Life Cycle Assessment of the treatment of MSW in “the average“ European Waste-to-Energy plant

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LCA of Waste-to-Energy plants

Why has CEWEP done a Life Cycle Assessment ?

- **Contribution to the European Reference Life Cycle Data System (ELCD)**
  - ➔ The European Commission is addressing the use of LCA in regulations and directives and one can expect that the data sets will be used for various LCA studies e.g. end-of-life options or product LCAs.
  - ➔ The involvement of CEWEP in this work will enable CEWEP to have influence on the generation of this data set and to improve the existing ones.
  - ➔ ELCD is implemented on a website of the European Commission about Life Cycle Assessment (LCA) which will provide public stakeholders with LCA data.
- **LCA type of information can support the communication from our industry to the society and stakeholders in an objective way**

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How does LCA work?

- LCA analyses the potential environmental burden of a product or service in its **production**, **use phase** and **end-of-life**.
- All emissions and consumed resources related to the entire life cycle of a product or service (in our case the treatment of waste) are summarized in a Life Cycle Inventory.
- The Life Cycle Inventory is used for an Impact assessment expressed in a set of 10 environmental aspects e.g. Global Warming or Eutrophication.
- The results of an LCA can be used for a multitude of applications:
  - Identification of relevant steps in the complete life cycle of products
  - Development of sustainable products based on environmental information
  - Communication with politics and authorities
  - Decision support for the choice of several options

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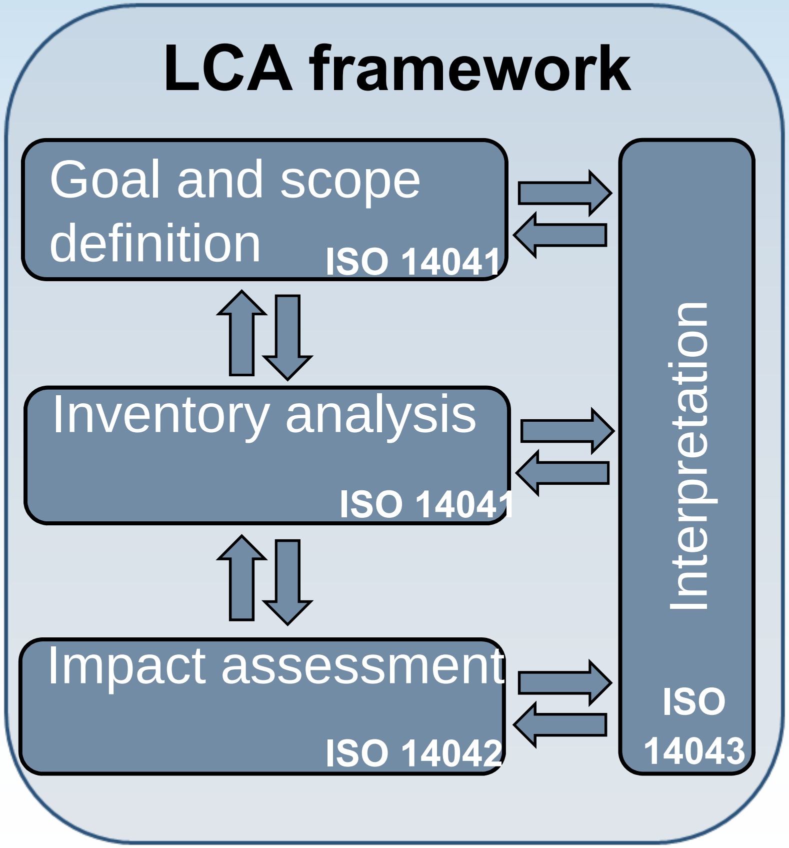
Internationally standardised Life Cycle Assessment



Direct applications:

- Product development and improvement
- Strategic planning
- Public policy making
- Marketing
- Other

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Foreseen deliverables of the study

- Average European waste composition data

  ➔ share of waste fractions and elementary composition data

- A Life Cycle Assessment of the treatment of MSW in an average European Waste-to- Energy plant

- Data sets for the European Reference Life Cycle Data System (ELCD)

  ➔ The data sets will include a description and the LCA data. Data sets will be produced for MSW and single waste fractions.

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Boundary conditions and assumptions for the modeling

- The composition of the “average” MSW feedstock being incinerated in an “average” European Waste-to-Energy plant has been calculated. MSW means municipal and comparable waste. Separately collected waste streams have been excluded from this.
- A mix of dry (67%) and wet (33%) flue gas treatment was applied and a mix of SNCR (67%) and SCR (33%) was used for NOx removal
- No recovery of sulphate slurry or brine
- Lime is being used as adsorbent
- Bottom ash: 60% reuse and 40% landfill
- APC residues: 43% salt mine and 57% landfill
- Metal recovery: Fe 10% of bottom ash, Al 1.2% of bottom ash, Cu, Pb and Zn together 0.6% of bottom ash

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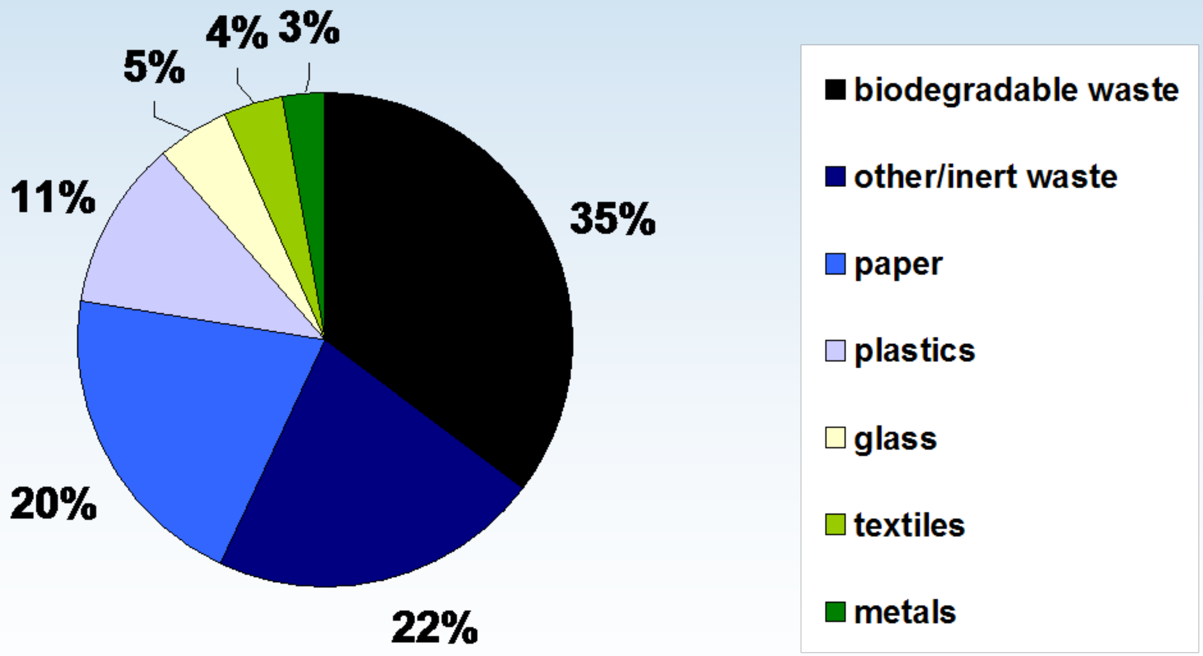
Fraction share of average European residual solid waste*



* The share does not contain separately collected waste streams

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Elementary composition of incinerated wet MSW

Elements	kg/t wet waste	Elements	kg/t wet waste
Ag	0,00016	Mn	0,33
Al	10	N	8,4
As	0,010	Na	4,4
Ba	0,0000072	Ni	0,11
Be	0,00047	O	180
Br	0,00011	P	0,76
C	250	Pb	0,20
Cd	0,014	S	1,3
Ca	20	Sb	0,0071
Cl	3,6	Se	0,000094
Co	0,0020	SiO2	99
Cr	0,19	Sn	0,012
Cu	1,1	Sr	0,000024
F	0,064	Te	0,00047
Fe	24	Ti	0,39
H	40	Tl	0,000046
Hg	0,00020	V	0,012
J	0,00001	Zn	0,72
K	3,3	H2O	340
Mg	2,9		
Mo	0,00047	Sum	1000

Ash content:

240 kg/t of dry waste

Net calorific value:

9.8 MJ/kg

Share of Biogenic Carbon:

63%

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Elementary composition of incinerated dry MSW

Elements	kg/t dry waste
Ag	0,00025
Al	16
As	0,015
Ba	0,000011
Be	0,00071
Br	0,00016
C	380,0
Cd	0,021
Ca	30
Cl	5,5
Co	0,0030
Cr	0,28
Cu	1,7
F	0,097
Fe	36
H	60
Hg	0,00030
K	5,1

Elements	kg/t dry waste
Mg	4,4
Mo	0,00071
Mn	0,51
N	13
Na	6,7
Ni	0,17
O	280
Sb	0,011
Se	0,00014
SiO2	150
Sn	0,018
Sr	0,000037
Te	0,00071
Ti	0,59
Tl	0,000070
V	0,018
Zn	1,1
Sum	1000

Ash content:

360 kg/t of dry waste

Water content:

34%

Share of Biogenic Carbon:
63%

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Used emission values

Element/ Substance	Emission value mg/m3
HCl	4,5
HF	0,3
NOx (SCR)	70
NOx (SNCR)	100
Dust	1
VOC	1
N2O	0
CO	17,5
NH3	10
SO2	10,1
Heavy metals	
As	0,0006
Cd	0,0017
Co	0,002
Cr	0,0012
Hg	0,005
Ni	0,0012
Pb	0,023
	[ng TEQ/m3]
Dioxin	0,01

- Emission values have been based on mean values in the BREF document *Waste Incineration* (2006) and have been cross checked with actual values

  (Transfer coefficients are derived from mass balance data)

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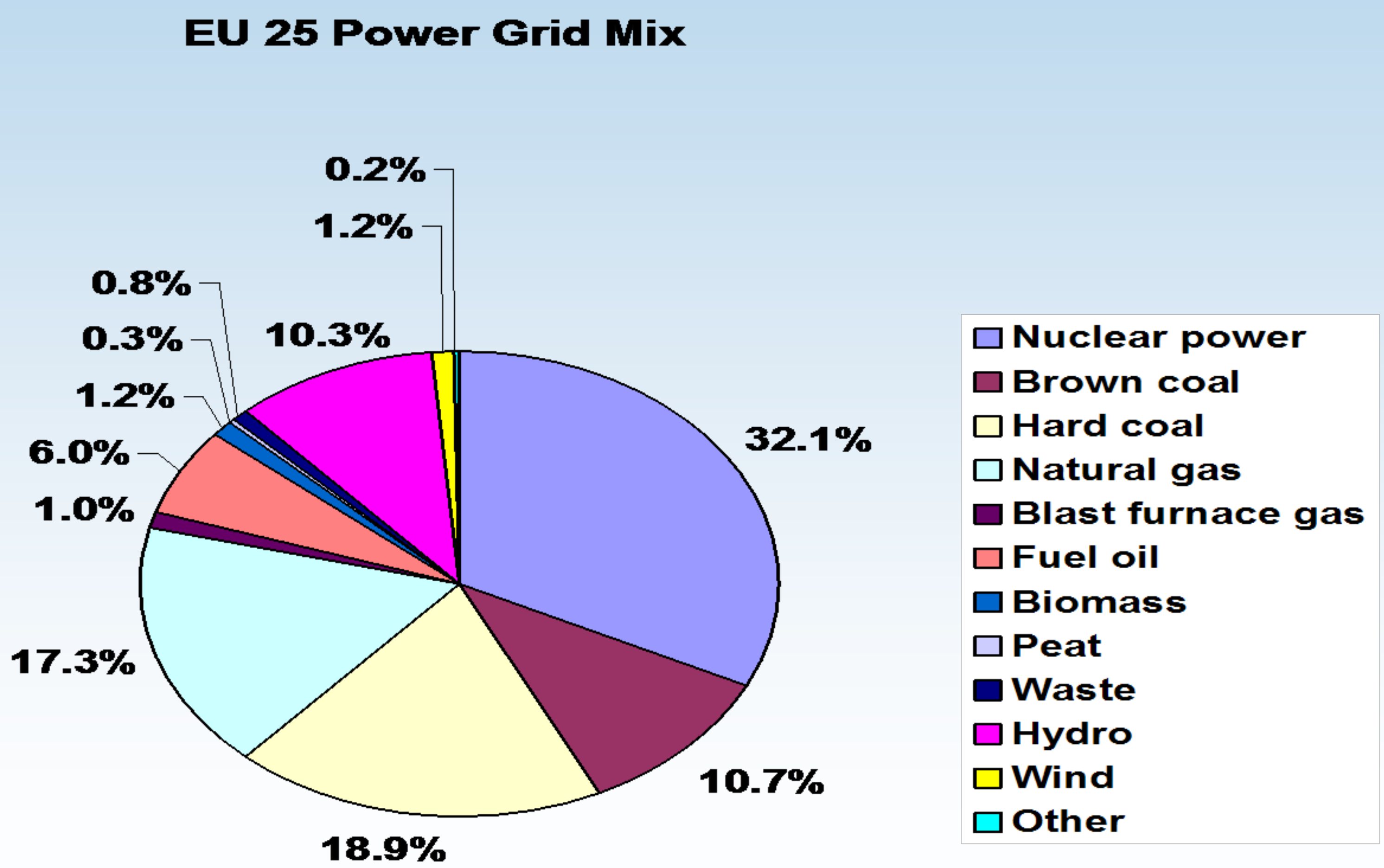
Life Cycle Impact Assessment

- The idea of the impact assessment is to quantify the impacts on all environmental aspects related to the thermal treatment of 1t MSW (including incineration, supply of auxiliaries, treatment of residues , export of electricity, heat and metals).
- Each input (resource) and output (emission) contributing to an environmental aspect has a characterization factor depending on the severity of its impact.
- Each emitted greenhouse gas has been multiplied by the characterization factor and summed to a so called Global Warming Potential. Avoided emissions due to the export of electricity or metals have been subtracted as credits.

Substitution mixes power and heat for calculation of credits

Power substitution mix	Heat substitution mix
EU 25 power mix	EU 25 heat mix
32 % nuclear 19 % coal 17 % gas 11 % lignite 10 % oil 11 % others	41 % natural gas 35 % coal 9 % biomass 7 % lignite 8 % others

Power substitution mix assumed for the study



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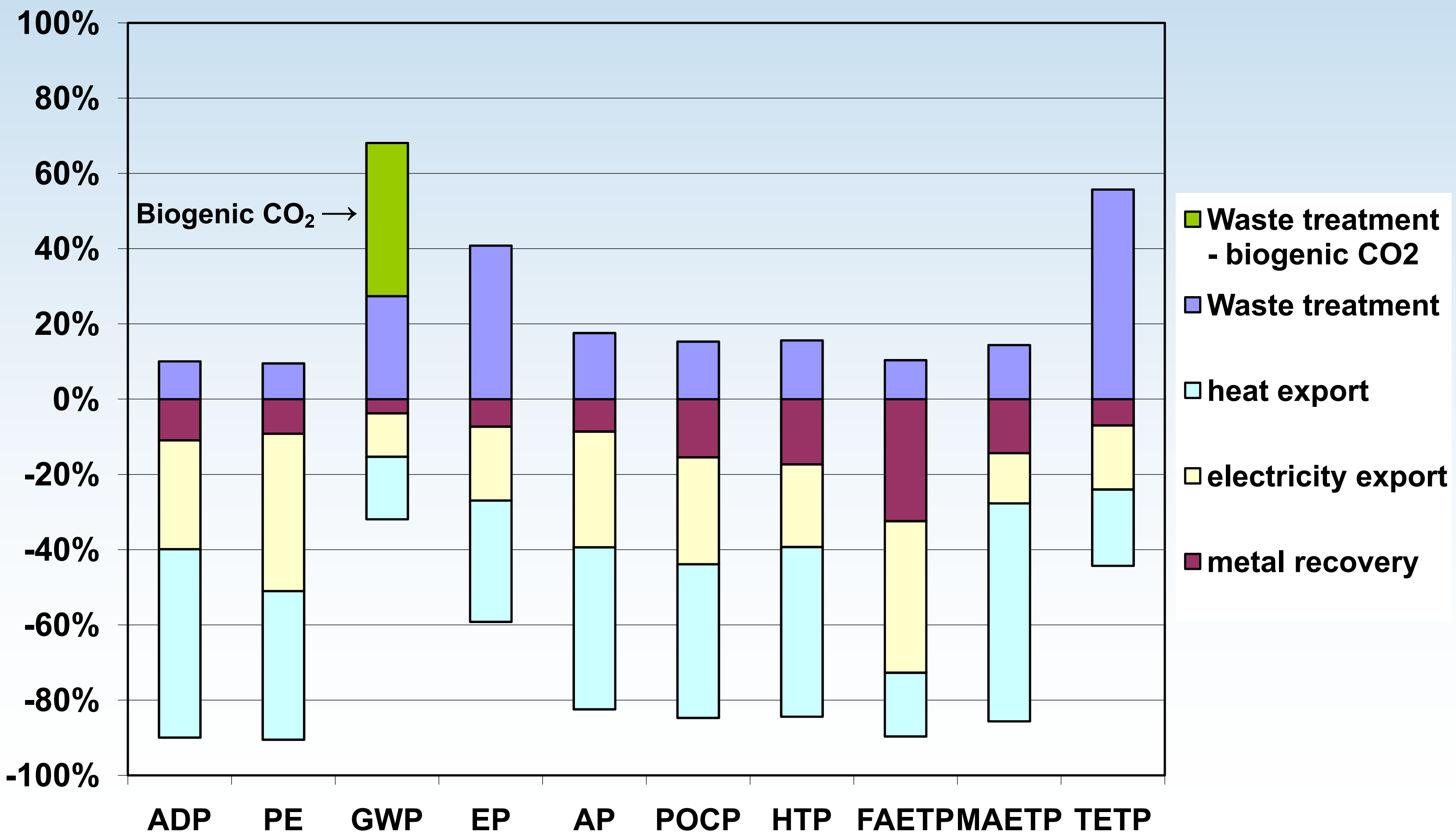
Used Impact categories

Abbreviation	Name	Unit
ADP	Abiotic Depletion Potential	kg antimony equivalent
PE	Primary Energy	MJ
GWP	Global Warming Potential	kg CO_2 eq.
EP	Eutrophication Potential	kg PO_4 eq.
AP	Acidification Potential	kg SO_2 eq.
POCP	Photochemical Ozone Creation Potential	kg ethylene eq.
HTP	Human Toxicity Potential	
FAETP	Freshwater Aquatic Ecotoxicity Potential	kg 1,4-dichloro-benzene eq.
MAETP	Marine Aquatic Ecotoxicity Potential	
TETP	Terrestrial Ecotoxicity Potential	

Source: Institute of Environmental Science – University of Leiden: CML Methodology, http://www.leidenuniv.nl/cml/ssp/projects/lca2/index.html

Summary of Impact analysis

Graphic representation of results for the incineration of MSW



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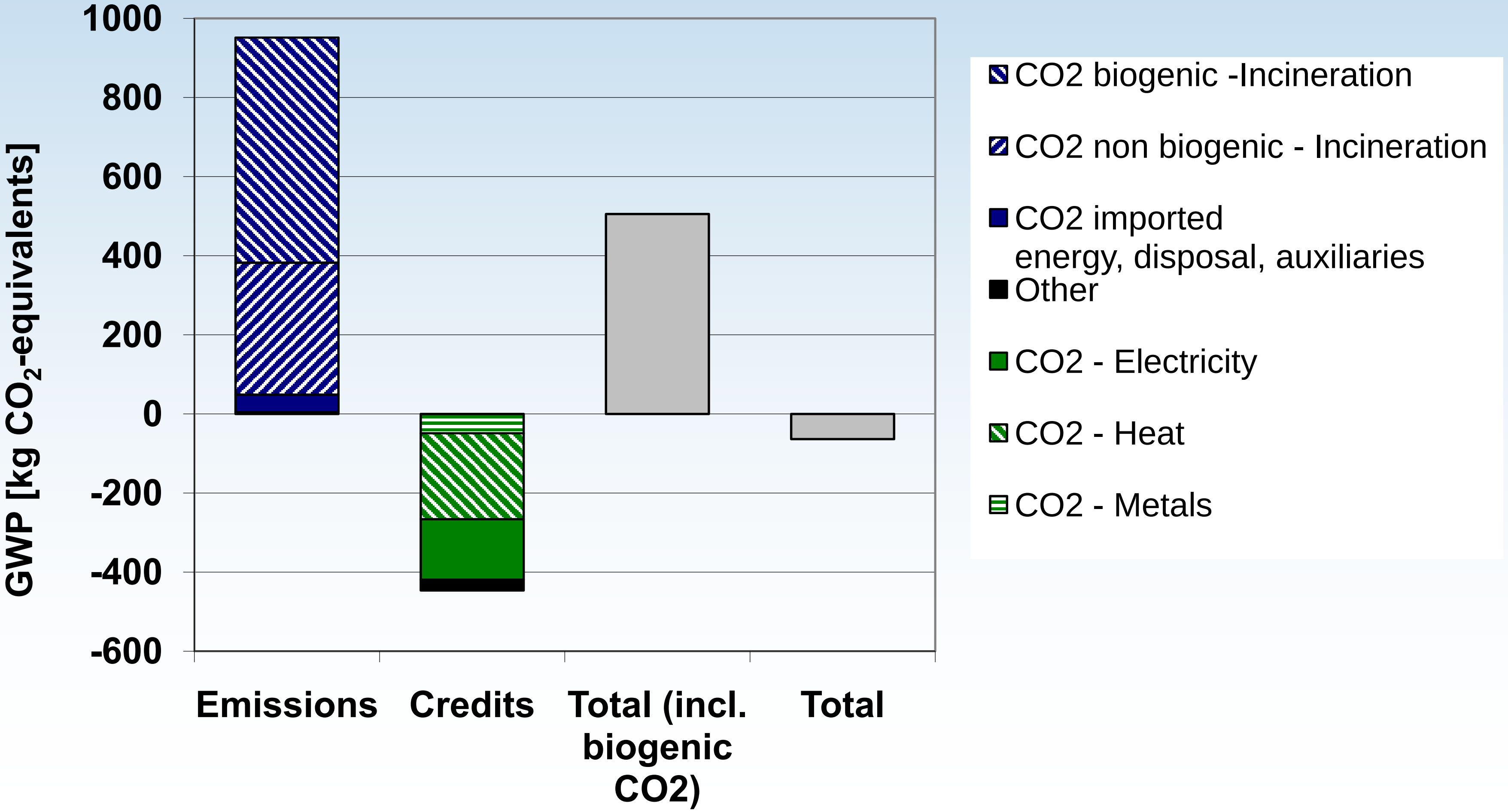
Analysis for the Global Warming Potential



Key data Greenhouse Gas (GWP) in kg CO_2 eq. per tonne of MSW incinerated

Emissions kg CO2 eq.		Credits kg CO2 eq.		Net kg CO2 eq.
Biogenic	569			
Fossil ex waste	334	Electricity	161	
Imported etc.	44	Heat	232	
Other GHG	5	Metals(Al,Cu Fe)	53	
Total	**383**	**Total**	**446**	**383 – 446= - 63**

This is valid for the avg waste mix, the avg plant performance ,the avg substitution mix for power and heat in EU 25

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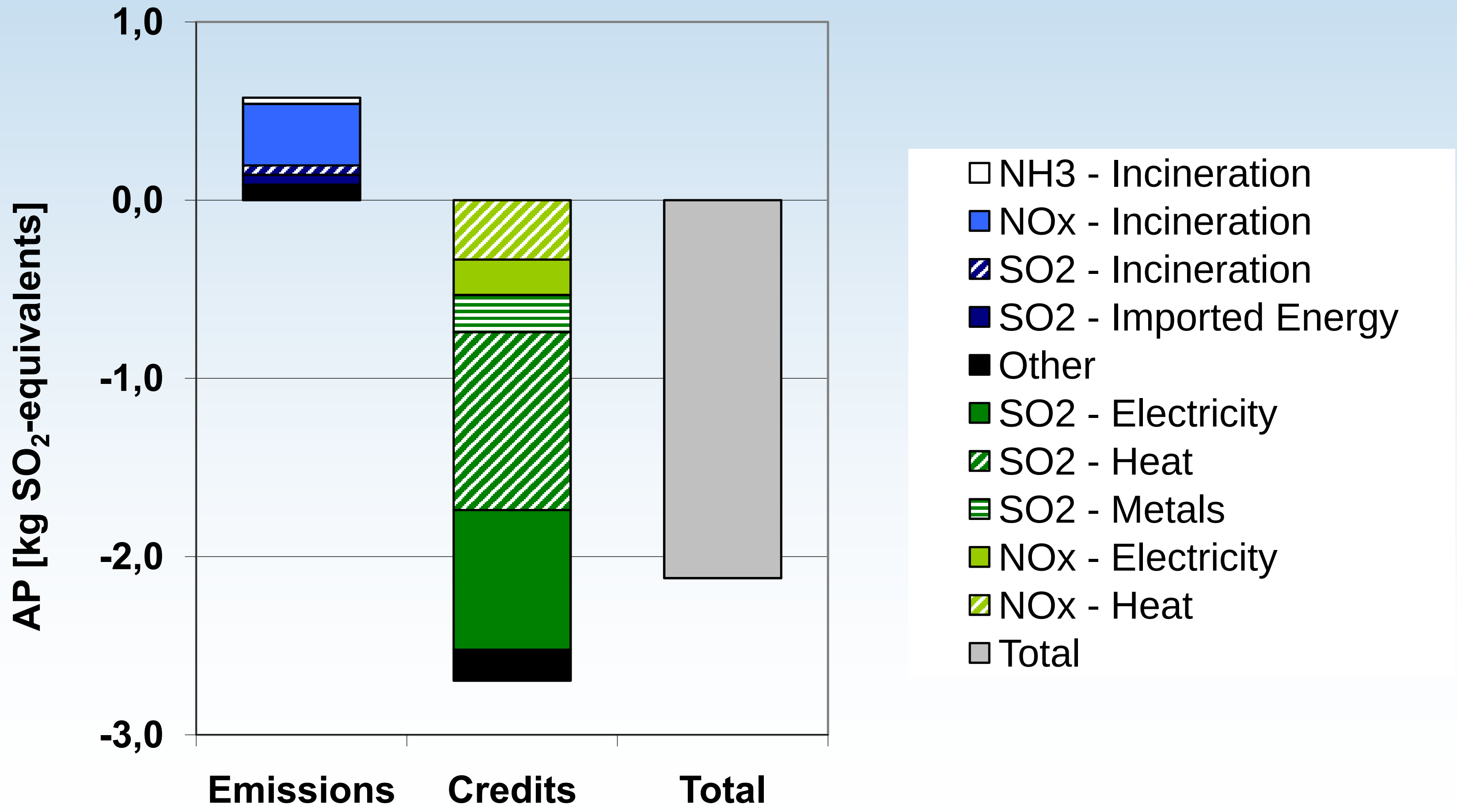
Analysis for the Acidification Potential



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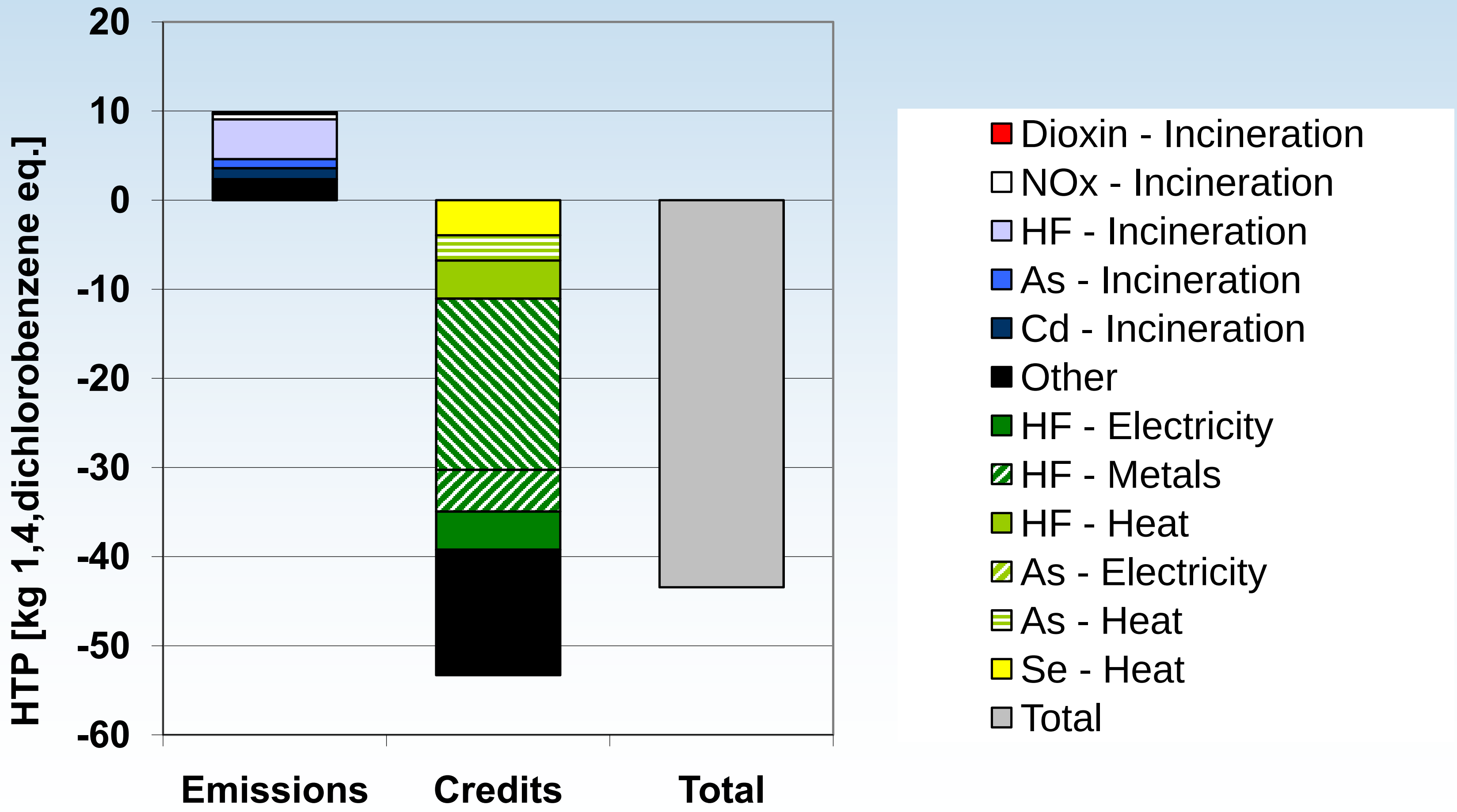
Analysis for the Human Toxicity Potential



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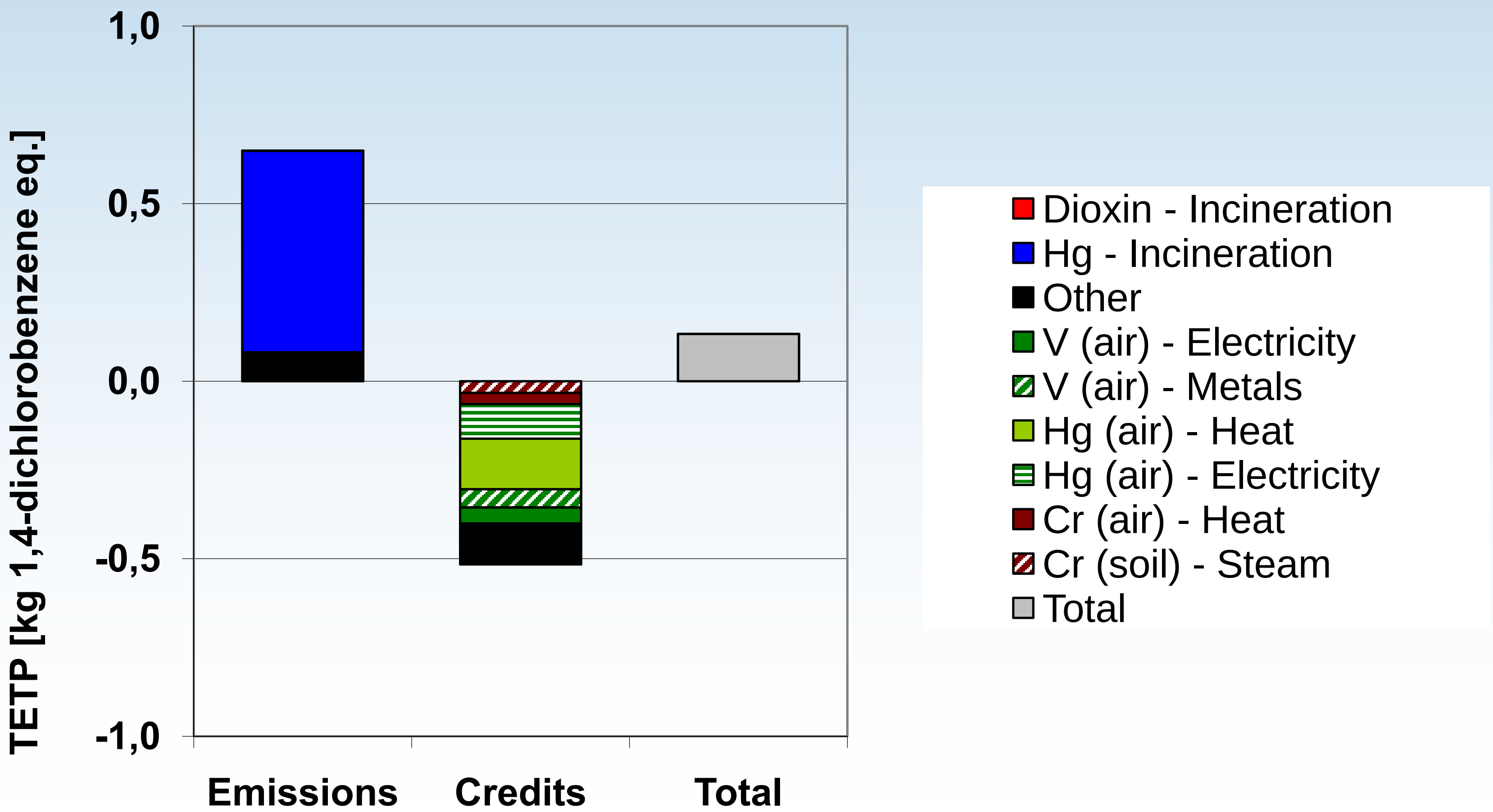
Analysis for the Terrestrial Ecotoxicity Potential



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Sensitivity studies carried out

-**Effect of variation of % biogenic carbon in waste on GWP**

-**Effect of mercury content in waste on TETP**

-**Effect of variation of waste composition**

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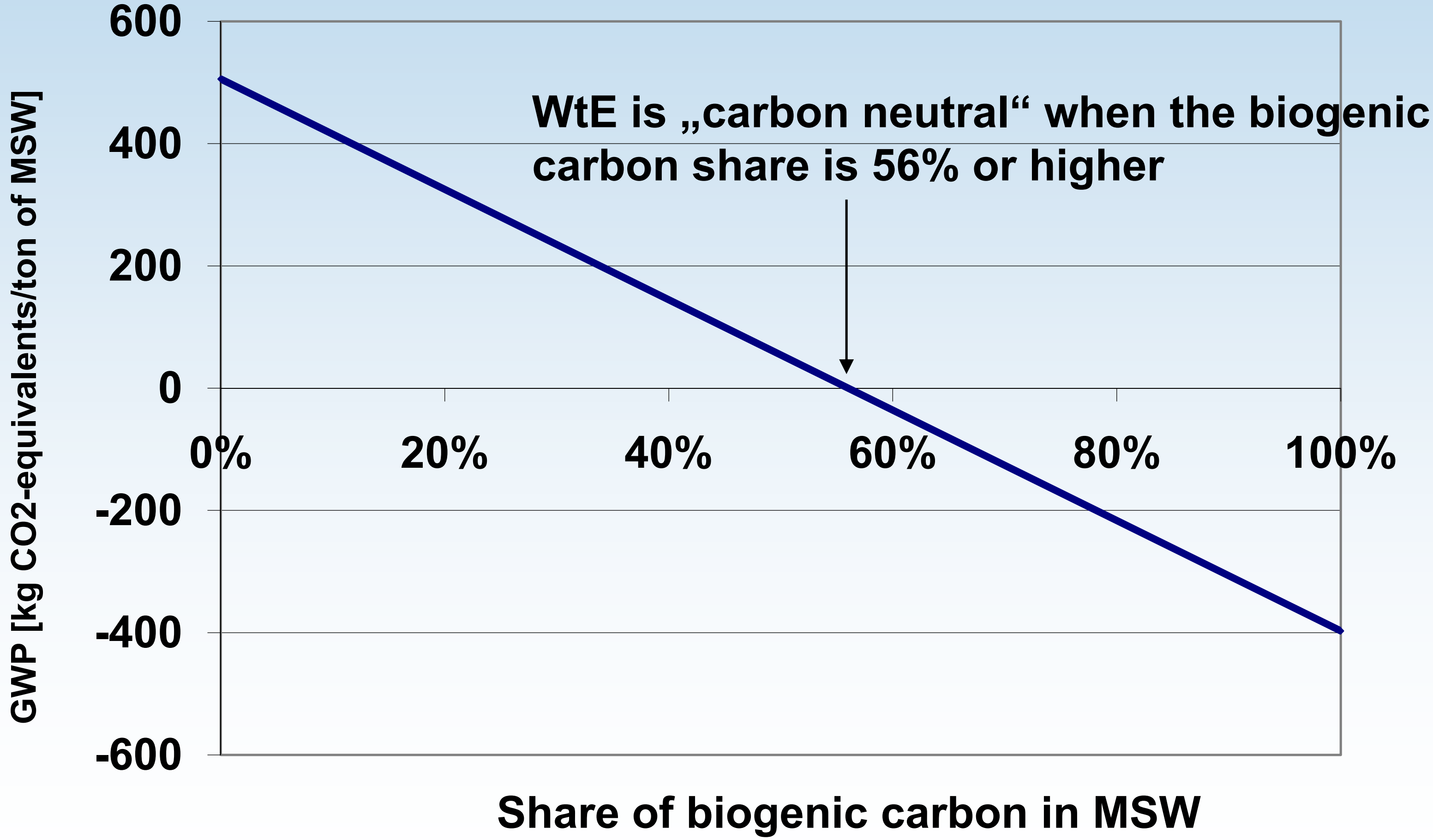

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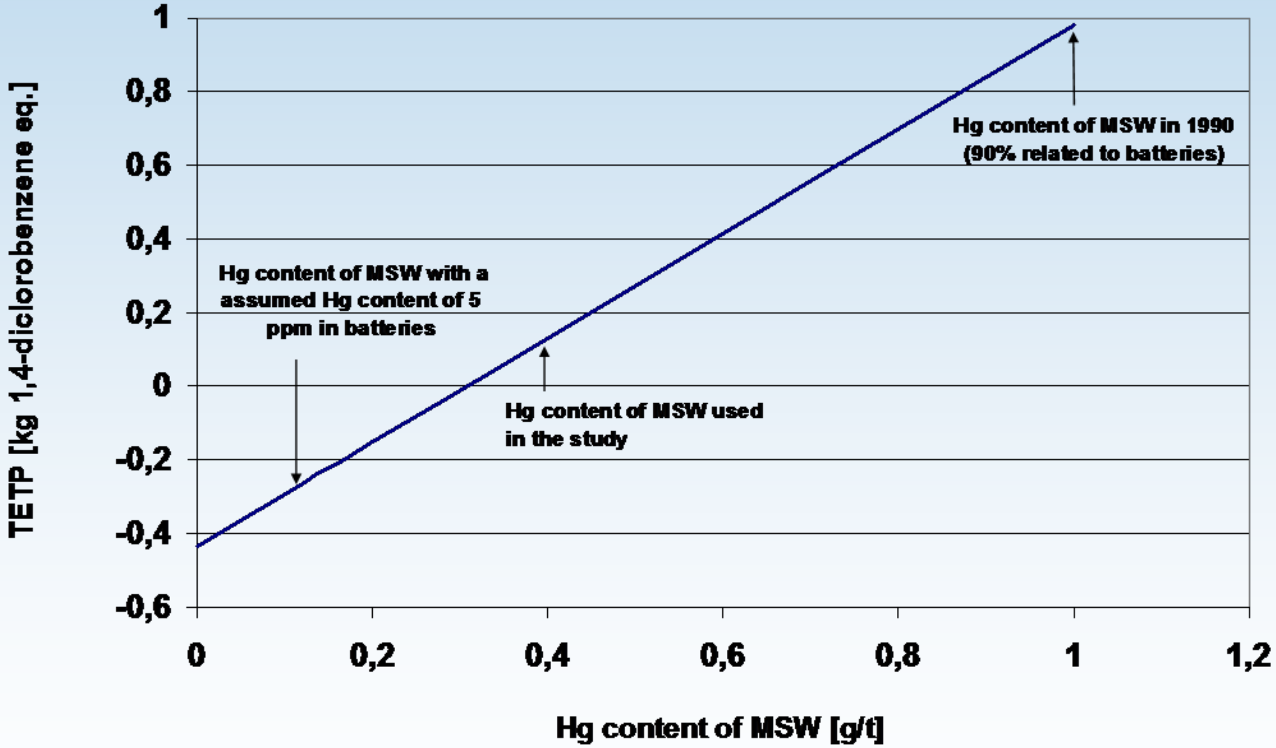
Impact of mercury in MSW on the TETP

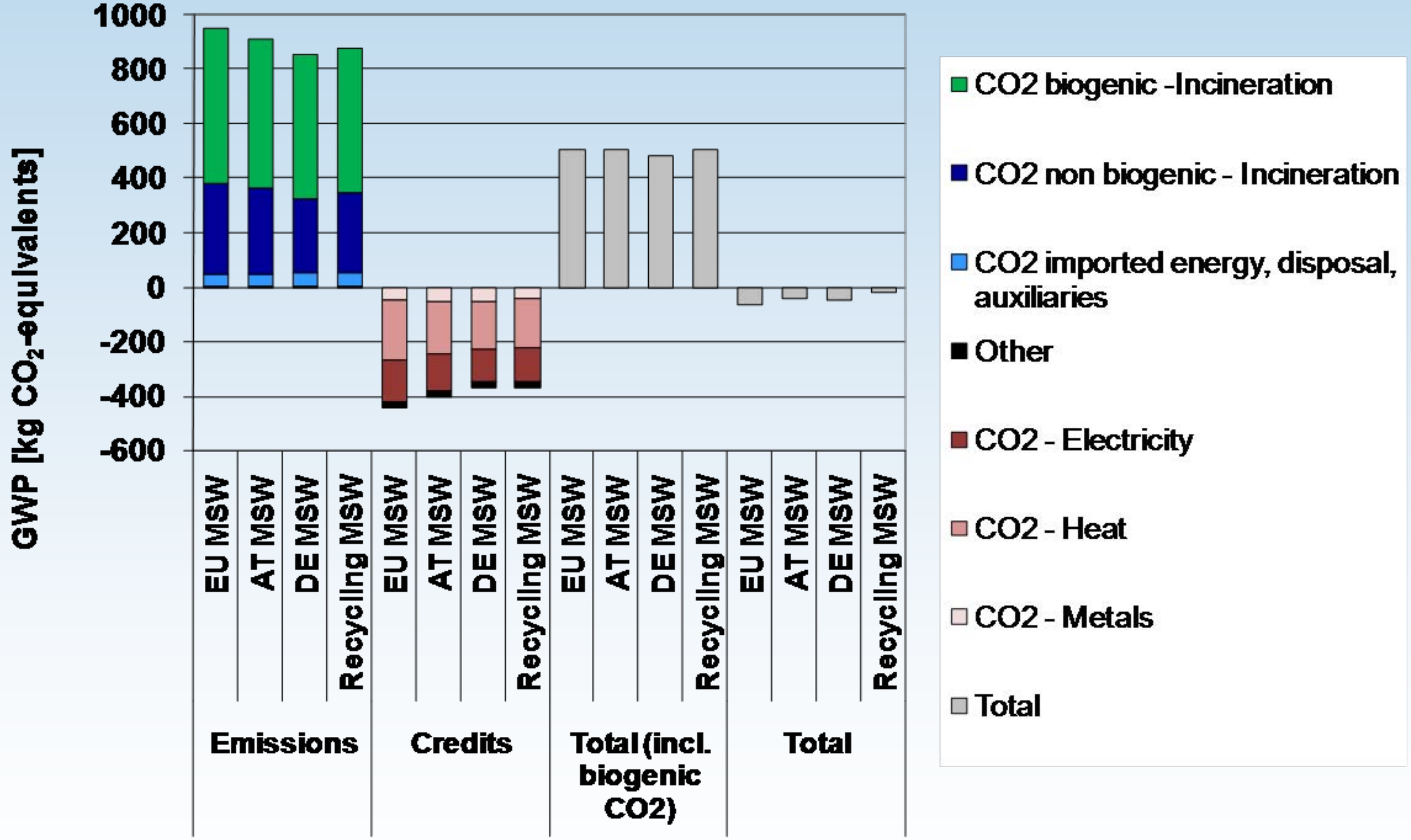


➔ A further reduction of the mercury content in MSW, which can be expected over time, will reduce the TETP emitted from the WtE treatment route.

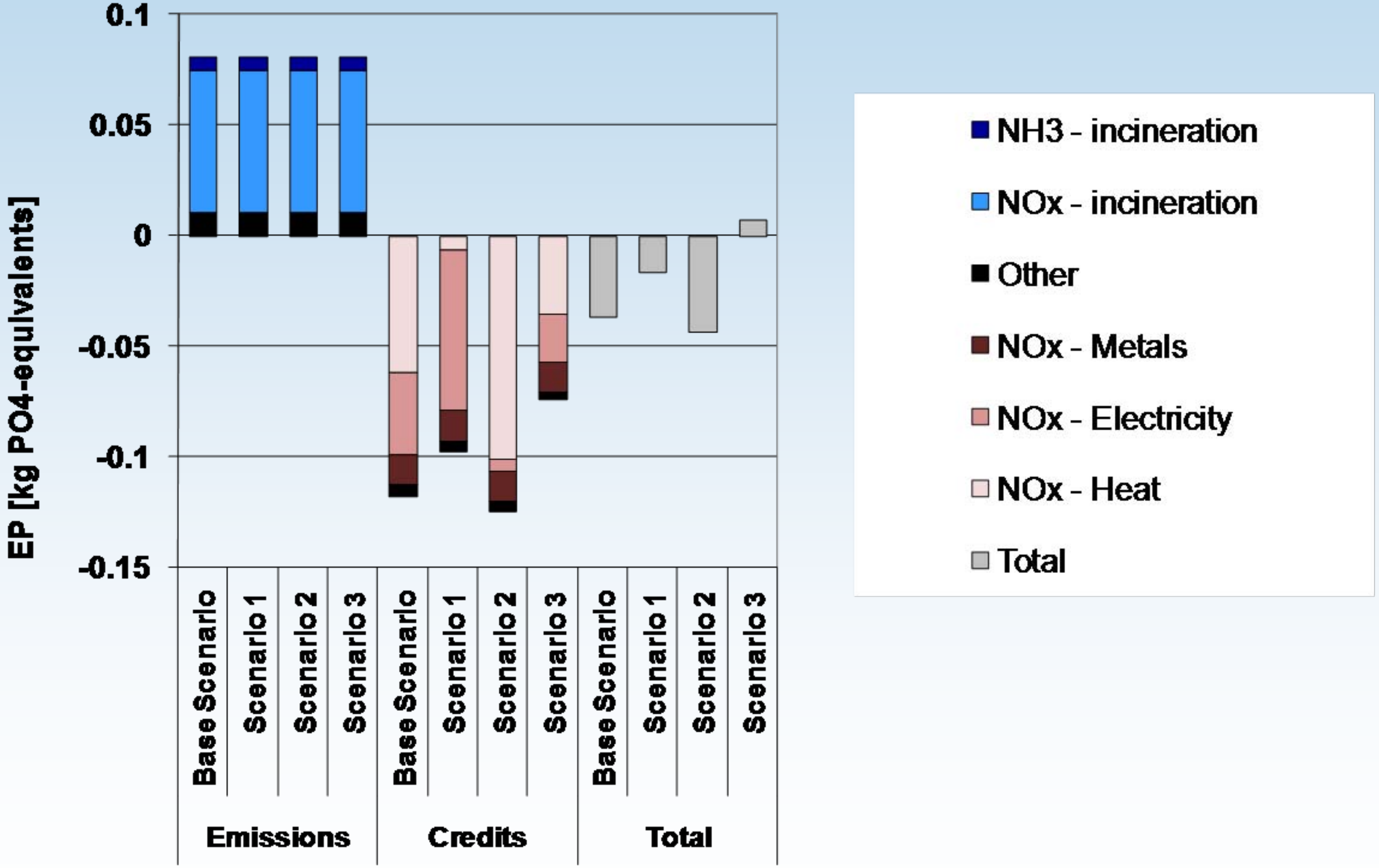
Scenarios for variation of waste composition

Variant Fraction (%)	Base case Avg EU mix	Austrian mix	German Mix	High Recycling Model mix
Paper	20	14	12	10
Textiles	4	5	3	4
Plastics	11	10	7	5
Glass	5	5	5	3
Metals	3	3	4	2
Organic	35	38	36	25
Other	22	25	33	51

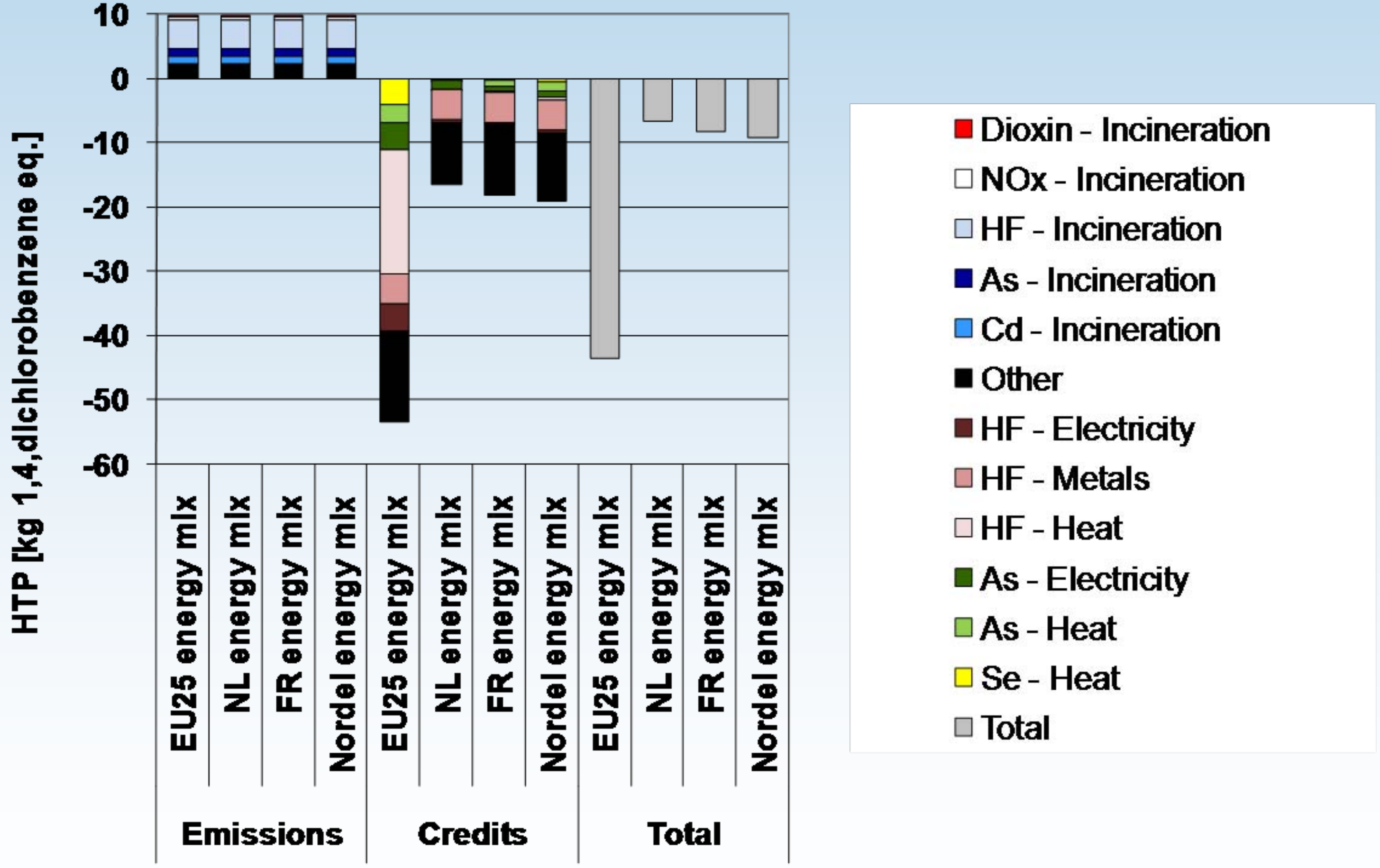
Effect of variation of waste composition on GWP: A relatively modest effect !



Effect of plant Energy output on EP is substantial due to differences in Energy output -> credit effects



Effect of substitution mix on HTP is large due to credit effects



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Conclusions

- The most impact categories show net benefits for Waste-to-Energy of MSW over the whole life cycle with the exception of TETP
- The results on TETP are highly dependent on data from the mercury balance and assumptions on Hg content of the MSW. A sensitivity study indicates that the rapidly decreasing content of Hg in MSW will resolve the TETP issue.
- The carbon balance of the waste treatment in an average European Waste-to-Energy plant is carbon neutral as long as the biogenic carbon share of MSW is 56 % or higher. (For the average base case the % biogenic is 63)
- The effects of changing waste mix are modest except for effects on TETP due to the assumed accumulation of heavy metals and the like in the waste as the result of the high Others fraction.

Other observations

- GWP thinking and analysis is becoming very widespread in the world. This is being Used and MisUsed for many purposes !
- LCA is becoming a « conditio sine qua non » for doing business. Demand from customers, authorities, …
- CEWEP has made a professional contribution which is available for review and debate.
- CEWEP will participate in similar exercises comparing WtE with other treatment routes and recycling.

Acknowledgment

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