0,6	27,6	0,42	0,68	0,19
Africa: Eastern	7,7	1,7	53,9	7,0				1,1	28,6	0,29	0,69	0,15
Africa: Middle	16,8	2,5	43,4	6,5					30,8	0,29	0,69	0,17
Africa: Northern	16,5	2,5	51,1	2,0					27,9	0,29	0,69	0,16
Africa: Southern	25,0		23,0	15,0					37,0	0,29	0,69	0,20
Africa: Western	9,8	1,0	40,4	4,4					44,4	0,29	0,69	0,12
Europe: Eastern	21,8	4,7	30,1	7,5				1,4	34,5	0,38	0,90	0,18
Europe: Northern	30,6	2,0	23,8	10,0					33,6	0,64	0,47	0,21
Europe: Southern	17,0		36,9	10,6					35,5	0,52	0,85	0,17
Europe: Western	27,5		24,2	11,0					37,3	0,56	0,47	0,19
Oceania: Austrailia & New Zealand	30,0		36,0	24,0					10,0	0,69	0,85	0,28
Oceania: Other Oceania	6,0		67,5	2,5					24,0	0,69	0,85	0,14
America: North	23,2	3,9	33,9	6,2				1,4	31,4	0,65	0,58	0,19
America: Central	13,7	2,6	43,8	13,5				1,8	24,6	0,21	0,50	0,19
America: South	17,1	2,6	44,9	4,7				0,7	30,0	0,26	0,54	0,16
Caribbean	17,0	5,1	46,9	2,4				1,9	26,7	0,49	0,83	0,17

IPCC Default k values

		Temperate				Tropical			
		Dry		Wet		Dry		Moist and Wet	
Type of Waste		Default Value	Range	Default Value	Range	Default Value	Range	Default Value	Range
Slowly degrading waste	Paper/textile waste	0,04	0.03–0.05	0,06	0.05–0.07	0,045	0.04–0.06	0,07	0.06–0.085
	Wood/ straw/ rubber waste	0,02	0.01–0.03	0,03	0.02–0.04	0,025	0.02–0.04	0,035	0.03–0.05
Moderately degrading waste	Garden and park waste	0,05	0.04–0.06	0,1	0.06–0.1	0,065	0.05–0.08	0,17	0.15–0.2
Rapidly degrading waste	Food waste/ sewage sludge	0,06	0.05–0.08	0,185	0.1–0.2	0,085	0.07–0.1	0,4	0.17–0.7
Bulk MSW or Industrial Waste	Mixed composition	0,05	0.04–0.06	0,09	0.08–0.1	0,065	0.05–0.08	0,17	0.15–0.2

IPCC Climate Zone Definitions

	MAT	MAP	MAP/PET
Dry temperate	0 - 20°C		<1
Wet temperate	0 - 20°C		>1
Dry tropical	> 20°C	<1000 mm	
Moist and wet tropical	> 20°C	>1000 mm	

MAT – Mean annual temperature;
MAP – Mean annual precipitation;
PET – Potential evapotranspiration.
The average annual MAT, MAP and PET during the time series selected to estimate the emission and indicated by the nearest representative meteorological station. The information available is not adequate to subdivide temperate into cold (<10°C) and warm (10-20°C). In this IPCC classification for warm temperate, MAT is referred to the growing season.

Parameters sheet for FOD (S1)

	IPCC default value		Country-specific parameters	
			Value	Reference and remarks
Starting year		1950	1950	
DOC (Degradable organic carbon)				
(weight fraction, wet basis)	**Range**	**Default**		
Food waste	0.08-0.20	0,15	0,15	
Garden	0.18-0.22	0,2	0,2	
Paper	0.36-0.45	0,4	0,4	
Wood and straw	0.39-0.46	0,43	0,43	
Textiles	0.20-0.40	0,24	0,24	
Disposable nappies	0.18-0.32	0,24	0,24	
Sewage sludge	0.04-0.05	0,05	0,05	
Industrial waste	0-0.54	0,15	0,15	
DOCf (fraction of DOC dissimilated)		0,5	0,5	
Methane generation rate constant (k)				
(years^{-1})	**Range**	**Default**		
Food waste	0.1–0.2	0,185	0,185	
Garden	0.06–0.1	0,1	0,1	
Paper	0.05–0.07	0,06	0,06	
Wood and straw	0.02–0.04	0,03	0,03	
Textiles	0.05–0.07	0,06	0,06	
Disposable nappies	0.06–0.1	0,1	0,1	
Sewage sludge	0.1–0.2	0,185	0,185	
Industrial waste	0.08–0.1	0,09	0,09	
Delay time (months)		6	6	
Fraction of methane (F) in developed gas		0,5	0,55	
Conversion factor, C to CH_4		1,33	1,33	
Oxidation factor (OX)		0	0,1	

Reference FOD (S1) scenario MCF

	MSW					
	Un-managed, shallow	**Un-managed, deep**	**Managed**	**Managed, semi-aerobic**	**Uncate-gorised**	**Distri-bution Check**
	MCF	MCF	MCF	MCF	MCF	
IPCC default	0,4	0,8	1	0,5	0,6	
	Distribution of Waste by Waste Management Type					
Year	%	%	%	%	%	
1950	50%	50%	0%	0%	0%	100%
1951	50%	50%	0%	0%	0%	100%
1952	50%	50%	0%	0%	0%	100%
1953	50%	50%	0%	0%	0%	100%
1954	50%	50%	0%	0%	0%	100%
1955	50%	50%	0%	0%	0%	100%
1956	50%	50%	0%	0%	0%	100%
1957	50%	50%	0%	0%	0%	100%
1958	50%	50%	0%	0%	0%	100%
1959	50%	50%	0%	0%	0%	100%
1960	50%	50%	0%	0%	0%	100%
1961	50%	50%	0%	0%	0%	100%
1962	50%	50%	0%	0%	0%	100%
1963	50%	50%	0%	0%	0%	100%
1964	50%	50%	0%	0%	0%	100%
1965	50%	50%	0%	0%	0%	100%
1966	50%	50%	0%	0%	0%	100%
1967	50%	50%	0%	0%	0%	100%
1968	50%	50%	0%	0%	0%	100%
1969	50%	50%	0%	0%	0%	100%
1970	0%	100%	0%	0%	0%	100%
1971	0%	100%	0%	0%	0%	100%
1972	0%	100%	0%	0%	0%	100%
1973	0%	100%	0%	0%	0%	100%
1974	0%	100%	0%	0%	0%	100%
1975	0%	100%	0%	0%	0%	100%
1976	0%	100%	0%	0%	0%	100%
1977	0%	100%	0%	0%	0%	100%
1978	0%	100%	0%	0%	0%	100%
1979	0%	100%	0%	0%	0%	100%
1980	0%	100%	0%	0%	0%	100%
1981	0%	50%	50%	0%	0%	100%
1982	0%	50%	50%	0%	0%	100%
1983	0%	50%	50%	0%	0%	100%
1984	0%	50%	50%	0%	0%	100%
1985	0%	50%	50%	0%	0%	100%
1986	0%	50%	50%	0%	0%	100%
1987	0%	50%	50%	0%	0%	100%
1988	0%	50%	50%	0%	0%	100%
1989	0%	50%	50%	0%	0%	100%
1990	0%	0%	100%	0%	0%	100%
1991	0%	0%	100%	0%	0%	100%
1992	0%	0%	100%	0%	0%	100%

1993	0%	0%	100%	0%	0%	100%
1994	0%	0%	100%	0%	0%	100%
1995	0%	0%	100%	0%	0%	100%
1996	0%	0%	100%	0%	0%	100%
1997	0%	0%	100%	0%	0%	100%
1998	0%	0%	100%	0%	0%	100%
1999	0%	0%	100%	0%	0%	100%
2000	0%	0%	100%	0%	0%	100%
2001	0%	0%	100%	0%	0%	100%
2002	0%	0%	100%	0%	0%	100%
2003	0%	0%	100%	0%	0%	100%
2004	0%	0%	100%	0%	0%	100%
2005	0%	0%	100%	0%	0%	100%

MSW activity data

IPCC default			30%	0%	22%	8%	5%	0%	36%	100%
Composition of waste going to solid waste disposal sites										
	Total MSW	% to SWDS	Food	Garden	Paper	Wood	Textile	Nappies	Plastics, other inert	Total
	Gg	%	%	%	%	%	%	%	%	(=100%)
1950	687,722	100%	30%	0%	22%	8%	5%	0%	36%	100%
1951	729,834	100%	30%	0%	22%	8%	5%	0%	36%	100%
1952	771,946	100%	30%	0%	22%	8%	5%	0%	36%	100%
1953	814,058	100%	30%	0%	22%	8%	5%	0%	36%	100%
1954	856,17	100%	30%	0%	22%	8%	5%	0%	36%	100%
1955	898,282	100%	30%	0%	22%	8%	5%	0%	36%	100%
1956	940,394	100%	30%	0%	22%	8%	5%	0%	36%	100%
1957	982,506	100%	30%	0%	22%	8%	5%	0%	36%	100%
1958	1024,618	100%	30%	0%	22%	8%	5%	0%	36%	100%
1959	1066,73	100%	30%	0%	22%	8%	5%	0%	36%	100%
1960	1108,842	100%	30%	0%	22%	8%	5%	0%	36%	100%
1961	1150,954	100%	30%	0%	22%	8%	5%	0%	36%	100%
1962	1193,066	100%	30%	0%	22%	8%	5%	0%	36%	100%
1963	1235,178	100%	30%	0%	22%	8%	5%	0%	36%	100%
1964	1277,29	100%	30%	0%	22%	8%	5%	0%	36%	100%
1965	1319,402	100%	30%	0%	22%	8%	5%	0%	36%	100%
1966	1361,514	100%	30%	0%	22%	8%	5%	0%	36%	100%
1967	1403,626	100%	30%	0%	22%	8%	5%	0%	36%	100%
1968	1445,738	100%	30%	0%	22%	8%	5%	0%	36%	100%
1969	1487,85	100%	30%	0%	22%	8%	5%	0%	36%	100%
1970	1529,962	100%	30%	0%	22%	8%	5%	0%	36%	100%
1971	1572,074	100%	30%	0%	22%	8%	5%	0%	36%	100%
1972	1614,186	100%	30%	0%	22%	8%	5%	0%	36%	100%
1973	1656,298	100%	30%	0%	22%	8%	5%	0%	36%	100%
1974	1698,41	100%	30%	0%	22%	8%	5%	0%	36%	100%
1975	1740,522	100%	30%	0%	22%	8%	5%	0%	36%	100%
1976	1782,634	100%	30%	0%	22%	8%	5%	0%	36%	100%

1977	1824,746	100%	30%	0%	22%	8%	5%	0%	36%	100%
1978	1866,858	100%	30%	0%	22%	8%	5%	0%	36%	100%
1979	1908,97	100%	30%	0%	22%	8%	5%	0%	36%	100%
1980	1951,082	100%	30%	0%	22%	8%	5%	0%	36%	100%
1981	1993,194	100%	30%	0%	22%	8%	5%	0%	36%	100%
1982	2035,306	100%	30%	0%	22%	8%	5%	0%	36%	100%
1983	2077,418	100%	30%	0%	22%	8%	5%	0%	36%	100%
1984	2119,53	100%	30%	0%	22%	8%	5%	0%	36%	100%
1985	2161,642	100%	30%	0%	22%	8%	5%	0%	36%	100%
1986	2203,754	100%	30%	0%	22%	8%	5%	0%	36%	100%
1987	2245,866	100%	30%	0%	22%	8%	5%	0%	36%	100%
1988	2287,978	100%	30%	0%	22%	8%	5%	0%	36%	100%
1989	2330,09	100%	30%	0%	22%	8%	5%	0%	36%	100%
1990	2371	100%	30%	0%	22%	8%	5%	0%	36%	100%
1991	2388	100%	30%	0%	22%	8%	5%	0%	36%	100%
1992	2484	100%	30%	0%	22%	8%	5%	0%	36%	100%
1993	2543	100%	30%	0%	22%	8%	5%	0%	36%	100%
1994	2561	100%	30%	0%	22%	8%	5%	0%	36%	100%
1995	2621	100%	30%	0%	22%	8%	5%	0%	36%	100%
1996	2683	100%	30%	0%	22%	8%	5%	0%	36%	100%
1997	2739	100%	30%	0%	22%	8%	5%	0%	36%	100%
1998	2804	100%	30%	0%	22%	8%	5%	0%	36%	100%
1999	2632	100%	30%	0%	22%	8%	5%	0%	36%	100%
2000	2803	100%	30%	0%	22%	8%	5%	0%	36%	100%
2001	2826	100%	30%	0%	22%	8%	5%	0%	36%	100%
2002	2511	100%	30%	0%	22%	8%	5%	0%	36%	100%
2003	2924	100%	30%	0%	22%	8%	5%	0%	36%	100%
2004	2997	100%	30%	0%	22%	8%	5%	0%	36%	100%
2005	3072	100%	30%	0%	22%	8%	5%	0%	36%	100%

Amounts deposited in SWDS

Year	Food	Garden	Paper	Wood	Textile	Nappies	Sludge	Deposited MSW	Inert
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1950	207	0	150	52	32	0	0	688	247
1951	220	0	159	55	34	0	0	730	262
1952	232	0	168	58	36	0	0	772	277
1953	245	0	177	61	38	0	0	814	292
1954	258	0	187	64	40	0	0	856	307
1955	270	0	196	67	42	0	0	898	322
1956	283	0	205	71	44	0	0	940	338
1957	296	0	214	74	46	0	0	983	353
1958	308	0	223	77	48	0	0	1 025	368
1959	321	0	233	80	50	0	0	1 067	383
1960	334	0	242	83	52	0	0	1 109	398
1961	346	0	251	86	54	0	0	1 151	413
1962	359	0	260	89	56	0	0	1 193	428
1963	372	0	269	93	58	0	0	1 235	443
1964	384	0	278	96	60	0	0	1 277	459
1965	397	0	288	99	62	0	0	1 319	474

1966	410	0	297	102	64	0	0	1 362	489
1967	422	0	306	105	66	0	0	1 404	504
1968	435	0	315	108	68	0	0	1 446	519
1969	448	0	324	112	70	0	0	1 488	534
1970	461	0	334	115	72	0	0	1 530	549
1971	473	0	343	118	74	0	0	1 572	564
1972	486	0	352	121	76	0	0	1 614	579
1973	499	0	361	124	78	0	0	1 656	595
1974	511	0	370	127	80	0	0	1 698	610
1975	524	0	379	131	82	0	0	1 741	625
1976	537	0	389	134	84	0	0	1 783	640
1977	549	0	398	137	86	0	0	1 825	655
1978	562	0	407	140	88	0	0	1 867	670
1979	575	0	416	143	90	0	0	1 909	685
1980	587	0	425	146	92	0	0	1 951	700
1981	600	0	435	149	94	0	0	1 993	716
1982	613	0	444	153	96	0	0	2 035	731
1983	625	0	453	156	98	0	0	2 077	746
1984	638	0	462	159	100	0	0	2 120	761
1985	651	0	471	162	102	0	0	2 162	776
1986	663	0	480	165	104	0	0	2 204	791
1987	676	0	490	168	106	0	0	2 246	806
1988	689	0	499	172	108	0	0	2 288	821
1989	701	0	508	175	110	0	0	2 330	837
1990	714	0	517	178	111	0	0	2 371	851
1991	719	0	521	179	112	0	0	2 388	857
1992	748	0	542	186	117	0	0	2 484	892
1993	765	0	554	191	120	0	0	2 543	913
1994	771	0	558	192	120	0	0	2 561	919
1995	789	0	571	197	123	0	0	2 621	941
1996	808	0	585	201	126	0	0	2 683	963
1997	824	0	597	205	129	0	0	2 739	983
1998	844	0	611	210	132	0	0	2 804	1 007
1999	792	0	574	197	124	0	0	2 632	945
2000	844	0	611	210	132	0	0	2 803	1 006
2001	851	0	616	212	133	0	0	2 826	1 015
2002	756	0	547	188	118	0	0	2 511	901
2003	880	0	637	219	137	0	0	2 924	1 050
2004	902	0	653	225	141	0	0	2 997	1 076
2005	925	0	670	230	144	0	0	3 072	1 103

Methane Recovery and methane oxidised in top layer (OX)

	Amount of Methane Recovered from SWDS	**References / remarks**	**Fraction recovered methane**	**Methane oxidised (OX)**
IPCC default	0			0
Year	Gg			Fraction

1950	0,0		0,00	0,10
1951	0,0		0,00	0,10
1952	0,0		0,00	0,10
1953	0,0		0,00	0,10
1954	0,0		0,00	0,10
1955	0,0		0,00	0,10
1956	0,0		0,00	0,10
1957	0,0		0,00	0,10
1958	0,0		0,00	0,10
1959	0,0		0,00	0,10
1960	0,0		0,00	0,10
1961	0,0		0,00	0,10
1962	0,0		0,00	0,10
1963	0,0		0,00	0,10
1964	0,0		0,00	0,10
1965	0,0		0,00	0,10
1966	0,0		0,00	0,10
1967	0,0		0,00	0,10
1968	0,0		0,00	0,10
1969	0,0		0,00	0,10
1970	0,0		0,00	0,10
1971	0,0		0,00	0,10
1972	0,0		0,00	0,10
1973	0,0		0,00	0,10
1974	0,0		0,00	0,10
1975	0,0		0,00	0,10
1976	0,0		0,00	0,10
1977	0,0		0,00	0,10
1978	0,0		0,00	0,10
1979	0,0		0,00	0,10
1980	0,0		0,00	0,10
1981	0,0		0,00	0,10
1982	0,0		0,00	0,10
1983	0,0		0,00	0,10
1984	0,0		0,00	0,10
1985	0,0		0,00	0,10
1986	0,0		0,00	0,10
1987	0,0		0,00	0,10
1988	0,0		0,00	0,10
1989	0,0		0,00	0,10
1990	3,25		0,04	0,10
1991	3,25		0,03	0,10
1992	3,45		0,03	0,10
1993	3,45		0,03	0,10
1994	3,45		0,03	0,10
1995	3,45		0,03	0,10
1996	6,03		0,05	0,10
1997	11,79		0,10	0,10
1998	13,06		0,11	0,10
1999	13,68		0,11	0,10
2000	13,36		0,11	0,10

2001	14,07		0,11	0,10
2002	15,45		0,12	0,10
2003	15,97		0,12	0,10
2004	16,38		0,12	0,10
2005	17,0		0,12	0,10

Appendix 3

(Detailed results)

Results (Gg CH4) – S1

	Methane generated												
Year	**Food**	**Garden**	**Paper**	**Wood**	**Textile**	**Nappies**	**Sludge**	**MSW**	**Industrial**	**Total**	**Methane recovery**		**Methane emission**
	A	B	C	D	E	F	G	H	J	K	L		M = (K-L)*(1-OX)
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg		Gg
1950	0	0	0	0	0	0	0		0	0	0		0
1951	1	0	1	0	0	0	0		0	2	0		2
1952	2	0	2	0	0	0	0		0	4	0		4
1953	3	0	2	0	0	0	0		0	6	0		6
1954	4	0	3	1	0	0	0		0	8	0		7
1955	5	0	4	1	0	0	0		0	10	0		9
1956	5	0	5	1	1	0	0		0	12	0		10
1957	6	0	5	1	1	0	0		0	13	0		12
1958	7	0	6	1	1	0	0		0	15	0		13
1959	7	0	7	1	1	0	0		0	17	0		15
1960	8	0	8	2	1	0	0		0	18	0		16
1961	8	0	9	2	1	0	0		0	20	0		18
1962	9	0	9	2	1	0	0		0	21	0		19
1963	9	0	10	2	1	0	0		0	23	0		21
1964	10	0	11	2	1	0	0		0	25	0		22
1965	10	0	12	3	2	0	0		0	26	0		24
1966	11	0	13	3	2	0	0		0	28	0		25
1967	11	0	13	3	2	0	0		0	29	0		26
1968	12	0	14	3	2	0	0		0	31	0		28
1969	12	0	15	3	2	0	0		0	32	0		29
1970	13	0	16	4	2	0	0		0	34	0		31
1971	14	0	17	4	2	0	0		0	37	0		33
1972	15	0	18	4	2	0	0		0	40	0		36
1973	16	0	20	5	3	0	0		0	43	0		39
1974	17	0	21	5	3	0	0		0	46	0		41
1975	18	0	22	5	3	0	0		0	49	0		44
1976	19	0	24	6	3	0	0		0	51	0		46
1977	20	0	25	6	3	0	0		0	54	0		48
1978	20	0	26	6	3	0	0		0	56	0		51
1979	21	0	27	7	4	0	0		0	59	0		53
1980	22	0	29	7	4	0	0		0	61	0		55
1981	23	0	30	7	4	0	0		0	64	0		57
1982	24	0	32	8	4	0	0		0	67	0		60
1983	25	0	33	8	4	0	0		0	70	0		63
1984	26	0	35	9	4	0	0		0	74	0		66
1985	27	0	36	9	5	0	0		0	77	0		69
1986	28	0	38	9	5	0	0		0	80	0		72
1987	29	0	39	10	5	0	0		0	83	0		74
1988	29	0	41	10	5	0	0		0	86	0		77
1989	30	0	42	11	5	0	0		0	88	0		80
1990	31	0	44	11	6	0	0		0	91	3		**79**
1991	32	0	45	12	6	0	0		0	95	3		**83**
1992	34	0	47	12	6	0	0		0	99	3		**86**

1993	35	0	49	13	6	0	0		0	103	3		**89**
1994	36	0	51	13	7	0	0		0	107	3		**93**
1995	37	0	53	14	7	0	0		0	110	3		**96**
1996	38	0	55	14	7	0	0		0	114	6		**97**
1997	39	0	56	15	7	0	0		0	118	12		**95**
1998	40	0	58	15	8	0	0		0	121	13		**97**
1999	41	0	60	16	8	0	0		0	125	14		**100**
2000	42	0	61	16	8	0	0		0	127	13		**102**
2001	42	0	63	17	8	0	0		0	130	14		**105**
2002	43	0	65	17	8	0	0		0	133	15		**106**
2003	43	0	66	17	8	0	0		0	135	16		**107**
2004	44	0	67	18	9	0	0		0	138	16		**109**
2005	45	0	69	18	9	0	0		0	141	17		**112**
2006	46	0	71	19	9	0	0		0	145	0		130
2007	38	0	66	18	9	0	0		0	132	0		118
2008	32	0	63	18	8	0	0		0	120	0		108
2009	26	0	59	17	8	0	0		0	110	0		99
2010	22	0	56	17	7	0	0		0	101	0		91
2011	18	0	52	16	7	0	0		0	94	0		84
2012	15	0	49	16	6	0	0		0	87	0		78
2013	13	0	46	15	6	0	0		0	80	0		72
2014	10	0	44	15	6	0	0		0	75	0		67
2015	9	0	41	15	5	0	0		0	70	0		63
2016	7	0	39	14	5	0	0		0	65	0		59
2017	6	0	36	14	5	0	0		0	61	0		55
2018	5	0	34	13	4	0	0		0	57	0		51
2019	4	0	32	13	4	0	0		0	54	0		48
2020	3	0	30	12	4	0	0		0	50	0		45
2021	3	0	29	12	4	0	0		0	47	0		43
2022	2	0	27	12	3	0	0		0	45	0		40
2023	2	0	25	11	3	0	0		0	42	0		38
2024	2	0	24	11	3	0	0		0	40	0		36
2025	1	0	23	11	3	0	0		0	38	0		34
2026	1	0	21	10	3	0	0		0	36	0		32
2027	1	0	20	10	3	0	0		0	34	0		30
2028	1	0	19	10	2	0	0		0	32	0		29
2029	1	0	18	10	2	0	0		0	30	0		27
2030	1	0	17	9	2	0	0		0	29	0		26

Long-term stored C in SWDS

Year	MSW	Food	Garden	Paper	Wood	Textiles	Nappies	Sludge	C, Industry	Paper, industry subtotal	Wood, industry subtotal	Long-term stored C	Long-term stored C accumulated
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1950	0	9	0	18	7	2	0	0	0	0	0	36	36
1951	0	10	0	19	7	2	0	0	0	0	0	39	75
1952	0	10	0	20	7	3	0	0	0	0	0	41	116
1953	0	11	0	21	8	3	0	0	0	0	0	43	158
1954	0	12	0	22	8	3	0	0	0	0	0	45	204
1955	0	12	0	23	9	3	0	0	0	0	0	47	251
1956	0	13	0	25	9	3	0	0	0	0	0	50	301
1957	0	13	0	26	10	3	0	0	0	0	0	52	353
1958	0	14	0	27	10	3	0	0	0	0	0	54	407
1959	0	14	0	28	10	4	0	0	0	0	0	56	463
1960	0	15	0	29	11	4	0	0	0	0	0	59	521
1961	0	16	0	30	11	4	0	0	0	0	0	61	582
1962	0	16	0	31	12	4	0	0	0	0	0	63	645
1963	0	17	0	32	12	4	0	0	0	0	0	65	710
1964	0	17	0	33	12	4	0	0	0	0	0	67	778
1965	0	18	0	35	13	4	0	0	0	0	0	70	847
1966	0	18	0	36	13	5	0	0	0	0	0	72	919
1967	0	19	0	37	14	5	0	0	0	0	0	74	993
1968	0	20	0	38	14	5	0	0	0	0	0	76	1 069
1969	0	20	0	39	14	5	0	0	0	0	0	79	1 148
1970	0	28	0	53	20	7	0	0	0	0	0	108	1 256
1971	0	28	0	55	20	7	0	0	0	0	0	111	1 366
1972	0	29	0	56	21	7	0	0	0	0	0	114	1 480
1973	0	30	0	58	21	7	0	0	0	0	0	117	1 596
1974	0	31	0	59	22	8	0	0	0	0	0	119	1 716
1975	0	31	0	61	22	8	0	0	0	0	0	122	1 838
1976	0	32	0	62	23	8	0	0	0	0	0	125	1 964
1977	0	33	0	64	24	8	0	0	0	0	0	128	2 092
1978	0	34	0	65	24	8	0	0	0	0	0	131	2 223
1979	0	34	0	67	25	9	0	0	0	0	0	134	2 358
1980	0	35	0	68	25	9	0	0	0	0	0	137	2 495
1981	0	40	0	78	29	10	0	0	0	0	0	158	2 653
1982	0	41	0	80	30	10	0	0	0	0	0	161	2 814
1983	0	42	0	82	30	11	0	0	0	0	0	164	2 978
1984	0	43	0	83	31	11	0	0	0	0	0	168	3 146
1985	0	44	0	85	31	11	0	0	0	0	0	171	3 317
1986	0	45	0	86	32	11	0	0	0	0	0	174	3 491
1987	0	46	0	88	33	11	0	0	0	0	0	178	3 669
1988	0	46	0	90	33	12	0	0	0	0	0	181	3 850
1989	0	47	0	91	34	12	0	0	0	0	0	184	4 035
1990	0	54	0	103	38	13	0	0	0	0	0	209	4 243
1991	0	54	0	104	39	13	0	0	0	0	0	210	4 453
1992	0	56	0	108	40	14	0	0	0	0	0	218	4 672
1993	0	57	0	111	41	14	0	0	0	0	0	224	4 895
1994	0	58	0	112	41	14	0	0	0	0	0	225	5 120

1995	0	59	0	114	42	15	0	0	0	0	0	230	5 351
1996	0	61	0	117	43	15	0	0	0	0	0	236	5 587
1997	0	62	0	119	44	15	0	0	0	0	0	241	5 828
1998	0	63	0	122	45	16	0	0	0	0	0	247	6 074
1999	0	59	0	115	42	15	0	0	0	0	0	231	6 306
2000	0	63	0	122	45	16	0	0	0	0	0	246	6 552
2001	0	64	0	123	46	16	0	0	0	0	0	249	6 801
2002	0	57	0	109	40	14	0	0	0	0	0	221	7 022
2003	0	66	0	127	47	16	0	0	0	0	0	257	7 279
2004	0	68	0	131	48	17	0	0	0	0	0	264	7 542
2005	0	69	0	134	50	17	0	0	0	0	0	270	7 812
2006	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2007	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2008	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2009	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2010	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2011	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2012	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2013	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2014	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2015	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2016	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2017	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2018	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2019	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2020	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2021	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2022	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2023	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2024	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2025	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2026	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2027	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2028	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2029	0	0	0	0	0	0	0	0	0	0	0	0	7 812
2030	0	0	0	0	0	0	0	0	0	0	0	0	7 812

Methane calculation from: Food waste

		National values
DOC	DOC	0,15
DOCf	DOCf	0,500
Methane generation rate constant	k	0,185
Half-life time ($t_{1/2}$, years):	h = ln(2)/k	3,7
exp1	exp(-k)	0,83
Process start in deposition year. Month M	M	13,00
exp2	exp(-k*((13-M)/12))	1,00
Fraction to CH4	F	0,550

Year	Amount deposited	MCF	Decomposable DOC (DDOCm) deposited	DDOCm not reacted. Deposition year	DDOCm decomposed. Deposition year	DDOCm accumulated in SWDS end of year	DDOCm decomposed	CH_4 generated
	W	MCF	D = W * DOC * DOCf * MCF	B = D * exp2	C = D * (1-exp2)	H = B + ($H_{last\ year}$ * exp1)	E = C + $H_{last\ year}$ * (1 - exp1)	Q = E * 16/12 * F
	Gg	fraction	Gg	Gg	Gg	Gg	Gg	Gg
1950	207	0,60	9	9	0	9	0	0
1951	220	0,60	10	10	0	18	2	1
1952	232	0,60	10	10	0	25	3	2
1953	245	0,60	11	11	0	32	4	3
1954	258	0,60	12	12	0	38	5	4
1955	270	0,60	12	12	0	44	6	5
1956	283	0,60	13	13	0	49	7	5
1957	296	0,60	13	13	0	54	8	6
1958	308	0,60	14	14	0	59	9	7
1959	321	0,60	14	14	0	63	10	7
1960	334	0,60	15	15	0	68	11	8
1961	346	0,60	16	16	0	72	11	8
1962	359	0,60	16	16	0	76	12	9
1963	372	0,60	17	17	0	80	13	9
1964	384	0,60	17	17	0	84	13	10
1965	397	0,60	18	18	0	87	14	10
1966	410	0,60	18	18	0	91	15	11
1967	422	0,60	19	19	0	95	15	11
1968	435	0,60	20	20	0	98	16	12
1969	448	0,60	20	20	0	102	17	12
1970	461	0,80	28	28	0	112	17	13
1971	473	0,80	28	28	0	122	19	14
1972	486	0,80	29	29	0	130	21	15
1973	499	0,80	30	30	0	138	22	16
1974	511	0,80	31	31	0	146	23	17
1975	524	0,80	31	31	0	152	25	18

1976	537	0,80	32	32	0	159	26	19
1977	549	0,80	33	33	0	165	27	20
1978	562	0,80	34	34	0	171	28	20
1979	575	0,80	34	34	0	176	29	21
1980	587	0,80	35	35	0	182	30	22
1981	600	0,90	40	40	0	192	31	23
1982	613	0,90	41	41	0	201	32	24
1983	625	0,90	42	42	0	209	34	25
1984	638	0,90	43	43	0	217	35	26
1985	651	0,90	44	44	0	224	37	27
1986	663	0,90	45	45	0	231	38	28
1987	676	0,90	46	46	0	238	39	29
1988	689	0,90	46	46	0	244	40	29
1989	701	0,90	47	47	0	250	41	30
1990	714	1,00	54	54	0	261	42	31
1991	719	1,00	54	54	0	271	44	32
1992	748	1,00	56	56	0	281	46	34
1993	765	1,00	57	57	0	291	48	35
1994	771	1,00	58	58	0	300	49	36
1995	789	1,00	59	59	0	308	51	37
1996	808	1,00	61	61	0	317	52	38
1997	824	1,00	62	62	0	325	54	39
1998	844	1,00	63	63	0	334	55	40
1999	792	1,00	59	59	0	337	56	41
2000	844	1,00	63	63	0	343	57	42
2001	851	1,00	64	64	0	349	58	42
2002	756	1,00	57	57	0	347	59	43
2003	880	1,00	66	66	0	354	59	43
2004	902	1,00	68	68	0	362	60	44
2005	925	1,00	69	69	0	370	61	45
2006	0	1,00	0	0	0	308	63	46
2007	0	1,00	0	0	0	256	52	38
2008	0	1,00	0	0	0	213	43	32
2009	0	1,00	0	0	0	177	36	26
2010	0	1,00	0	0	0	147	30	22
2011	0	1,00	0	0	0	122	25	18
2012	0	1,00	0	0	0	101	21	15
2013	0	1,00	0	0	0	84	17	13
2014	0	1,00	0	0	0	70	14	10
2015	0	1,00	0	0	0	58	12	9
2016	0	1,00	0	0	0	48	10	7
2017	0	1,00	0	0	0	40	8	6
2018	0	1,00	0	0	0	33	7	5
2019	0	1,00	0	0	0	28	6	4
2020	0	1,00	0	0	0	23	5	3
2021	0	1,00	0	0	0	19	4	3
2022	0	1,00	0	0	0	16	3	2
2023	0	1,00	0	0	0	13	3	2
2024	0	1,00	0	0	0	11	2	2
2025	0	1,00	0	0	0	9	2	1
2026	0	1,00	0	0	0	8	2	1

2027	0	1,00	0	0	0	6	1	1
2028	0	1,00	0	0	0	5	1	1
2029	0	1,00	0	0	0	4	1	1
2030	0	1,00	0	0	0	4	1	1

Methane calculation from: Paper / card board

		National values
DOC	DOC	0,4
DOCf	DOCf	0,500
Methane generation rate constant	k	0,060
Half-life time ($t_{1/2}$, years):	h = ln(2)/k	11,6
exp1	exp(-k)	0,94
Process start in deposition year. Month M	M	13,00
exp2	exp(-k*((13-M)/12))	1,00
Fraction to CH4	F	0,550

Year	Amount deposited	MCF	Decomposable DOC (DDOCm) deposited	DDOCm not reacted. Deposition year	DDOCm decomposed. Deposition year	DDOCm accumulated in SWDS end of year	DDOCm decomposed	CH_4 generated
	W	MCF	D = W * DOC * DOCf * MCF	B = D * exp2	C = D * (1-exp2)	H = B + ($H_{last\ year}$ * exp1)	E = C + $H_{last\ year}$ * (1 - exp1)	Q = E * 16/12 * F
	Gg	fraction	Gg	Gg	Gg	Gg	Gg	Gg
1950	150	0,60	18	18	0	18	0	0
1951	159	0,60	19	19	0	36	1	1
1952	168	0,60	20	20	0	54	2	2
1953	177	0,60	21	21	0	72	3	2
1954	187	0,60	22	22	0	90	4	3
1955	196	0,60	23	23	0	109	5	4
1956	205	0,60	25	25	0	127	6	5
1957	214	0,60	26	26	0	145	7	5
1958	223	0,60	27	27	0	164	8	6
1959	233	0,60	28	28	0	182	10	7
1960	242	0,60	29	29	0	200	11	8
1961	251	0,60	30	30	0	219	12	9
1962	260	0,60	31	31	0	237	13	9
1963	269	0,60	32	32	0	256	14	10
1964	278	0,60	33	33	0	274	15	11
1965	288	0,60	35	35	0	293	16	12
1966	297	0,60	36	36	0	311	17	13
1967	306	0,60	37	37	0	330	18	13
1968	315	0,60	38	38	0	349	19	14
1969	324	0,60	39	39	0	367	20	15

1970	334	0,80	53	53	0	399	21	16
1971	343	0,80	55	55	0	431	23	17
1972	352	0,80	56	56	0	462	25	18
1973	361	0,80	58	58	0	493	27	20
1974	370	0,80	59	59	0	523	29	21
1975	379	0,80	61	61	0	554	30	22
1976	389	0,80	62	62	0	584	32	24
1977	398	0,80	64	64	0	613	34	25
1978	407	0,80	65	65	0	643	36	26
1979	416	0,80	67	67	0	672	37	27
1980	425	0,80	68	68	0	701	39	29
1981	435	0,90	78	78	0	738	41	30
1982	444	0,90	80	80	0	775	43	32
1983	453	0,90	82	82	0	811	45	33
1984	462	0,90	83	83	0	847	47	35
1985	471	0,90	85	85	0	883	49	36
1986	480	0,90	86	86	0	918	51	38
1987	490	0,90	88	88	0	953	53	39
1988	499	0,90	90	90	0	987	55	41
1989	508	0,90	91	91	0	1 021	57	42
1990	517	1,00	103	103	0	1 065	59	44
1991	521	1,00	104	104	0	1 107	62	45
1992	542	1,00	108	108	0	1 151	64	47
1993	554	1,00	111	111	0	1 195	67	49
1994	558	1,00	112	112	0	1 237	70	51
1995	571	1,00	114	114	0	1 279	72	53
1996	585	1,00	117	117	0	1 321	74	55
1997	597	1,00	119	119	0	1 364	77	56
1998	611	1,00	122	122	0	1 407	79	58
1999	574	1,00	115	115	0	1 440	82	60
2000	611	1,00	122	122	0	1 478	84	61
2001	616	1,00	123	123	0	1 515	86	63
2002	547	1,00	109	109	0	1 536	88	65
2003	637	1,00	127	127	0	1 574	89	66
2004	653	1,00	131	131	0	1 613	92	67
2005	670	1,00	134	134	0	1 653	94	69
2006	0	1,00	0	0	0	1 557	96	71
2007	0	1,00	0	0	0	1 466	91	66
2008	0	1,00	0	0	0	1 381	85	63
2009	0	1,00	0	0	0	1 301	80	59
2010	0	1,00	0	0	0	1 225	76	56
2011	0	1,00	0	0	0	1 153	71	52
2012	0	1,00	0	0	0	1 086	67	49
2013	0	1,00	0	0	0	1 023	63	46
2014	0	1,00	0	0	0	963	60	44
2015	0	1,00	0	0	0	907	56	41
2016	0	1,00	0	0	0	855	53	39
2017	0	1,00	0	0	0	805	50	36
2018	0	1,00	0	0	0	758	47	34
2019	0	1,00	0	0	0	714	44	32
2020	0	1,00	0	0	0	672	42	30

2021	0	1,00	0	0	0	633	39	29
2022	0	1,00	0	0	0	596	37	27
2023	0	1,00	0	0	0	561	35	25
2024	0	1,00	0	0	0	529	33	24
2025	0	1,00	0	0	0	498	31	23
2026	0	1,00	0	0	0	469	29	21
2027	0	1,00	0	0	0	442	27	20
2028	0	1,00	0	0	0	416	26	19
2029	0	1,00	0	0	0	392	24	18
2030	0	1,00	0	0	0	369	23	17

Methane calculation from: Wood

		National values
DOC	DOC	0,43
DOCf	DOCf	0,500
Methane generation rate constant	k	0,030
Half-life time ($t_{1/2}$, years):	h = ln(2)/k	23,1
exp1	exp(-k)	0,97
Process start in deposition year. Month M	M	13,00
exp2	exp(-k*((13-M)/12))	1,00
Fraction to CH4	F	0,550

Year	Amount deposited	MCF	Decomposable DOC (DDOCm) deposited	DDOCm not reacted. Deposition year	DDOCm decomposed. Deposition year	DDOCm accumulated in SWDS end of year	DDOCm decomposed	CH_4 generated
	W	MCF	D = W * DOC * DOCf * MCF	B = D * exp2	C = D * (1-exp2)	H = B + ($H_{last\ year}$ * exp1)	E = C + $H_{last\ year}$ * (1 - exp1)	Q = E * 16/12 * F
	Gg	fraction	Gg	Gg	Gg	Gg	Gg	Gg
1950	52	0,60	7	7	0	7	0	0
1951	55	0,60	7	7	0	14	0	0
1952	58	0,60	7	7	0	21	0	0
1953	61	0,60	8	8	0	28	1	0
1954	64	0,60	8	8	0	35	1	1
1955	67	0,60	9	9	0	43	1	1
1956	71	0,60	9	9	0	51	1	1
1957	74	0,60	10	10	0	59	2	1
1958	77	0,60	10	10	0	67	2	1
1959	80	0,60	10	10	0	75	2	1
1960	83	0,60	11	11	0	84	2	2
1961	86	0,60	11	11	0	92	2	2
1962	89	0,60	12	12	0	101	3	2
1963	93	0,60	12	12	0	110	3	2

1964	96	0,60	12	12	0	119	3	2
1965	99	0,60	13	13	0	129	4	3
1966	102	0,60	13	13	0	138	4	3
1967	105	0,60	14	14	0	147	4	3
1968	108	0,60	14	14	0	157	4	3
1969	112	0,60	14	14	0	167	5	3
1970	115	0,80	20	20	0	182	5	4
1971	118	0,80	20	20	0	197	5	4
1972	121	0,80	21	21	0	212	6	4
1973	124	0,80	21	21	0	227	6	5
1974	127	0,80	22	22	0	242	7	5
1975	131	0,80	22	22	0	257	7	5
1976	134	0,80	23	23	0	273	8	6
1977	137	0,80	24	24	0	288	8	6
1978	140	0,80	24	24	0	304	9	6
1979	143	0,80	25	25	0	319	9	7
1980	146	0,80	25	25	0	335	9	7
1981	149	0,90	29	29	0	354	10	7
1982	153	0,90	30	30	0	373	10	8
1983	156	0,90	30	30	0	392	11	8
1984	159	0,90	31	31	0	411	12	9
1985	162	0,90	31	31	0	431	12	9
1986	165	0,90	32	32	0	450	13	9
1987	168	0,90	33	33	0	469	13	10
1988	172	0,90	33	33	0	489	14	10
1989	175	0,90	34	34	0	508	14	11
1990	178	1,00	38	38	0	531	15	11
1991	179	1,00	39	39	0	554	16	12
1992	186	1,00	40	40	0	578	16	12
1993	191	1,00	41	41	0	602	17	13
1994	192	1,00	41	41	0	625	18	13
1995	197	1,00	42	42	0	649	18	14
1996	201	1,00	43	43	0	673	19	14
1997	205	1,00	44	44	0	697	20	15
1998	210	1,00	45	45	0	722	21	15
1999	197	1,00	42	42	0	743	21	16
2000	210	1,00	45	45	0	766	22	16
2001	212	1,00	46	46	0	789	23	17
2002	188	1,00	40	40	0	806	23	17
2003	219	1,00	47	47	0	830	24	17
2004	225	1,00	48	48	0	853	25	18
2005	230	1,00	50	50	0	878	25	18
2006	0	1,00	0	0	0	852	26	19
2007	0	1,00	0	0	0	827	25	18
2008	0	1,00	0	0	0	802	24	18
2009	0	1,00	0	0	0	778	24	17
2010	0	1,00	0	0	0	755	23	17
2011	0	1,00	0	0	0	733	22	16
2012	0	1,00	0	0	0	711	22	16
2013	0	1,00	0	0	0	690	21	15
2014	0	1,00	0	0	0	670	20	15

2015	0	1,00	0	0	0	650	20	15
2016	0	1,00	0	0	0	631	19	14
2017	0	1,00	0	0	0	612	19	14
2018	0	1,00	0	0	0	594	18	13
2019	0	1,00	0	0	0	577	18	13
2020	0	1,00	0	0	0	560	17	12
2021	0	1,00	0	0	0	543	17	12
2022	0	1,00	0	0	0	527	16	12
2023	0	1,00	0	0	0	511	16	11
2024	0	1,00	0	0	0	496	15	11
2025	0	1,00	0	0	0	482	15	11
2026	0	1,00	0	0	0	467	14	10
2027	0	1,00	0	0	0	454	14	10
2028	0	1,00	0	0	0	440	13	10
2029	0	1,00	0	0	0	427	13	10
2030	0	1,00	0	0	0	415	13	9

Methane calculation from: Textiles

		National values
DOC	DOC	0,24
DOCf	DOCf	0,500
Methane generation rate constant	k	0,060
Half-life time ($t_{1/2}$, years):	h = ln(2)/k	11,6
exp1	exp(-k)	0,94
Process start in deposition year. Month M	M	13,00
exp2	exp(-k*((13-M)/12))	1,00
Fraction to CH4	F	0,550

Year	Amount deposited	MCF	Decomposable DOC (DDOCm) deposited	DDOCm not reacted. Deposition year	DDOCm decomposed. Deposition year	DDOCm accumulated in SWDS end of year	DDOCm decomposed	CH_4 generated
	W	MCF	D = W * DOC * DOCf * MCF	B = D * exp2	C = D * (1-exp2)	H = B + ($H_{last\ year}$ * exp1)	E = C + $H_{last\ year}$ * (1 - exp1)	Q = E * 16/12 * F
	Gg	fraction	Gg	Gg	Gg	Gg	Gg	Gg
1950	32	0,60	2	2	0	2	0	0
1951	34	0,60	2	2	0	5	0	0
1952	36	0,60	3	3	0	7	0	0
1953	38	0,60	3	3	0	9	0	0
1954	40	0,60	3	3	0	12	1	0
1955	42	0,60	3	3	0	14	1	0
1956	44	0,60	3	3	0	16	1	1
1957	46	0,60	3	3	0	19	1	1

1958	48	0,60	3	3	0	21	1	1
1959	50	0,60	4	4	0	24	1	1
1960	52	0,60	4	4	0	26	1	1
1961	54	0,60	4	4	0	28	2	1
1962	56	0,60	4	4	0	31	2	1
1963	58	0,60	4	4	0	33	2	1
1964	60	0,60	4	4	0	35	2	1
1965	62	0,60	4	4	0	38	2	2
1966	64	0,60	5	5	0	40	2	2
1967	66	0,60	5	5	0	43	2	2
1968	68	0,60	5	5	0	45	2	2
1969	70	0,60	5	5	0	48	3	2
1970	72	0,80	7	7	0	52	3	2
1971	74	0,80	7	7	0	56	3	2
1972	76	0,80	7	7	0	60	3	2
1973	78	0,80	7	7	0	64	3	3
1974	80	0,80	8	8	0	68	4	3
1975	82	0,80	8	8	0	72	4	3
1976	84	0,80	8	8	0	75	4	3
1977	86	0,80	8	8	0	79	4	3
1978	88	0,80	8	8	0	83	5	3
1979	90	0,80	9	9	0	87	5	4
1980	92	0,80	9	9	0	91	5	4
1981	94	0,90	10	10	0	95	5	4
1982	96	0,90	10	10	0	100	6	4
1983	98	0,90	11	11	0	105	6	4
1984	100	0,90	11	11	0	110	6	4
1985	102	0,90	11	11	0	114	6	5
1986	104	0,90	11	11	0	119	7	5
1987	106	0,90	11	11	0	123	7	5
1988	108	0,90	12	12	0	128	7	5
1989	110	0,90	12	12	0	132	7	5
1990	111	1,00	13	13	0	138	8	6
1991	112	1,00	13	13	0	143	8	6
1992	117	1,00	14	14	0	149	8	6
1993	120	1,00	14	14	0	155	9	6
1994	120	1,00	14	14	0	160	9	7
1995	123	1,00	15	15	0	165	9	7
1996	126	1,00	15	15	0	171	10	7
1997	129	1,00	15	15	0	176	10	7
1998	132	1,00	16	16	0	182	10	8
1999	124	1,00	15	15	0	186	11	8
2000	132	1,00	16	16	0	191	11	8
2001	133	1,00	16	16	0	196	11	8
2002	118	1,00	14	14	0	199	11	8
2003	137	1,00	16	16	0	204	12	8
2004	141	1,00	17	17	0	209	12	9
2005	144	1,00	17	17	0	214	12	9
2006	0	1,00	0	0	0	201	12	9
2007	0	1,00	0	0	0	190	12	9
2008	0	1,00	0	0	0	179	11	8

2009	0	1,00	0	0	0	168	10	8
2010	0	1,00	0	0	0	158	10	7
2011	0	1,00	0	0	0	149	9	7
2012	0	1,00	0	0	0	141	9	6
2013	0	1,00	0	0	0	132	8	6
2014	0	1,00	0	0	0	125	8	6
2015	0	1,00	0	0	0	117	7	5
2016	0	1,00	0	0	0	111	7	5
2017	0	1,00	0	0	0	104	6	5
2018	0	1,00	0	0	0	98	6	4
2019	0	1,00	0	0	0	92	6	4
2020	0	1,00	0	0	0	87	5	4
2021	0	1,00	0	0	0	82	5	4
2022	0	1,00	0	0	0	77	5	3
2023	0	1,00	0	0	0	73	4	3
2024	0	1,00	0	0	0	68	4	3
2025	0	1,00	0	0	0	64	4	3
2026	0	1,00	0	0	0	61	4	3
2027	0	1,00	0	0	0	57	4	3
2028	0	1,00	0	0	0	54	3	2
2029	0	1,00	0	0	0	51	3	2
2030	0	1,00	0	0	0	48	3	2

Appendix 4

(Data tables for figures in text)

Fig. 1: MSW data and regression back to 1950

Year	Waste Data	Regresion (trend)	Regresion (social produkt)
1950		688	388,601
1951		730	437,202
1952		772	485,803
1953		814	534,404
1954		856	583,005
1955		898	631,606
1956		940	680,207
1957		983	728,808
1958		1025	777,409
1959		1067	826,01
1960		1109	874,611
1961		1151	923,212
1962		1193	971,813
1963		1235	1020,414
1964		1277	1069,015
1965		1319	1117,616
1966		1362	1166,217
1967		1404	1214,818
1968		1446	1263,419
1969		1488	1312,02
1970	1250	1530	1360,621
1971		1572	1409,222
1972		1614	1457,823
1973		1656	1506,424
1974		1698	1555,025
1975		1741	1603,626
1976		1783	1652,227
1977	2100	1825	1700,828
1978		1867	1749,429
1979		1909	1798,03
1980		1951	1846,631
1981		1993	1895,232
1982		2035	1943,833
1983		2077	1992,434
1984		2120	2041,035
1985		2162	2089,636
1986		2204	2138,237
1987	2300	2246	2186,838
1988		2288	2235,439
1989		2330	2284,04
1990	2371	2372	2332,641
1991	2388	2414	2381,242
1992	2484	2456	2429,843
1993	2543	2499	2478,444
1994	2561	2541	2527,045
1995	2621	2583	2575,646
1996	2683	2625	2624,247
1997	2739	2667	2672,848
1998	2804	2709	2721,449
1999	2632	2751	2770,05
2000	2803	2793	2818,651
2001	2826	2835	2867,252
2002	2511	2878	2915,853

2003	2924	2920	2964,454
2004	2997	2962	3013,055
2005	3072	3004	3061,656

Fig. 2: Methane generation, oxidation and recovery in 1990-2005

Year	Food	Paper	Wood	Textile	Methane recovery	Methane oxidised	Methane emission
1990	31,0	43,6	11,0	5,6	-3,3	-8,8	79,2
1991	32,4	45,5	11,5	5,9	-3,3	-9,2	82,8
1992	33,6	47,3	12,0	6,1	-3,5	-9,6	86,0
1993	34,9	49,1	12,5	6,4	-3,5	-9,9	89,5
1994	36,1	51,0	13,0	6,6	-3,5	-10,3	93,0
1995	37,1	52,8	13,5	6,8	-3,5	-10,7	96,2
1996	38,2	54,6	14,1	7,1	-6,0	-10,8	97,1
1997	39,3	56,4	14,6	7,3	-11,8	-10,6	95,2
1998	40,3	58,2	15,1	7,5	-13,1	-10,8	97,3
1999	41,3	60,1	15,6	7,8	-13,7	-11,1	100,0
2000	41,7	61,5	16,1	8,0	-13,4	-11,4	102,5
2001	42,5	63,1	16,6	8,2	-14,1	-11,6	104,7
2002	43,2	64,7	17,1	8,4	-15,5	-11,8	106,1
2003	42,9	65,6	17,5	8,5	-16,0	-11,9	106,7
2004	43,9	67,2	18,0	8,7	-16,4	-12,1	109,3
2005	44,8	68,9	18,5	8,9	-17,0	-12,4	111,7

Fig. 3: Comparison of TYG and FOD results for the Czech Republic (1990-2005)

FOD	TYG
79,2	93,2
82,8	93,9
86,0	96,0
89,5	92,0
93,0	92,7
96,2	94,9
97,1	95,0
95,2	80,9
97,3	81,9
100,0	74,8
102,5	76,0
104,7	73,5
106,1	80,6
106,7	83,4
109,3	85,5
111,7	87,7

Fig. 4: Development of methane emissions from SWDS in the Czech Republic under different sensitivity scenarios (1990-2005)

	S1 - FOD	S2 - TYG	S3 - 1950	S4 - high DOC	S5 - low DOC	S6 - dry climate	S7 - Uncategorised waste	S8 - Bulk waste
1990	79,2	93,2	76,7	97,4	60,5	60,9	55,7	91,5
1991	82,8	93,9	80,5	101,9	63,3	63,7	61,6	95,5
1992	86,0	96,0	84,1	105,8	65,7	66,3	66,8	99,1
1993	89,5	92,0	87,8	110,1	68,4	69,2	72,0	103,0
1994	93,0	92,7	91,4	114,3	71,1	72,1	77,0	106,8
1995	96,2	94,9	94,9	118,2	73,7	74,9	81,6	110,5
1996	97,1	95,0	96,0	119,9	73,9	75,4	83,7	111,8
1997	95,2	80,9	94,2	118,6	71,3	73,0	82,8	110,2
1998	97,3	81,9	96,5	121,4	72,7	74,7	85,9	112,7
1999	100,0	74,8	98,8	124,8	74,8	77,1	89,4	115,8
2000	102,5	76,0	101,8	127,7	76,9	79,7	92,6	118,5
2001	104,7	73,5	104,0	130,5	78,5	81,7	95,5	120,9
2002	106,1	80,6	104,7	132,5	79,5	83,1	97,6	122,6
2003	106,7	83,4	106,4	133,1	80,0	84,4	98,7	123,3
2004	109,3	85,5	109,1	136,3	82,0	86,7	101,8	126,0
2005	111,7	87,7	111,7	139,4	83,8	88,8	104,7	128,6

Appendix 5

(Data sources for parameters - overview)

	Waste amount	Waste composition	MCF	DOC	F	R	OX	k
1950	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1951	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1952	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1953	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1954	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1955	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1956	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1957	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1958	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1959	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1960	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1961	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1962	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1963	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1964	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1965	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1966	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1967	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1968	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1969	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1970	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1971	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1972	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1973	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1974	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1975	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1976	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1977	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1978	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1979	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1980	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default

1981	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1982	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1983	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1984	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1985	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1986	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1987	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1988	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1989	Trend estimate	IPCC model default	Expert estimate	IPCC model default	NA	NA	IPCC model default	IPCC model default
1990	Trend estimate	IPCC model default	Law obligation	IPCC model default	MTI (2005)	Straka (2000)	IPCC model default	IPCC model default
1991	Trend estimate	IPCC model default	Law obligation	IPCC model default	MTI (2005)	Straka (2000)	IPCC model default	IPCC model default
1992	Trend estimate	IPCC model default	Law obligation	IPCC model default	MTI (2005)	Straka (2000)	IPCC model default	IPCC model default
1993	Trend estimate	IPCC model default	Law obligation	IPCC model default	MTI (2005)	Straka (2000)	IPCC model default	IPCC model default
1994	Statistical Environmental Yearbook	IPCC model default	Law obligation	IPCC model default	MTI (2005)	Straka (2000)	IPCC model default	IPCC model default
1995	Statistical Environmental Yearbook	IPCC model default	Law obligation	IPCC model default	MTI (2005)	Straka (2000)	IPCC model default	IPCC model default
1996	Statistical Environmental Yearbook	IPCC model default	Law obligation	IPCC model default	MTI (2005)	Straka (2000)	IPCC model default	IPCC model default
1997	Statistical Environmental Yearbook	IPCC model default	Law obligation	IPCC model default	MTI (2005)	Straka (2000)	IPCC model default	IPCC model default
1998	Statistical Environmental Yearbook	IPCC model default	Law obligation	IPCC model default	MTI (2005)	Straka (2000)	IPCC model default	IPCC model default
1999	Statistical Environmental Yearbook	IPCC model default	Law obligation	IPCC model default	MTI (2005)	Straka (2000)	IPCC model default	IPCC model default
2000	Statistical Environmental Yearbook	IPCC model default	Law obligation	IPCC model default	MTI (2005)	Straka (2000)	IPCC model default	IPCC model default
2001	Statistical Environmental Yearbook	IPCC model default	Law obligation	IPCC model default	MTI (2005)	Straka (2000)	IPCC model default	IPCC model default
2002	Statistical Environmental Yearbook	IPCC model default	Law obligation	IPCC model default	MTI (2005)	Expert estimate	IPCC model default	IPCC model default
2003	Statistical Environmental Yearbook	IPCC model default	Law obligation	IPCC model default	MTI (2005)	MTI (2005)	IPCC model default	IPCC model default
2004	Statistical Environmental Yearbook	IPCC model default	Law obligation	IPCC model default	MTI (2005)	MTI (2005)	IPCC model default	IPCC model default
2005	Statistical Environmental Yearbook	IPCC model default	Law obligation	IPCC model default	MTI (2005)	MTI (2005)	IPCC model default	IPCC model default