CBA Forum meeting on Environment sectors

Focus: Estimation of GHG emission from Waste Projects

Francesco Angelini

JASPERS

Energy and Solid Waste

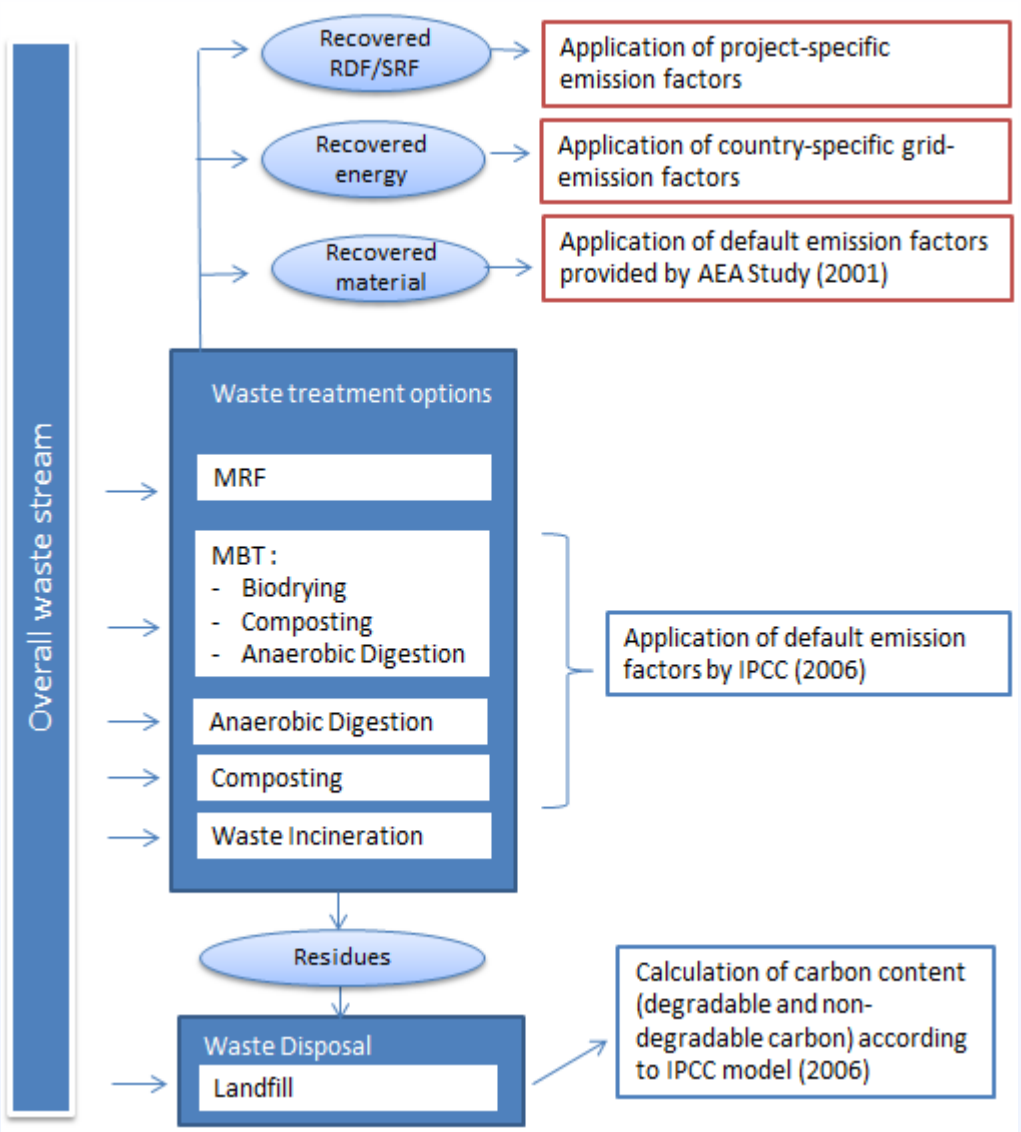
Brussels, 12 May 2017

Why is GHG calculation needed?

- Solid waste management projects have large potentials for Climate Change mitigation, mainly originating from:
  - Reduction of methane (CH_4) and nitrous oxide (N_2O) from landfills (by proper landfill construction/management, installation of landfill gas collection systems, reduction of biodegradable waste deposited in landfills)
  - Savings in CO_2 emissions through the recovery of materials / energy
- At the same time, new waste management facilities built in projects may also produce climate relevant CO_2 emissions:
  - Consuming fossil fuels and electricity in plant operations / waste transport
  - Incinerating materials from fossil origin (i.e. plastics)
  - CH_4 / N_2O emissions / leakages (composting facilities, AD, incineration)
- In the Major Projects Application, GHG emissions calculation needed to
  - Quantify environmental externalities in the economic analysis (§ E.2.)
  - Report on the project's impact on Climate Change mitigation (§ F.8.)

JASPERS Model for GHG Calculation

http://www.jaspersnetwork.org/plugins/servlet/documentRepository/downloadDocument?documentId=41



Calculation of annual changes in GHG emission (tCO_2eq/y) based on differences in emissions of the with- and without-project scenario, to be inputted in the CBA economic analysis model

Input Spreadsheet: Basic Assumptions

- Step 1: Verify technical assumptions on:
  - carbon content of waste streams

	Variable	Min	Value	Max	Unit	Remark	Min	Default	Max
	Total carbon contents in individual MSW fractions								
1	Food waste		15%		% of wet mass	AEA (2001), p. 97	8%	15%	20%
2	Garden waste		24%		% of wet mass	AEA (2001), p. 97	18%	20%	22%
3	Wood		45%		% of wet mass	JASPERS estimate	39%	43%	46%
4	Textiles		39%		% of wet mass	AEA (2001), p. 97, p. 114	20%	40%	40%
5	Paper + cardboard		32%		% of wet mass	AEA (2001), p. 97, p. 114	38%	41%	45%
6	Plastics		67%		% of wet mass	AEA (2001), p. 114	67%	75%	85%
7	Metal		0%		% of wet mass	AEA (2001), p. 114	0%	0%	0%
8	Glass		0%		% of wet mass	AEA (2001), p. 114	0%	0%	0%
9	Other		24%		% of wet mass	AEA (2001), p. 114			
	Degradable Organic Carbon (DOC) contents in individual MSW fractions								
10	Food waste		15%		% of wet mass	AEA (2001), p. 97	8%	15%	20%
11	Garden waste		24%		% of wet mass	AEA (2001), p. 97	18%	20%	22%
12	Wood		30%		% of wet mass	JASPERS estimate	39%	43%	46%
13	Textiles		20%		% of wet mass	AEA (2001), p. 97	20%	24%	40%
14	Paper + cardboard		32%		% of wet mass	AEA (2001), p. 97	38%	40%	45%
15	Plastics		0%		% of wet mass	AEA (2001), p. 114	0%	0%	0%
16	Metal		0%		% of wet mass	AEA (2001), p. 114	0%	0%	0%
17	Glass		0%		% of wet mass	AEA (2001), p. 114	0%	0%	0%
18	Other		10%		% of wet mass	JASPERS estimate based on data from AEA (2001)			
	Dissimilable Organic Carbon (DOC!) in individual MSW fractions								
19	Food waste		75%		% of DOC	AEA (2001), p. 97			
20	Garden waste		50%		% of DOC	AEA (2001), p. 97			
21	Wood		50%		% of DOC	JASPERS estimate			
22	Textiles		30%		% of DOC	AEA (2001), p. 97			
23	Paper + cardboard	20%	35%	50%	% of DOC	AEA (2001), p. 97			
24	Plastics		0%		% of DOC	AEA (2001), p. 114			
25	Metal		0%		% of DOC	AEA (2001), p. 114			
26	Glass		0%		% of DOC	AEA (2001), p. 114			
27	Other		30%		% of DOC	JASPERS estimate based on data from AEA (2001)			
	Fossil Carbon in individual MSW fractions								
28	Food waste		0%		% of wet mass	AEA (2001), p. 97			
29	Garden waste		0%		% of wet mass	AEA (2001), p. 97			
30	Wood		0%		% of wet mass				
31	Textiles		19%		% of wet mass	AEA (2001), p. 97			
32	Paper + cardboard		0%		% of wet mass	AEA (2001), p. 97			
33	Plastics		0%		% of wet mass	AEA (2001), p. 114			
34	Metal		0%		% of wet mass	AEA (2001), p. 114			
35	Glass		0%		% of wet mass	AEA (2001), p. 114			
36	Other		6%		% of wet mass	JASPERS estimate based on data from AEA (2001)			

  - emission factors of relevant waste management activities

	GHG emission factors for electricity and heat recovery from waste						
37	Electricity - country grid GHG emission factor, for own consumption (incl. grid losses)		0.000		t CO_2(eq)/MWh	To be used for electricity consumed from grid	
38	Electricity - country grid GHG emission factor, for export to grid (excl. grid losses)		0.000		t CO_2(eq)/MWh	To be used for electricity produced in the project that is exported to grid	
39	Heat - specific GHG emission factor for heat source displaced		0.000		t CO_2(eq)/MWh	To be used for heat produced in the project that displaces heat produced from fossil fuels	
40	GHG emission factor for fuel displaced		0.000		t CO_2(eq)/TJ	To be entered for specific fuel displaced	
41	Efficiency of heat generation facility displaced		0%		%	To be entered for specific facility displaced	
	GHG emission factors for material recycling						
42	Ferrous metal		-1.52		t CO_2(eq) / t recycled mate	AEA (2001), p. 187	
43	Non-ferrous metal		-9.10		t CO_2(eq) / t recycled mate	AEA (2001), p. 187	
44	PET		-0.93		t CO_2(eq) / t recycled mate	AEA (2001), p. 187	
45	HDPE		-1.80		t CO_2(eq) / t recycled mate	AEA (2001), p. 187	
46	Glass		-0.28		t CO_2(eq) / t recycled mate	AEA (2001), p. 187	
47	Paper/cardboard		-0.63		t CO_2(eq) / t recycled mate	AEA (2001), p. 187	
	GHG emission factors for waste collection and transport						
48	Separately collected metal to sorting and recycling		0.014		t CO_2(eq) / t recycled mate	AEA (2001), p. 88	
49	Separately collected plastic to sorting and recycling		0.014		t CO_2(eq) / t recycled mate	AEA (2001), p. 88	
50	Separately collected paper/cardboard to sorting and recycling		0.014		t CO_2(eq) / t recycled mate	AEA (2001), p. 88	
51	Separately collected glass to sorting and recycling		0.014		t CO_2(eq) / t recycled mate	AEA (2001), p. 88	
52	Separately collected biowaste to composting		0.021		t CO_2(eq) / t composted m	AEA (2001), p. 87, modified by JASPERS	
53	Separately collected biowaste to AD		0.021		t CO_2(eq) / t composted m	AEA (2001), p. 87, modified by JASPERS	
54	Mixed waste to MBT		0.021		t CO_2(eq) / t composted m	AEA (2001), p. 87, modified by JASPERS	
55	Mixed waste to incineration		0.021		t CO_2(eq) / t composted m	AEA (2001), p. 87, modified by JASPERS	
56	Mixed waste to landfill		0.021		t CO_2(eq) / t composted m	AEA (2001), p. 87, modified by JASPERS	
	GHG emission factors for composting						
57	CH_4 emissions from composting, default emission factor		0.004		t CH_4/t BDW (wet mass)	Default value: 4 kg CH_4/t; IPCC (2006)	
58	N_2O emissions from composting, default emission factor		0.000		t N_2O/t BDW (wet mass)	Default value: 0.3 kg N_2O/t, IPCC (2006)	
	GHG emission factors for anaerobic digestion						
59	CH_4 emissions from anaerobic digestion, default emission factor		0.002		t CH_4/t BDW (wet mass)	Default value: 1 kg t CH_4/t; IPCC (2006)	
60	CH_4 share in biogas	40%	60%	60%	%	Use reported/predicted value or default value: 60%	
61	CO_2 share in biogas	30%	35%	40%	%	Use reported/predicted value or default value: 35%	
	GHG emission factors for incineration						
62	Lower calorific value MSW	8.0	9.7	12.0	MJ/kg	Use reported/predicted value or estimate	
63	MSW fossil (non-biomass) combustible share		40%		% of energy content	Default value: 40%	
64	Fossil CO_2 emissions from MSW		91.7		t CO_2(eq)/MJ	Default value: 91.7 t CO_2/MJ; IPCC (2006), for mixed MSW from households and similar wastes only	
65	CH_4 emissions from MSW		0.000007		t CH_4/t of waste (wet mass	Default value: 0.2 kg CH_4/Mt, IPCC (2006), Vol 5, Ch5	
66	N_2O emissions from MSW		0.00005		t N_2O/t of waste (wet mass	Default value: 50 kg CH_4/Mt, IPCC (2006), Vol 5, Ch5	
	GHG emission factors for landfilling						
67	Methane correction factor (MCF)	with project	0.4	1	1		Use reported/predicted value or estimate
68		without project	0.4	1	1		Use reported/predicted value or estimate
69	Volumetric CH_4 fraction in landfill gas (F)		40%	50%	60%	%	Use reported/predicted value or default value: 50%
70	Volume of CH_4 recovered per year for energy use or flaring (RG)	with project	0%	75%	75%	%	Use reported/predicted value or estimate
71		without project	0%	75%	75%	%	Use reported/predicted value or estimate
72	Fraction of CH_4 released that is oxidised below surface within the site (OX)	with project	0%	10%	10%	%	Use reported/predicted value or default value: 10%
73		without project	0%	10%	10%	%	Use reported/predicted value or default value: 10%
74	Share of collected methane flared	with project	0%	100%	100%	%	Use reported/predicted value
75		without project	0%	100%	100%	%	Use reported/predicted value
76	Flare efficiency		0%	90%	90%	%	Use reported/predicted value or default value: 90%
77	Share of collected methane transformed in electricity	with project	0%	0%	100%	%	Use reported/predicted value
78		without project	0%	0%	100%	%	Use reported/predicted value
79	Methane LCV (Lower calorific value)			48		MJ/kg	
80	Energy efficiency of gas engine	with project	30%	30%	80%	%	Use reported/predicted value
81		without project	30%	30%	80%	%	Use reported/predicted value
82	GHG emissions from operations at the landfill			1.5		CO_2(eq)/t waste	AEA (2001), p. 94

- Default values and ranges are provided. Certain parameters are however project specific and may require adjusting

Input Spreadsheet: Waste forecasts

- Step 2: Data input for waste generation / separation for with-project and without-project scenarios in tons/year

A Waste generation and separation: quantities and treatment/disposal pathways

1	**Total waste generation, thereof**	**t/y**			200,000	200,000	200,000	200,000
2	Plastic separated at source to MRF	t/y						
3	Glass separated at source to MRF	t/y						
4	Paper separated at source to MRF	t/y						
5	Metal separated at source to MRF	t/y						
6	Biowaste separated at source, thereof	t/y						
7	to composting	%	0%					
8	to AD	%	0%					
9	Mixed waste to MBT, thereof	t/y						
10	with biodrying of organic fraction	%	0%					
11	with composting of organic fraction	%	0%					
12	with AD of organic fraction	%	0%					
13	Mixed waste to incineration	t/y			-	-	200,000	**200,000**
14	Mixed waste to landfill (untreated)	t/y			200,000	200,000	-	-
				Check	ok	ok	ok	ok

Input Spreadsheet: Waste forecasts

- Step 3: Data Input for composition of individual waste streams

3.2.2	**Mixed Waste to Incineration**							
127	**Input Waste Composition, in % of total wet ma**	**%**		**100%**	**100%**	**100%**	**100%**
128	Food waste	%		41%	41%	41%	**41%**
129	Garden waste	%		3%	2%	2%	**2%**
130	Wood	%					
131	Textiles	%					
132	Paper + cardboard	%		11%	11%	10%	**10%**
133	Plastics	%		16%	17%	17%	**17%**
134	Metal	%		3%	3%	3%	**3%**
135	Glass	%		3%	3%	3%	**3%**
136	Other	%		23%	24%	24%	**25%**
137	**Input Waste Composition, in t/y wet mass**	**t/y**		**-**	**-**	**200,000**	**200,000**
147	**Total Carbon (TC)**	**t/y**	**% of wet mass**	**-**	**-**	**52,273**	**52,444**
157	TC content in Input Waste	%		0%	0%	26%	26%
158	**Degradable Organic Carbon (DOC)**	**t/y**	**% of wet mass**	**-**	**-**	**28,025**	**27,692**
168	DOC content in Input Waste	%		0%	0%	14%	14%
169	**Fossil Carbon (FC)**	**t/y**	**% of wet mass**	**-**	**-**	**24,248**	**24,753**
179	Fossil carbon content in Input Waste	%		0%	0%	12%	12%

GHG Calculation Example

- Mixed residual waste to WtE (incineration) in with-project scenario:

	Mass burn incineration								
96	MSW incinerated	t/y			-	-	200,000	200,000
97	Lower calorific value of MSW incinerated	MJ/kg	9					
98	Fossil combustible share in MSW incinerated	% of energy	40%					
99	Fossil carbon share in MSW incinerated	% of total mass			0%	0%	12%	12%
100	GHG emissions from waste collection and transport	t CO_2(eq)/y	0.008	Default emission factor in t CO_2/t waste treated (we	-	-	1,540	1,540
101	Fossil CO2 emissions from incineration	t CO_2(eq)/y		assumed 2% unoxidised carbon in fossil fraction (IF	-	-	87,133	88,945
102	For comparison, fossil CO2 emissions using LCV and average emission factor	t CO_2(eq)/y	91.7	Emission factor: 91.7 t/TJ (combustible share) and	-	-	64,704	64,704
103	CH4 emissions from incineration	t CH_4/y	0.0000002	Default emission factor in t CH_4/t waste treated (we	-	-	0	0
104	N2O emissions from incineration	t N_2O/y	0.00005	Default emission factor in t N_2O/t waste treated (we	-	-	10	10
105	Electricity generation, gross	MWh/y					106,250	106,250
106	Electricity consumption, from own generation	MWh/y					22,000	22,000
107	Electricity consumption, from grid	MWh/y						
108	Country grid emission factor, electricity imported (incl. grid losses)	t CO_2(eq)/MV	0.000		-	-	-	-
109	Country grid emission factor, electricity exported (excl. grid losses)	t CO_2(eq)/MV	0.356		0.356	0.356	0.356	0.356
110	GHG emissions from own electricity consumption	t CO_2(eq)/y			-	-	-	-
111	GHG emissions displaced through electricity generation	t CO_2(eq)/y			-	-	- 30,001	- 30,001
112	Heat generation exported	MWh/y					318,750	318,750
113	Specific emission factor for displaced heat source	t CO_2(eq)/MV	0.416		0.416	0.416	0.416	0.416
114	GHG emissions displaced through heat generation	t CO_2(eq)/y			-	-	- 132,705	- 132,705
115	Recovered metal, ferrous	t/y	-1.521	Specific emissions displaced through recycling of	-	-	4,000	4,000
116	Recovered metal, non-ferrous (aluminum)	t/y	-9.108	recovered materials (without considering	-	-	-	-
117	GHG emissions displaced through recycling of materials recovered from waste	t CO_2(eq)/y			-	-	- 6,084	- 6,084
118	Net GHG emissions from MSW incineration	t CO_2(eq)/y		Assuming CH_4 global warming potential of 21 times	-	-	- 77,018	- 75,205

GHG Calculation Example

- Mixed residual waste to landfill in without-project scenario:

	Landfill							
119	MSW landfilled (untreated)	t/y			200,000	200,000	200,000	200,000
123	GHG emissions from waste collection and transport	t CO_2(eq)/y	0.007	Default emission factor in t CO_2/t wa	1,440	1,440	1,440	1,440
124	Methane correction factor (MCF)		1					
125	DOCF in MSW	% of total mass			7.7%	7.7%	7.6%	7.5%
128	Volumetric CH_4 fraction in landfill gas (F)	%	50%					
129	Methane generation potential (LO)	t CH_4/t waste			0.05	0.05	0.05	0.05
130	Volume of CH_4 recovered per year for energy use or flaring (RG)	m^3	70%		10,722,392	10,678,138	10,633,883	10,493,003
131	Mass of CH_4 recovered per year for energy use or flaring (RG)	t/y		Density of methane: 0.00067 t/m^3, II	7,184	7,154	7,125	7,030
132	Fraction of CH_4 released that is oxidised below surface within the site (OX)	%	10%					
133	Landfill CH_4 emissions from non-collected gas	t CH_4/y			2,771	2,760	2,748	2,712
134	Share of collected methane flared	%	100%					
135	Flare efficiency	%	50%					
136	CH_4 emissions from flare	t CH_4/y			3,592	3,577	3,562	3,515
140	Electricity consumption, from grid	MWh/y						
141	Electricity generation, gross	MWh/y			-	-	-	-
142	Electricity consumption, from own generation	MWh/y						
143	Country grid emission factor, electricity imported (incl. grid losses)	t CO_2(eq)/MV	0.567	Country specific grid emission factor	0.567	0.567	0.567	0.567
144	Country grid emission factor, electricity exported (excl. grid losses)	t CO_2(eq)/MV	0.544	Country specific grid emission factor	0.544	0.544	0.544	0.544
145	GHG emissions from own electricity consumption	t CO_2(eq)/y			-	-	-	-
146	GHG emissions displaced through electricity generation	t CO_2(eq)/y			-	-	-	-
147	Heat generation exported	MWh/y						
148	Specific emission factor for displaced heat source	t CO_2(eq)/MV	0.402		0.402	0.402	0.402	0.402
149	GHG emissions displaced through heat generation	t CO_2(eq)/y			-	-	-	-
150	CO2 emissions from fuel consumption at the landfill	t CO_2(eq)/y	1.2	Specific CO2 emissions from fuel us	240	240	240	240
151	Net GHG emissions from landfill	t CO_2(eq)/y		Assuming CH_4 global warming poter	135,302	134,751	134,199	132,444

GHG Model Summary Output

Project: Case Study - Waste-to-Energy Facility	Unit	2015	2016	2017	2018
MSW flows treated in project	t/y	200,000	200,000	200,000	200,000
1 Mixed municipal waste from households & other similar wastes					
Total Net GHG emissions - "With-Project" Scenario	**t CO_2(eq)/y**	**135,302**	**134,751**	**- 77,018**	**- 75,205**
thereof GHG emissions from waste collection and transport	t CO_2(eq)/y	1,440	1,440	1,540	1,540
thereof GHG emissions from waste treatment	t CO_2(eq)/y	-	-	90,233	92,045
thereof GHG emissions from landfills	t CO_2(eq)/y	133,862	133,311	-	-
thereof GHG emissions displaced through recycling of materials recovered from waste	t CO_2(eq)/y	-	-	- 6,084	- 6,084
thereof GHG emissions displaced through energy produced from waste	t CO_2(eq)/y	-	-	- 162,706	- 162,706
GHG emission factor	t CO_2(eq) /t waste treated (	0.68	0.67	- 0.39	- 0.38
Total Net GHG emissions - "Without-Project" Scenario	**t CO_2(eq)/y**	**135,302**	**134,751**	**134,199**	**132,444**
thereof GHG emissions from waste collection and transport	t CO_2(eq)/y	1,440	1,440	1,440	1,440
thereof GHG emissions from waste treatment	t CO_2(eq)/y	-	-	-	-
thereof GHG emissions from landfills	t CO_2(eq)/y	133,862	133,311	132,759	131,004
thereof GHG emissions displaced through recycling of materials recovered from waste	t CO_2(eq)/y	-	-	-	-
thereof GHG emissions displaced through energy produced from waste	t CO_2(eq)/y	-	-	-	-
GHG emission factor	t CO_2(eq) /t waste treated (	0.68	0.67	0.67	0.66
Total Net GHG emissions - Incremental	**t CO_2(eq)/y**	**-**	**-**	**- 211,217**	**- 207,649**
thereof GHG emissions from waste collection and transport	t CO_2(eq)/y	-	-	100	100
thereof GHG emissions from waste treatment	t CO_2(eq)/y	-	-	90,233	92,045
thereof GHG emissions from landfills	t CO_2(eq)/y	-	-	- 132,759	- 131,004
thereof GHG emissions displaced through recycling of materials recovered from waste	t CO_2(eq)/y	-	-	- 6,084	- 6,084
thereof GHG emissions displaced through energy produced from waste	t CO_2(eq)/y	-	-	- 162,706	- 162,706
GHG emission factor	t CO_2(eq) /t waste treated (	-	-	- 1.06	- 1.04




Thank you!

f.angelini@eib.org

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JASPERS Networking and Competence Centre

jaspersnetwork@eib.org

www.jaspersnetwork.org