Global warming factors of MSW management in Europe

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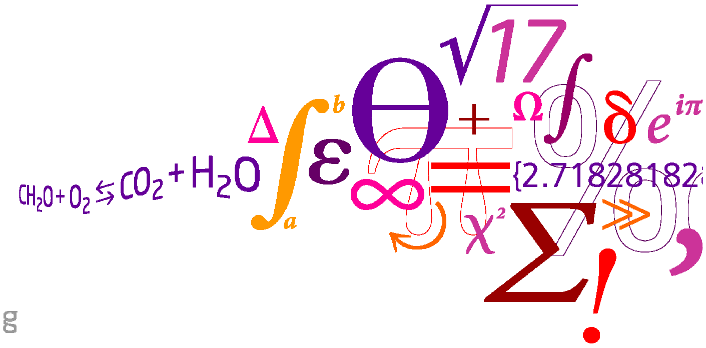

Introduction: Greenhouse gas (GHG) accounting

- Waste management must like any other sector determine its contribution to global warming by presenting its GHG-account – and contribute to the solution by improving its performance
- Many GHG emission-factors are being made available and published these years – using different approaches and different assumptions - but very little consensus exist
- Most of the activities in waste management are GHG loads while the savings come from what we offer to other parts of society: recyclable paper, metal scrap, electricity, heat, compost etc.
- The lack of consensus is not beneficial to the sector if it shall convince society that we are contributing to reducing GHG emissions in society although most of the savings take place outside our sector

Introduction: Greenhouse gas (GHG) accounting

- The GHG-account of a waste management technology depends per tonne of waste on:
  - indirect up-stream: the use of electricity, materials and the provision of fuels
  - direct emissions from the facility: fuel combustion, process emissions etc.
  - indirect dow am: the substitutional value of the out-puts
- Thus f waste management technologies wrt. GHG-contrib place only on a system level: integrated systems same type of waste
- To illustr different waste management scenarios the Europe and modeled their GHG contri bution by waste model EASEWASTE (www.easewaste.dk)

This one is the most important and most uncertain factor

Purpose of GHG-modeling

- To compare modern, good European waste management systems in order to identify where GHG loads and savings take place within a system and to compare systems with different technological approaches, including recycling activities
- To assess the importance of waste composition
- To assess the importance of energy substitutions

Full paper:

Christensen, T.H., Simion, F., Tonini, D. & Møller, J. (2009): Global warming factors modelled for 40 generic municipal waste management scenarios.

Waste Management & Research, **28**, 871-884

Defining the system

- Waste composition: Average European MSW + variations
- Up-to-date modern technologies as they could be build in year 2010 and on
- Source-separation schemes are efficient where introduced
- A carbon-limited economy:
  - strong efforts to reduce fossil-C emission: coal burning is the electricity marginal + variations
  - biomass is a limited resource and saved biomass from paper recycling is as renewable fuel also substituting for hard coal
- GHG counting:
  o C-fossil emitted as CO_2: GWP = 1 Kg CO_2-eqivalents/ kg CO_2
  o C-fossil bound: GWP = 0
  o C-biogenic emitted as CO_2: GWP = 0
  o C-biogenic bound: - 3.67 Kg CO_2-eqivalents/ kg C bound

Technologies:

- Source separation of paper (65%), glass (55%), plastic (50%), biowaste for composting(60%)/biowaste (50%) for anaerobic digestion
- Collection of recyclables and residual waste
- Transport of recyclables and residual waste
- Recycling of paper
- Recycling of glass
- Recycling of plastic
- Recycling of iron
- Recycling of aluminum
- Composting (tunnel composting plant)+ rational use of compost in agriculture (15% C left after 100 years, fertilizer saving)
- Anaerobic digestion (70% of methane potential collected and used producing electricity at 35% efficiency) + rational use of digestate on land (8% C left after 100 years, fertilizer saving)

Technologies (residual waste)

- Landfilling with gas collection and flaring/electricity production (35% efficiency). Gas collection over 100 years were 50% for conventional and 80% for bioreactor landfill
- Incineration (use of electricity, 21% (LHV) electricity delivered to grid, 40 % (LHV) heat delivered, recovery of iron scrap and aluminum) + landfilling of bottom ash
- MBT:
  - MBP: Mechanical removal of RDF fraction (14-15 GJ/tonne) to power plant directly substituting for coal+ metal scrap, followed by composting prior to landfilling
  - MBS: Bio-drying followed by mechanical separation of RDF fraction going to incinerator with energy recoveries as other incinerator + metal scrap + small fraction to inert waste landfill.

Mass flows

Scenario – Incinerator-based	Source separation of paper	Source separation of glass	Source separation of plastic	Source separation of organics	Compost	Anaerobic digestate	Incineration	Recovery of iron scrap from bottom ash	Landfilling of bottom ash	Electricity from digester	Electricity from incinerator	Heat from incinerator
1000 kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	kWh	kWh	kWh
INC1-0							1000	13	165	-	587	
INC2-0	-	-	-	-	-	-	1000	13	165	-	587	1134
INC1-1	143	33	-	-	-	-	824	13	110	-	477	
INC2-1	143	33	-	-	-	-	824	13	110	-	477	921
INC1-2	143	33	13	-	-	-	811	13	109	-	452	
INC2-2	143	33	13	-	-	-	811	13	109	-	452	873
INC1-3	143	33	13	231	58	-	580	13	98	-	396	
INC2-3	143	33	13	231	58	-	580	13	98	-	396	765
INC1-4	143	33	13	173	-	609*	638	13	106	47	410	
INC2-4	143	33	13	173	-	609*	638	13	106	47	410	792

CO_2-eqv. (Kg per tonne)

Scenario	Total	Collection	Transport	Recycling of paper	Recycling of glass	Recycling of plastic	Composting plant (total)	Use of compost	Digester (total)	Use of Digestate	Incinerator (consumption)	Incinerator: air emissions	Incinerator: scrap iron recovery	Incinerator: bottom ash landfilling	Incinerator: electricity recovery	Incinerator: heat recovery
NC1-0	-239	9	8	-	-	-	-	-	-	-	72	297	-22	2	-606	-
NC2-0	-620	9	8	-	-	-	-	-	-	-	72	297	-22	2	-606	-380
NC1-1	-398	10	12	-255	-8	-	-	-	-	-	59	296	-22	1	-492	-
NC2-1	-707	10	12	-255	-8	-	-	-	-	-	59	296	-22	1	-492	-309
NC1-2	-416	10	13	-255	-8	-10	-	-	-	-	58	263	-22	1	-466	-
NC2-2	-708	10	13	-255	-8	-10	-	-	-	-	58	263	-22	1	-466	-293
NC1-3	-352	12	15	-255	-8	-10	23	-3	-	-	42	262	-22	1	-408	-
NC2-3	-608	12	15	-255	-8	-10	23	-3	-	-	42	262	-22	1	-408	-256
NC1-4	-419	12	17	-255	-8	-10	-	-	-34	-6	46	262	-22	1	-423	-
NC2-4	-684	12	17	-255	-8	-10	-	-	-34	-6	46	262	-22	1	-423	-265

Mass flows

Scenario – MBT-based	Source separation of paper	Source separation of glass	Source separation of plastic	MBP	MBS	Recovery of iron scrap from MBT	Landfilling of MBT waste	RDF to power plant	RDF to incinerator	Landfilling of bottom ash	Electricity from incinerator	Heat from incinerator
1000 kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	kWh	kWh
MBT1-0	-	-	-	1000	-	40	188	530	-	-	-	-
MBT2-0	-	-	-	1000	-	40	188	-	530	61	446	-
MBT3-0	-	-	-	1000	-	40	188	-	530	61	446	863
MBT4-0	-	-	-	-	1000	38	-	-	597	102	518	-
MBT5-0	-	-	-	-	1000	38	-	-	597	102	518	1001
MBT1-1	143	33	-	824	-	40	131	420	-	-	-	-
MBT2-1	143	33	-	824	-	40	131	-	420	37	357	-
MBT3-1	143	33	-	824	-	40	131	-	420	37	357	690
MBT4-1	143	33	-	-	824	38	-	-	437	67	408	-
MBT5-1	143	33	-	-	824	38	-	-	437	67	408	789
MBT1-2	143	33	13	811	-	40	130	400	-	-	-	-
MBT2-2	143	33	13	811		40	130		400	37	335	-
MBT3-2	143	33	13	811	-	40	130	-	400	37	335	648
MBT4-2	143	33	13	-	811	37	-	-	425	66	386	-
MBT5-2	143	33	13	-	811	37	-		425	66	386	746

CO_2-eqv. (Kg per tonne)

Scenario	Total	Collection	Transport	Recycling of paper	Recycling of glass	Recycling of plastic	MBT plant (total)	MBT plant: Iron scrap recovery	Power plant: Emissions from RDF	Power plant: Coal substitution	Incinerator (consumption)	Incinerator: Emissions	Incinerator: Electricity recovery	Incinerator : heat recovery	Landfilling: C-binding
MBT1-0	-684	9	34	-	-	-	51	-60	270	-892	-	-	-	-	-101
MBT2-0	-234	9	20	-	-	-	51	-60	-	-	39	261	-460	-	-101
MBT3-0	-523	9	20	-	-	-	51	-60	-	-	39	261	-460	-289	-101
MBT4-0	-190	9	19	-	-	-	125	-118	-	-	43	268	-534	-	-
MBT5-0	-525	9	19	-	-	-	125	-118	-	-	43	268	-534	-335	-
MBT1-1	-757	10	33	-255	-8	-	42	-60	267	-715	-	-	-	-	-74
MBT2-1	-397	10	23	-255	-8	-	42	-60	-	-	30	260	-369	-	-74
MBT3-1	-628	10	23	-255	-8	-	42	-60	-	-	30	260	-369	-231	-74
MBT4-1	-372	10	21	-255	-8	-	103	-118	-	-	31	267	-421		-
MBT5-1	-636	10	21	-255	-8	-	103	-118	-	-	31	267	-421	-264	-
MBT1-2	-752	10	33	-255	-8	-10	41	-60	237	-671	-	-	-	-	-74
MBT2-2	-414	10	23	-255	-8	-10	41	-60	-	-	29	231	-346	-	-74
MBT3-2	-631	10	23	-255	-8	-10	41	-60	-	-	29	231	-346	-217	-74
MBT4-2	-388	10	21	-255	-8	-10	101	-118	-	-	31	238	-399	-	-
MBT5-2	-638	10	21	-255	-8	-10	101	-118	-	-	31	238	-399	-250	-

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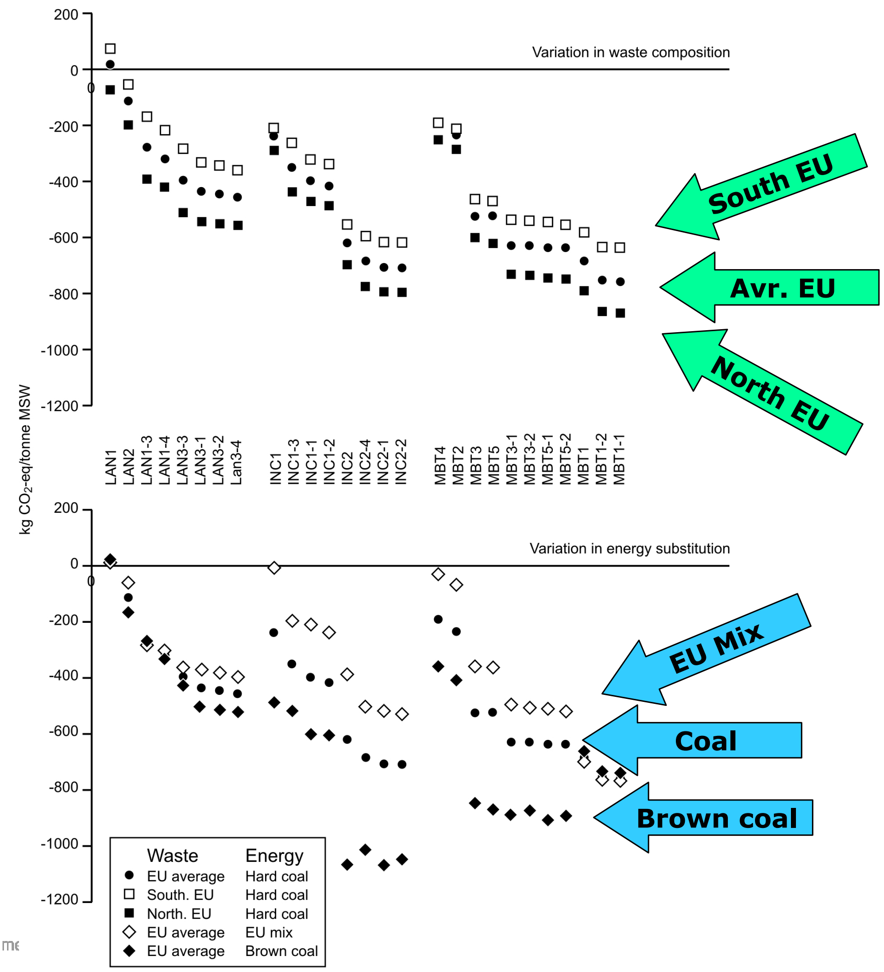
Waste composition

Energy substitution



Conclusions

- For modern well managed waste management systems (Europe):
  - Scenarios with landfilling may have GHG savings in the range 0-400 kg CO_2-eqv. per tonne
  (Technology factor: gas recovery and utilization)
  - Scenarios with incineration may have GHG savings in the range 200-700 kg CO_2-eqv. per tonne
  (Technology factor: electricity and heat production (here 40%))
  - Scenarios with MBT may have GHG savings in the range 200-750 kg CO_2-eqv. per tonne
  (Technology factor: direct substitution for coal burning)
- Major contributors to savings: paper recycling and use of excessive wood, energy recovery and storage of C in landfills
- Waste management activities as collection, transport, glass recycling, plastic recycling, anaerobic digestion and composting play only minor roles

Conclusions

- Waste composition matters: Different savings available in north and south Europe – but ranking of technological systems does not change
- The energy substitution is crucial to the results: the dirtier the better
- Significant savings can be obtained by a rational waste management system
- GHG accounting for decision making on future waste management systems must take place on a system level – not on a single technology level

Thank You