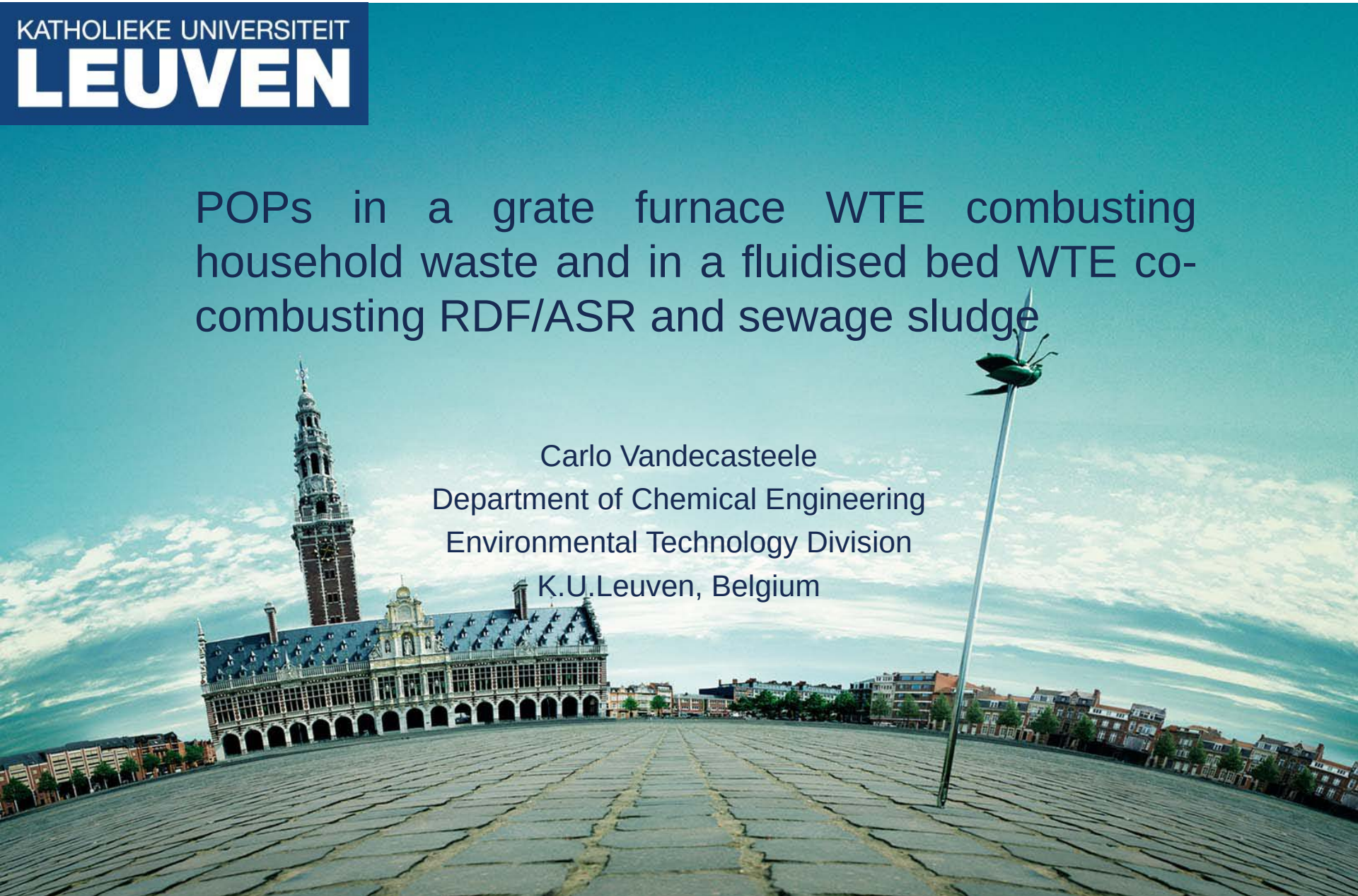
KATHOLIEKE UNIVERSITEIT
LEUVEN

POPs in a grate furnace WTE combusting household waste and in a fluidised bed WTE co-combusting RDF/ASR and sewage sludge



Carlo Vandecasteele
Department of Chemical Engineering
Environmental Technology Division
K.U.Leuven, Belgium

Introduction

At the division of environmental technology:

- 20 years of research collaboration with INDAVER NV, major waste treatment company in Belgium, with installations for recycling, incineration, disposal of waste at 6 locations
- Research
  - Leaching behavior of heavy metals, oxyanion forming elements in incinerator residues
  - Solidification/stabilisation
  - Treatment of residues in view of landfilling, recycling
  - **Formation and environmental impact of *PCDD/Fs and other POPs* in waste incinerators**

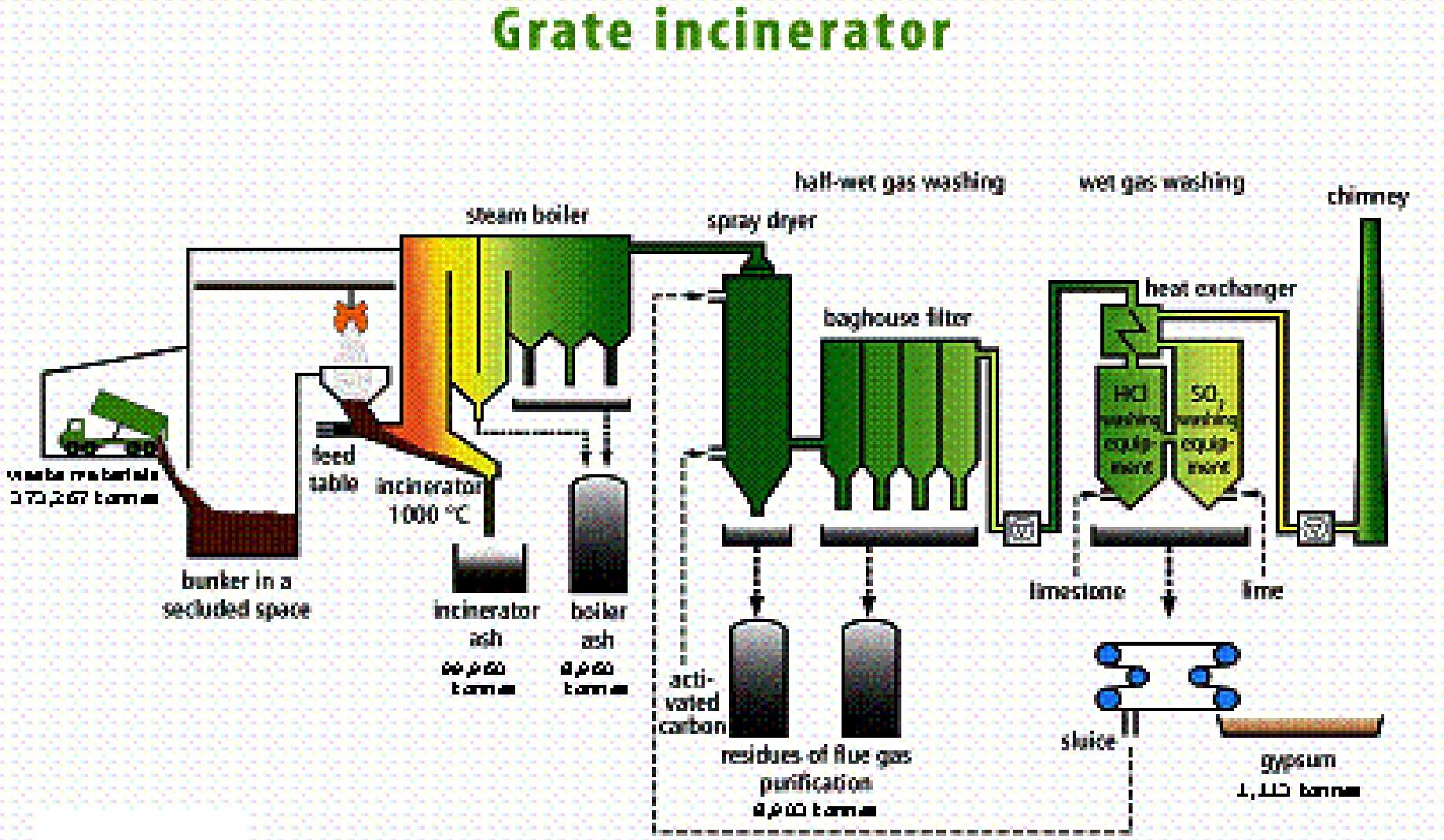
Grate furnace incineration of municipal waste

- Indaver N.V., Doel, Antwerp grate furnace incinerator for MSW (non-recyclable, non-hazardous, not selectively collected fraction of household waste), comparable industrial waste, and wastewater treatment sludge

- Three grate furnace lines, in total 400.000 ton/year

- Important aspects
  - WTE
  - Careful monitoring and control of air pollution
  - Recycling of bottom ashes

Indaver grate furnace incinerator



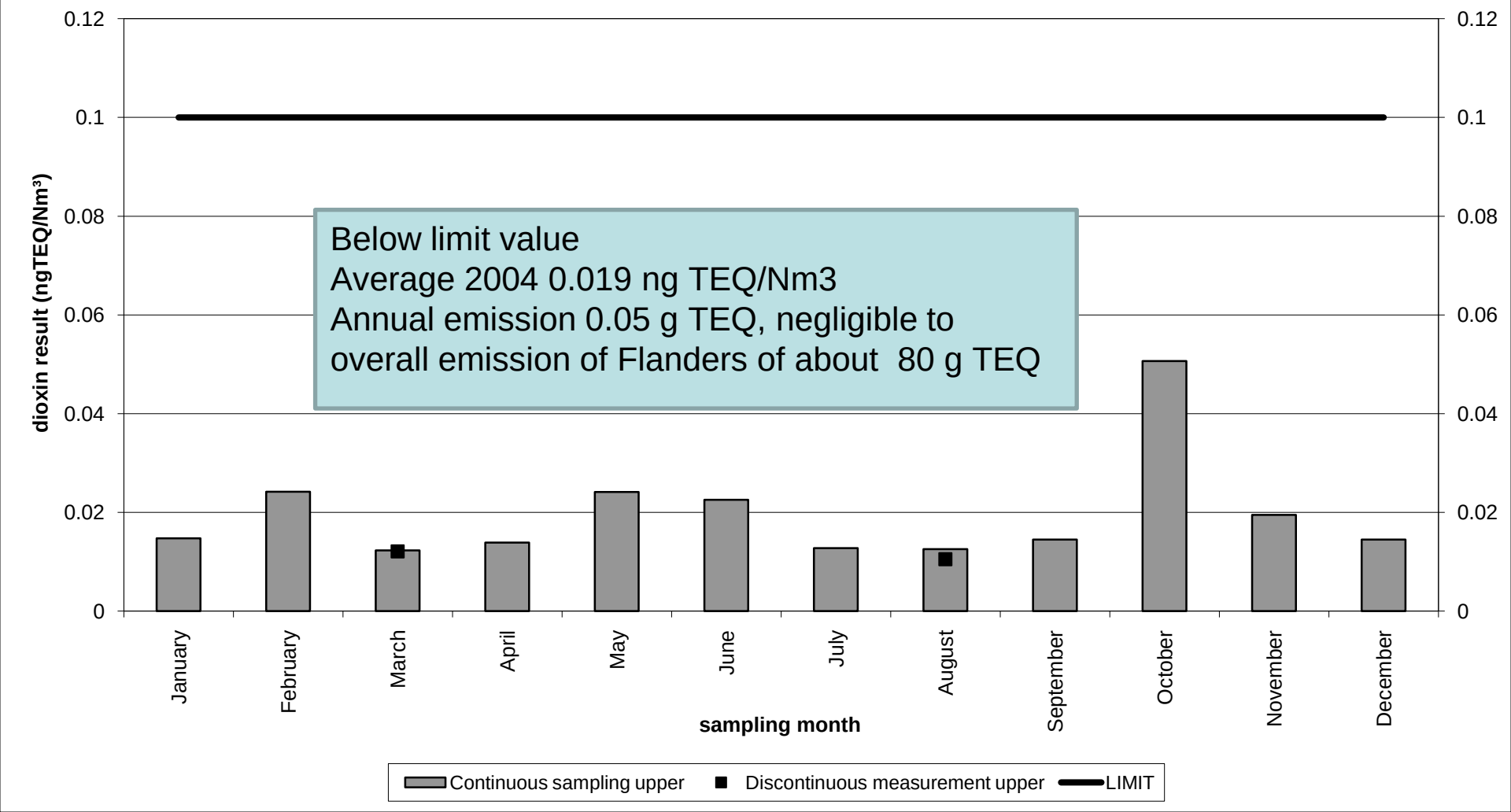
Indaver grate furnace incinerator

- In boiler superheated **steam** (40bar, 400°C) produced
  - Supplied directly to neighbouring industry
  - Used in turbine driven generator to generate electricity
  - Gross energy yield: 50.2 %, net: 40.8%
- Residues
  - Bottom ash wet treated,
    - Metals removed, recycled
    - Granulates: road construction, embankment...
    - leaching of heavy metals!
  - Fly ash and APC residu
    - solidification/stabilisation
    - landfill

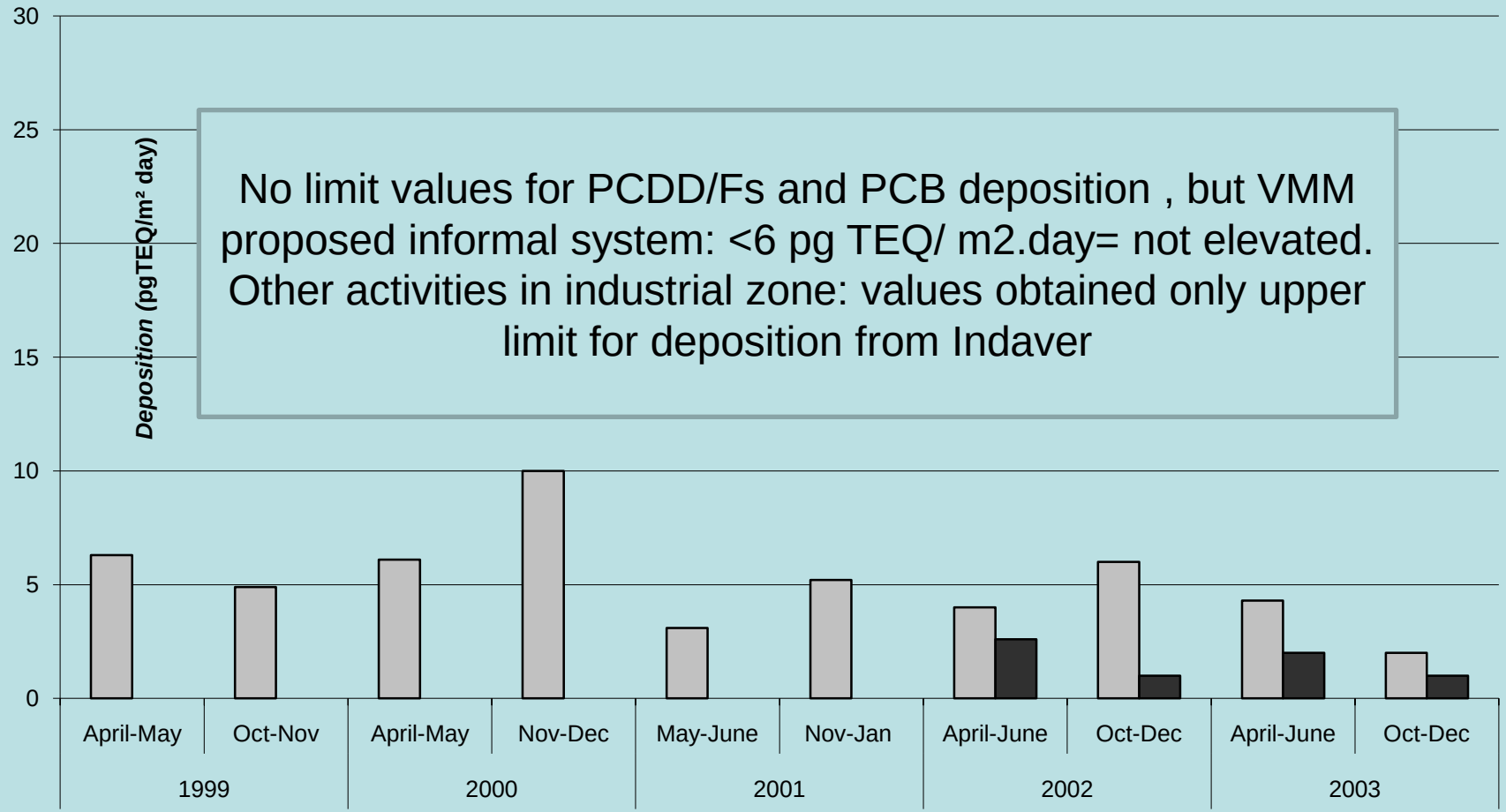
Indaver grate furnace incinerator

- The **flue gases are** sampled every 2 weeks, for 14 days using sampling equipment of AMESA type, according to EN 1948-1 standard
- Subsequently POPS determined by accredited lab according to EN 1948-2 standard: PCDD/Fs, PCBs, PAHs, HCB...

PCDD/Fs EMISSIONS for GRATE FURNACES, 2004



PCDD/F and PCB deposition (pgTEQ/m² day) a few km from incinerator



Indaver grate furnace incinerator

- POPs not only measured in flue gases, but also in:
  - Bottom ash
  - Boiler ash
  - Flue gas cleaning residu
- Answer question: is incinerator a POP source or sink?
- Methodology developed, to compare weighed sum of input POPs with weighed sum of output POPs
  - *NON-CANCER EFFECTS*

    Minimal risk dose (MRD) for non-carcinogenic effects of *chronic oral exposure* (when available), is used to weigh in- and output

  Weighing factor = 1/MRD
  - *CANCER EFFECTS*

    Potency factor (slope of linear part of (oral) dose-response curve)) is used to weigh in- and output

  Weighing factor = Potency factor

Input/output ratios

	All output fractions		Only flue gas	
	Non-cancer	Cancer	Non-cancer	Cancer
Grate furnace MSW	0.3 – 1.8	0.1 – 1.0	200 – 1 000	30 - 300

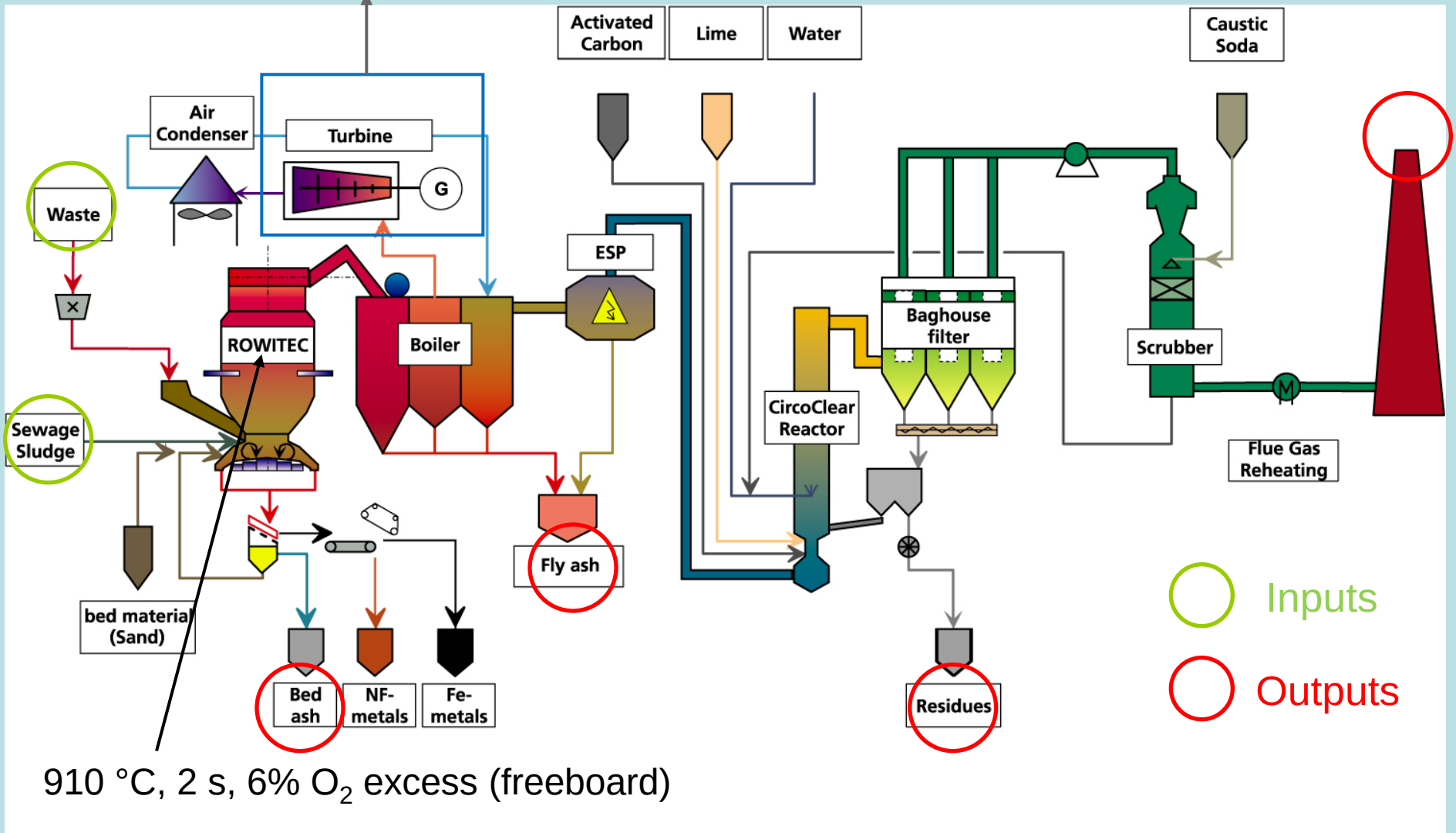
If all output fractions are considered, weighted input is comparable to output

Fluidised bed WTE co-combusting RDF/ASR and sewage sludge

- Sleco operates FBC at Indaver site, close to grate furnace incinerator
- Circulating fluidised bed, largest FBC in Europe for this purpose
- Traditional fuel: high calorific RDF from MBT (70%) and wastewater treatment (WWT) sludge (30%). In 2008
  - $313x10^3$ ton of RDF (~70%) and $134x10^3$ ton of WWT (~30%) sludge incinerated
  - $250x10^3$ MWh electricity produced
- 5-day trial
  - Fuel: 25% RDF, 25% ASR, 50% WWT sludge
  - inputs and outputs sampled
  - PCDD/Fs (dirty 17), co-planar PCBs (12), PCBs (7

Sleco FBC

250x10^3 MWh electricity generated in 2008



Sleco FBC: waste input

- RDF is one of the remaining fractions of MBT of MSW
- Contains mainly plastics, paper and dried organic material

  +/- 10 MJ/kg

1x1cm

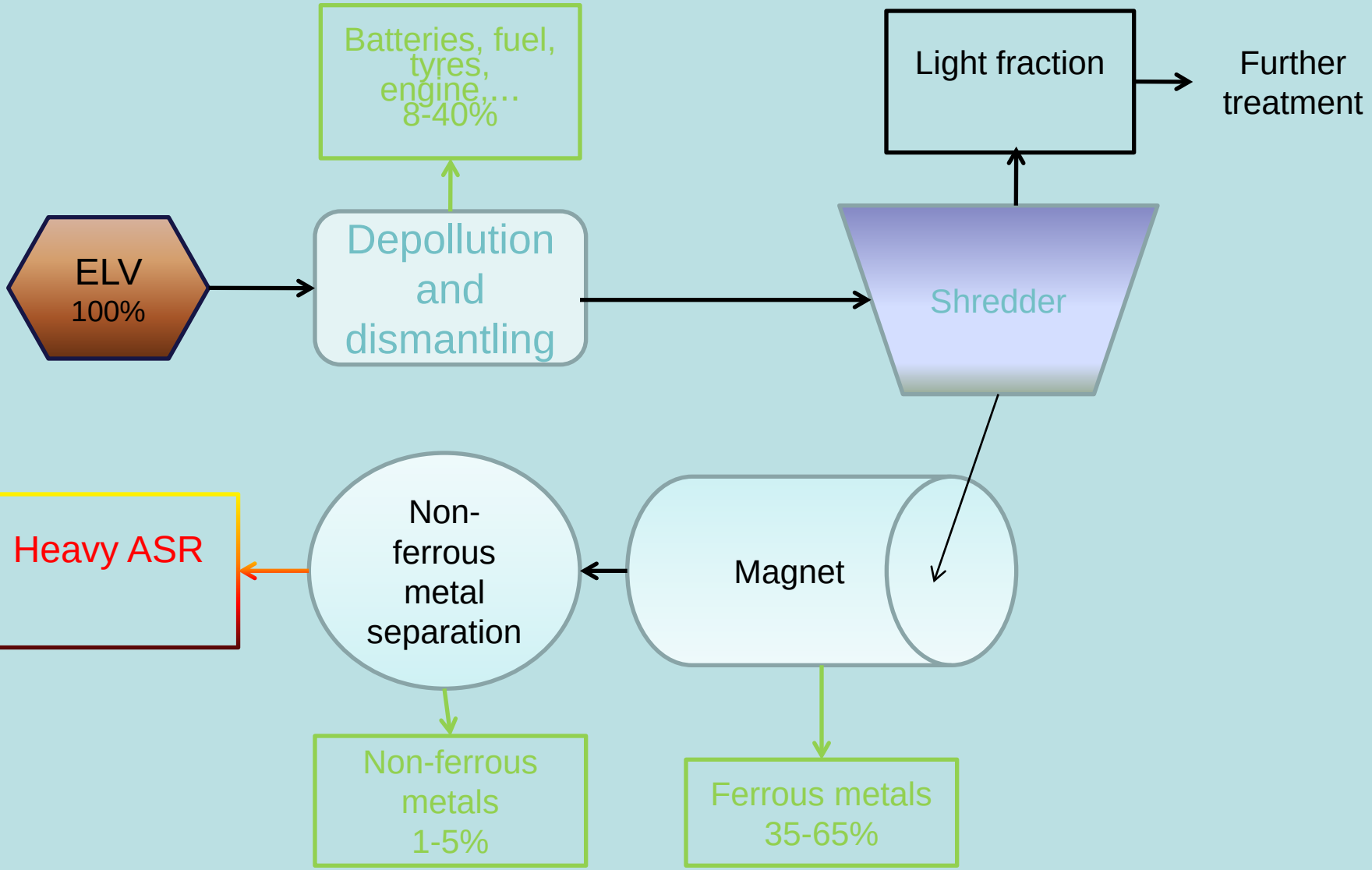
Sleco FBC: waste input

- Sludge from industrial and municipal biological wastewater treatment
  - Mixture of dewatered and digested sludge, average dry matter content of 24%
  - +/- 2 MJ/kg

Sleco FBC: waste input

- ASR considered is the fraction remaining after a dismantled car is shredded and ferrous, non-ferrous are separated
  - Contains 50% combustibles (PU-foam, plastic fibres and foil) and 50% inert materials (sand, small stones, iron and rust)
  - +/- 19 MJ/kg

Sleco FBC: waste input



Sleco FBC: waste input

- EU Directive 2000/53/EC implies a “reuse and recovery” rate for ELVs of 95% (reuse and recycling 85%) by 2015
- In Belgium, in 2008 “reuse and recovery” rate was 90% (in EU-15 78%)
- One option to achieve 95%: increase energy recovery by incineration of ASR, actually sent to landfill, in FBC
- Will this increase POP output?

Sleco FBC: input waste

	PCDD/Fs pg TEQ/g_{dw}	**Dioxin-like PCBs** [a] pg TEQ/g_{dw}	**PCBs** [b] ng/g_{dw}	**PAH** [c] ng/g_{dw}	**DEHP** µg/g_{dw}	**Mass flow Normal feed** ton_{dw}/year	**Mass flow Trial** ton_{dw}/year
RDF	0.954 – 3.92	1.57 – 6.11	170 - 620	5,300 – 8,400		313,185	223,704
Sludge	0.591 – 3.92	2.36 – 2.37	130 - 380	340 - 740		134,222	111,852
ASR	242 - 329	481 - 631	13,000 – 15,000	37,000 – 140,000	2,900 – 8,300		111,852
Total input co-incineration (25% ASR, 25% RDF, 50% sludge), kg/year	$(2.73 – 3.80)x10^{-2}$ d	$(5.45 – 7.18)x10^{-2}$ d	$(1.51 – 1.86)x10^{3}$	$(4.81 – 16.8)x10^{3}$	$(3.24 – 9.28)x10^{5}$		
Total input usual waste feed (70% RDF, 30% sludge), kg/year	$(3.78 – 13.8)x10^{-4}$ d	$(8.08 – 22.3)x10^{-4}$ d	$(6.4 – 20.2)x\ 10^{1}$	$(1.71 – 2.73)x10^{3}$			

~ 100x

- ASR contains more POPS
- PCDD/F, dioxin-like PCB, and PCB input about 100 times higher during co-incineration of ASR
- Will POP output increase?

Sleco FBC: output

	PCDD/Fs	Dioxin-like PCBs [a]	PCBs [b]	PAH [c]	Mass flow
	pg TEQ/g_{dw}	pg TEQ/g_{dw}	ng/g_{dw}	ng/g_{dw}	ton_{dw}/year
Incineration of 25% ASR, 25% RDF and 50% sludge					
Flue gas	6.7 [d]	0.649 [d]	n.d	786 [e]	2,278,031 [f]
Fly and boiler ash	23.0 – 205	0.004 – 0.567	4.2 – 4.8	n.d.	52,546
Bottom ash	n.d – 0.00078	0.0101 - 0.0169	n.d.	10 - 110	38,502
Flue gas cleaning residue	797 – 1,420	14.8 – 25.2	3.8 – 4.3	n.d. - 12	12,704
Total output (kg/year)	(1.13 – 2.88)x10^{-2} [g]	(1.90 – 3.56)x10^{-4} [g]	(2.69 – 3.07)x10^{-1}	2.05 – 4.79	
Incineration of usual waste feed (70% RDF and 30% sludge)					
Flue gas	4 - 12 [d]	3.0 [d]	23 [e]	7,350 [e]	2,278,031 [f]
Fly and boiler ash	30.5	n.d.	n.d.	n.d.	52,546
Bottom ash	0.0412	0.0216	n.d.	270	25,909
Flue gas cleaning residue	980	11.9	n.d.	36	12,704
Total output (kg/year)	1.41x10^{-2} [g]	1.59x10^{-4} [g]	5.24x10^{-2}	2.42x10^{1}	

- PCDD/F, dioxin-like PCB, outputs during trial comparable or slightly higher than for “usual” feed
- PCB output during trial is about 10 times higher
- PAH output during trial is about 10 times lower

Sleco FBC: input/output ratios

	PCDD/Fs	Dioxin-like PCBs	PCBs	PAHs
Incineration of 25% ASR, 25% RDF and 50% sludge				
Total input/output (flue gas)	1,780 – 2,490	36,900 – 48,600	n.d.	2,680 – 9,360
Total input/total output	0.95 – 3.35	150 - 380	4,900 – 6,900	1,000 –8,200
Incineration of usual waste feed (70% RDF and 30% sludge)				
Total input/output (flue gas)	14 - 150	120 - 330	1,200 – 3,900	100 - 160
Total input/total output	0.03 – 0.1	5 - 14	1,200 – 3,900	70 - 110

Sleco FBC: conclusions

- Due to higher POP concentration in ASR, POP concentration in input waste was significantly higher during the trial with ASR, than with the usual feed
- POP concentration in the outputs was comparable (or lower), except for PCBs.
- Input/output ratio for POPs in co-incineration of ASR is thus higher, more advantageous, than with the usual feed
- PCDD/Fs, dioxin-like PCBs and PCBs in input are destroyed, but new POPs are formed during cooling of flue gases (different fingerprints)

Sleco FBC: with weighing of POPs

	Weighing with (1/MRD)	Weighing with potency factor
Incineration of 25% ASR, 25% RDF and 50% sludge		
Total input/output (flue gas)	9,700 – 13,000	1,800 -21,500
Total input/total output	5.6 - 19	9.1 -127
Incineration of usual waste feed (70% RDF and 30% sludge)		
Total input/output (flue gas)	120 - 740	40 - 420
Total input/total output	0.31 – 0.97	3.2 - 14

Sleco FBC: with weighing of POPs

When masses of POPs were weighed and aggregated, the total POP input was higher during co-incineration of ASR than for normal feed, but POP output only showed limited increase

Input/output ratios more advantageous with ASR than with usual feed

POPs in the waste were destroyed and formation of new POPs during cooling of gases is to large extent independent from POP concentration in incinerated waste

References

- C. Vandecasteele, G. Wauters, S. Arickx, M. Jaspers, T. Van Gerven, integrated municipal solid waste treatment using a grate furnace incinerator: The Indaver Case, Waste Management, 27 (2007) 1366
- J. Van Caneghem, C. Block, A. Van Brecht, G. Wauters, C. Vandecasteele, 2009, Mass balance for POPs in hazardous and municipal solid waste incinerators. Chemosphere 78 (2010) 701
- J. Van Caneghem,C. Block, I. Vermeulen, A. Van Brecht, P. Van Royen, M. Jaspers, G. Wauters, C. Vandecasteele, Mass balance for POPs in a real scale fluidized bed combustor co-incinerating automotive shredder residue, J. Hazardous Materials, 181 (2010) 827