International Energy Agency

Fluidized Bed Conversion

44th IEA-FBC Meeting

VIENNA, May 27-28, 2002

Solid Recovered Fuels in Fluid Bed Incineration: calorific value, fuel qualities & process gas-monitoring

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FUTURE MIX of THERMAL ENERGY-SECURITY OF EU ENERGY SUPPLY DG TREN Green Paper, EIS - Brussels, 12-2002

- *"decline of coal"*
- *"gas, the rising star"*
- *"oil - preserving its supremacy"*
- *"nuclear on the crossroads"*
- *"renewables,not taking off*
- *- waste & biomass not really mentioned!! -*

FUTURE MIX of THERMAL ENERGY- Drivers and Constraints till 2010

Liberalization of Energy Markets

Transport, Logistics & Free Market

Political Acceptance & Hesitations

Kyoto+ & Environmental Considerations

Political Dependence & Infrastructure

Availability & Cost, Demand or Supply Side Controlled

Technology and Innovation Potential

EU Politics Development: Fair Rules or Wishful Thinking

Steady Development or Drastic Change…..

WHICH FUELS / FUEL MIX FOR NEW BOILER PLANTS ?

……&...SUSTAINABLE DEVELOPMENT……..

Co-COMBUSTION *vs.* CLEAN COAL Assessment of EU: CoCo = CCTech

- **Co-Combustion +++**
- **Kyoto goals by co-firing „renewables“ with coal [from wood, biomass to peat, waste, RDF]**
- **attractive for CFB circulating fluidized bed plants (new plants that can handle co-incineration erosion/ corrosion/ mechanical handling of non-regular/ recov‘d fuels) in the range 10 to >100 MW**
- **attractive for CHP**
- **attractive for alliances between different sectors (agriculture, industry, utilities, wastes)**
- **attractive for end-of-life-cycle use of redundant power plants (taken off grid due to liberalization schemes/stranded costs)**
- **gasification argument often applied in lieu for „non-incineration“, but useful as add-on with existing power plant**

- ***Clean* Coal +++**
- **Kyoto goals by efficiency upgrade (high temperature, high pressure boilers)**
- **attractive for research and technical demonstration into PFBC , IGCC**
- **attractive to building of new, very large FB plants (> 300 MW) to ease burden of high investment costs by lowering specific costs by „size“**

Non-regular / Recovered Fuels for ENERGY RECOVERY : how much ?

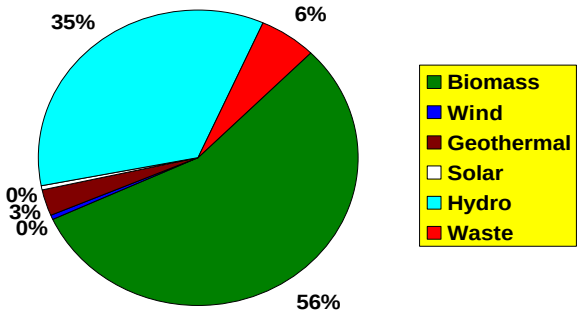
•***COMBUSTIBLE WASTES : MIXTURE of LEGAL POLTICS & TECHNICALITIES***

- *„combustible wastes“ being non-regular/recovered waste/fuels from private and industrial use amount to about 4 times the tonnage (and energy content) of the „original household wastes“ (before source recovery)*
- *they amount - in energy - to about 10% of a country‘s primary (fuel) energy, they are a plentiful , locally available source of energy*
- *these non-regular/recovered fuels contain a multiple of hazardous ingredients compared to other fuels (heavy metals, organic toxics)*

Non-regular / Recovered Fuels for ENERGY RECOVERY : how much ?

European Commission, DG TREN

Contribution of Waste to RES Energy Share (Eurostat 1997)/Hanreich 5-2001



Waste's contribution has been achieved thanks to the development of reliable & environmentally friendly technologies.

A PUZZLE OF DILEMMAS

- **The PRODUCER's DILEMMA**
  - **relevant quality-control, material or energy recovery, large markets to be created**
- **The USER's DILEMMA**
  - **limited experience, liberalization confused**
- **The STAKEHOLDER's DILEMMA**
  - **diverging interests (public/private, global/local)**
- **The GOVERNMENT's DILEMMA**
  - **harmonized legal framework, clear, adequate and decisive control monitoring, bridging local and national interests**

FUTURE MIX of THERMAL ENERGY -

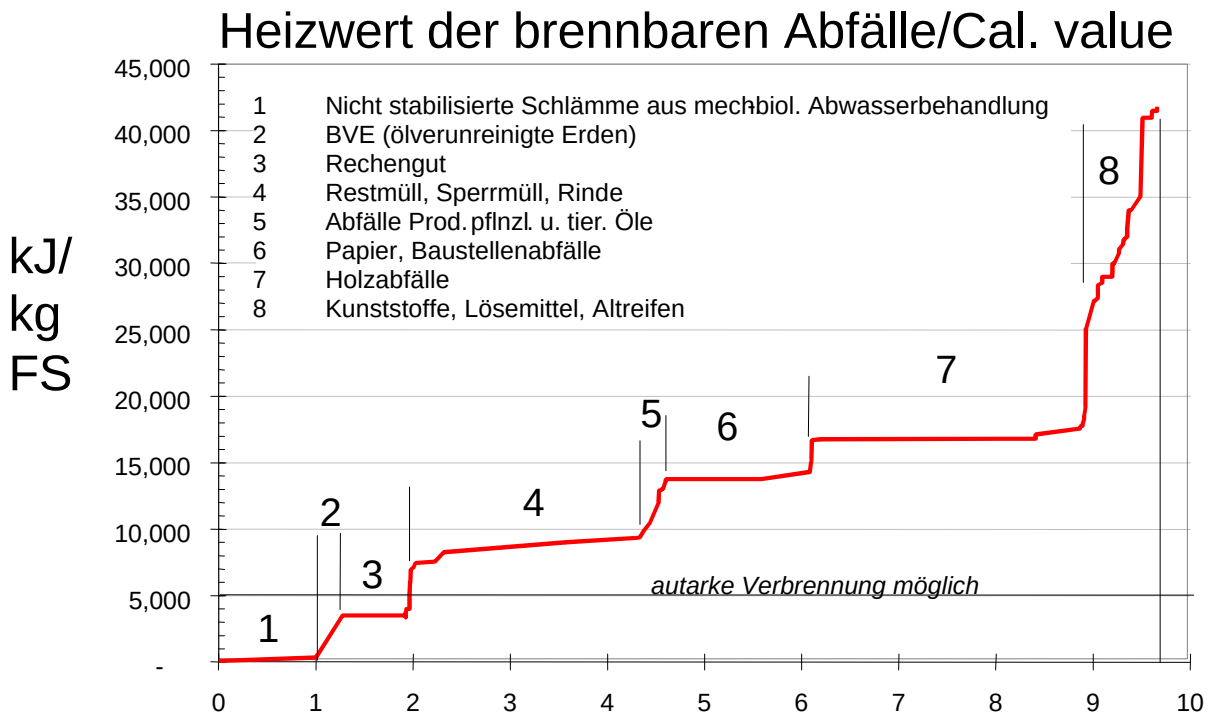
D: Annual Waste-to-Energy is 101 million tpy/1200 kg/cap.y !

Abfallstatistiken 1996 und 1998/9 für Deutschland/Reimann

Übersicht		Mio. Mg/a	Mio. Mg/a
Aufkommen von Primärabfällen (1996)		**335,954**	
	verteilt auf:		
	Bauabfälle, Abbruch, Bodenaushub		176,582
	unbehandelte Bergmaterialien aus dem Bergbau		67,814
	Abfälle aus dem produzierenden Gewerbe/Industrie		**56,948**
	Siedlungsabfälle		~34,000
Siedlungsabfälle (1998/9) einschl. ~10 Mio Mg/a hausmüllähnlicher Gewerbeabfall, Sperrmüll, Kehricht		**44,008**	
	davon:		
	Abfallbeseitigung		24,678
	Abfallverwertung		19,330
Siedlungsabfall (1998/9) in öffentlicher Verantwortung (andienungspflichtig)		**24,678**	
	davon:		
	zur Verbrennung		11,000
	zur Deponierung		13,678

FUTURE MIX of THERMAL ENERGY -

A: Annual Waste-to-Energy could be 9,7 million tpy/1,2 tpy & capita !



9.7 Mio t/a brennbarer Abfälle/combust. wastes

Quelle: ASTRA, PRIZMA

FUTURE MIX of THERMAL ENERGY -

Austria: but the 9,7 mio tpy contain environmentally relevant „ingredients“!

Calorific Value	Mass of Comb. Wastes to Recovery	Cl	Cd	Hg	Pb	Zn
		to Recovery				
MJ/kg	%	%	%	%	%	%
> 5	80	100	98	82	97	95
> 8	77	97	95	74	92	89
> 11	54	59	51	23	38	55
> 14	42	48	48	22	36	49
> 17	13	40	38	8	11	30
> 21	8	16	19	5	7	29

Non-regular / Recovered / Waste Fuels for ENERGY RECOVERY : where to?

- ***COMBUSTIBLE WASTES /SOLID RECOVERED FUELS SRF:***
- ***MIX of ENERGY & HAZARD POTENTIAL***
- ***product and waste have the same hazard potential; but waste has dramatically increased risk (misuse, unintended use, malpractice)***
- ***waste for (energy) recovery R1 is on the „free market“, waste for disposal (also with energy recovery: dedicated waste incinerators) D10 is under relatively strict control: transport guidance, emissions***
- ***wastes for recovery (R1) may contain over-reprentation of hazardous contents (heavy metals and organic toxics) which would be released to the biosphere during unsuspecting co-incineration***
- ***PLANT PARAMETERS MUST BE ADEQUATE TO MIXED FUEL FEED !***
- ***FLUID BED INCINERATION TECHNOLOGY IS FIRST CHOICE !!!***

NON-Regular/Recovered FUELs
FURTHER STEPS to SUCCESS

- Harmonization between mixed and separated waste streams markets
- Harmonization for waste definitions, recovery/ /disposal action
- Harmonization of control monitoring (SRF/emissions control
- Agreed quality classification of SRF, creation of credibility between producers/consumers; public/private; MSWI/industrial co-incinerators

FLEXIBLE (?) LEVEL PLAYING FIELDS, a few examples…:

"Future Directions for European Waste Policy"

INCINERATION & CO-INCINERATION (2000/76/EC):

"Clearly, prevention, reuse, recycling and energy recovery have to serve the objectives of environmental protection and sustainability."

"hierarchy is not a bible…there may be a valid argument for some flexibility on a case-by-case basis"

"The key question is therefore where to draw the line between RECOVERY & DISPOSAL"

BAT WASTE INCINERATION-RECOVERY/DISPOSAL-CO-INCINERATION:

"we should therefore base targets first on a clear and transparent analyses that everybody can understand…"

"waste quantities are not the *real* problem…it is the environmental impact"

CEN TF 118 SOLID RECOVERED FUELS / FUEL DATA:

"We will not hesitate to propose legislation.This concerns in particular haz. substances in products"

TAC RECOVERY & DISPOSAL:

"...env'l advantages can only be secured if the markets for secondary materials is stabilized and supported by clear targets" - "WASTE is not a good like any other"

SECURITY OF ENERGY SUPPLY:

"our env'l rules and standards shoud continue to provide a stimulus for technol. Innovation"

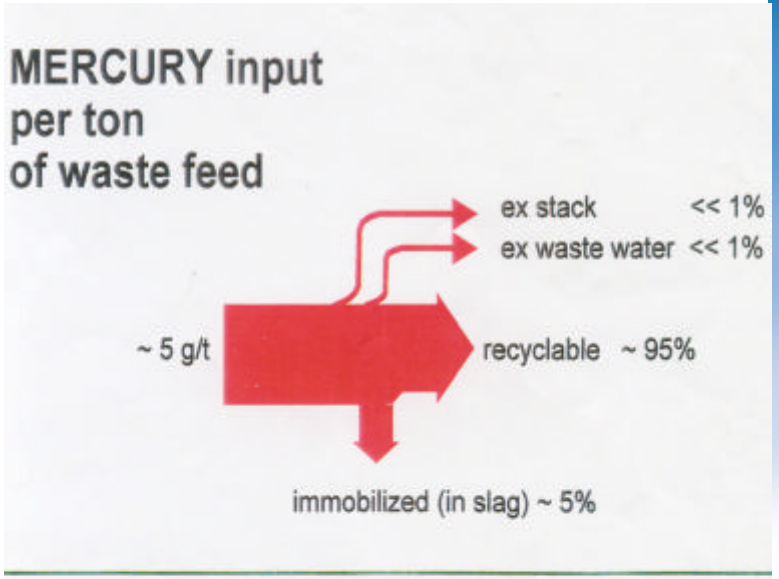
"there needs to be a balance between…functioning of the market and the need for control"

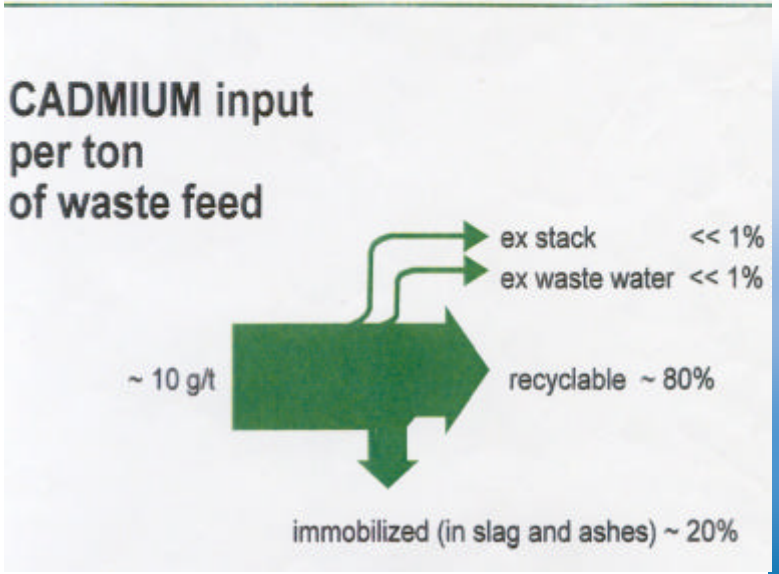
MODERN WASTE INCINERATORS:
MATERIAL FLOW MANAGMENT & HIGH SUBSTANCE CONCENTRATION EFFICIENCY & HIGH ENERGY RECOVERY

- -- HAZARDOUS SUBSTANCES
- CONCENTRATED

- -- PLANT FUNCTIONS AS SINK FOR
- HAZARDOUS SUBSTANCES

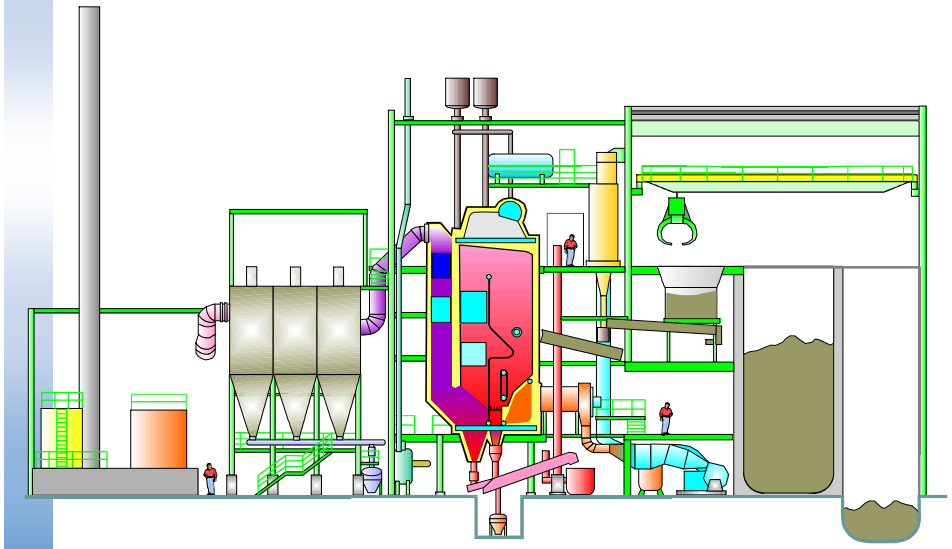
- -- CHP (combined heat & power)
- GUARANTEES HIGH ENERGY RECOVERY



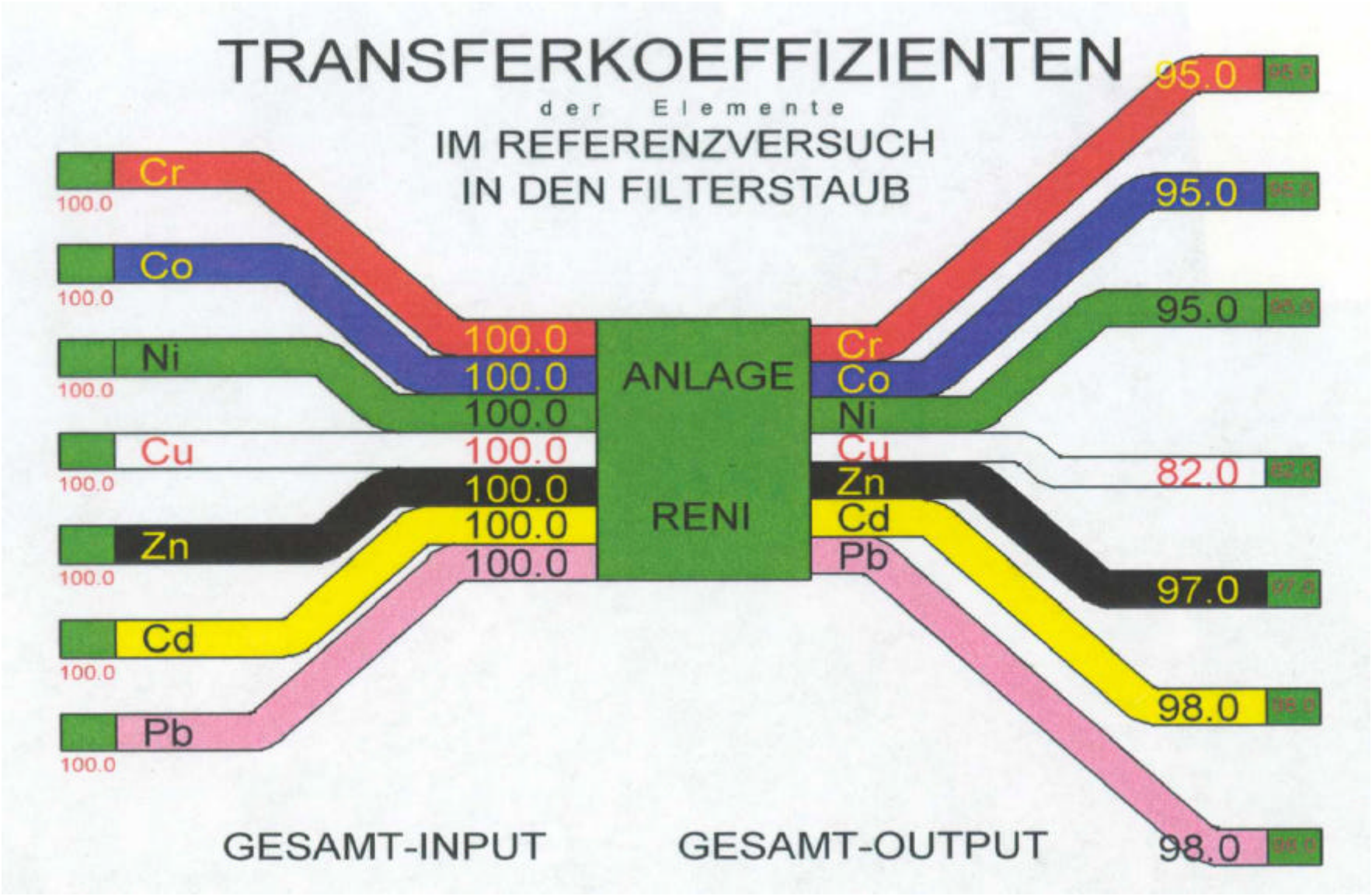


TURBO WS-Anlage RENI AG, Schweiz

Dampfdaten:	18,3 t/h; 15 bar; 230 °C
Hauptbrennstoffe:	Spuckstoffe aus der Papierindustrie, Sedimatschlamm, kommunaler Klärschlamm, Rechengut, Abfallholz, Geschwemmsel
Zusatzbrennstoff:	Leichtöl

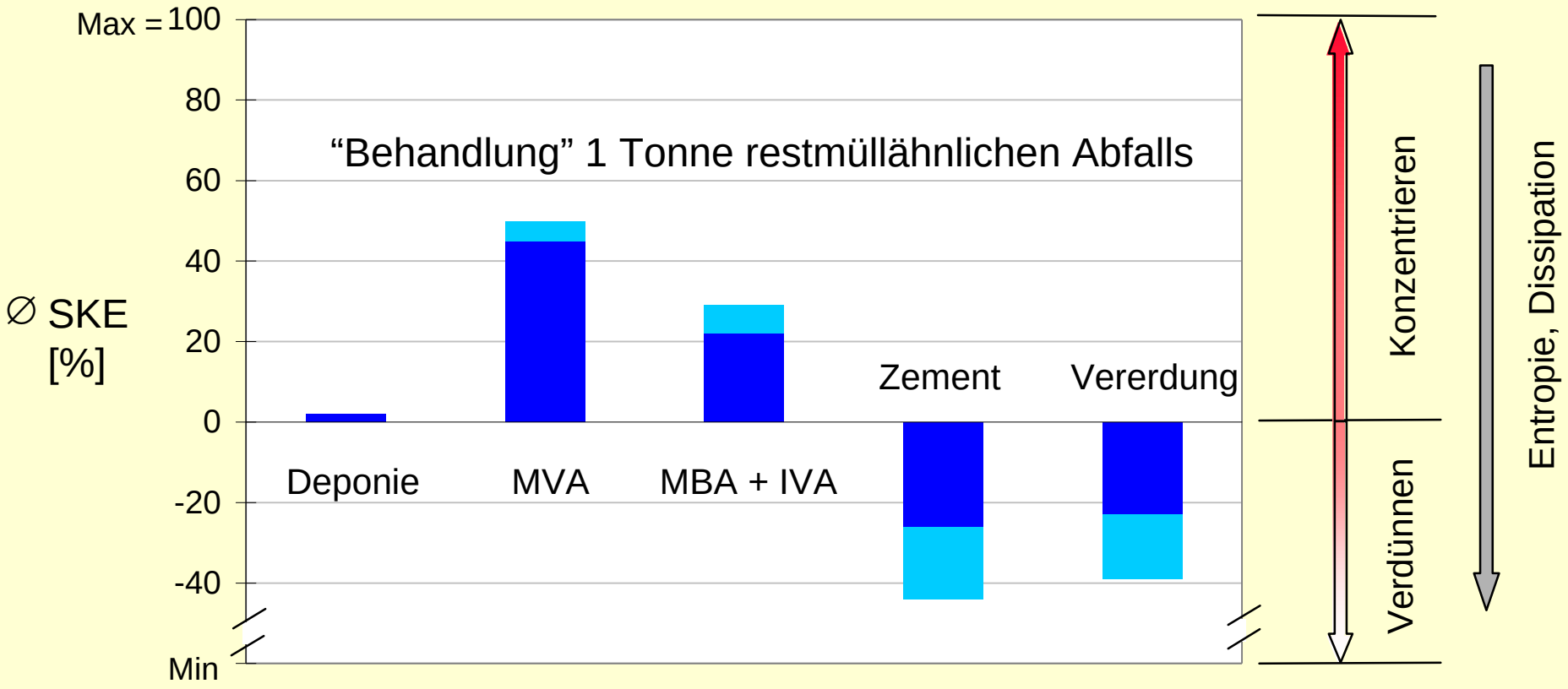


	Garantiewerte	Betriebswerte		
Max. Dauerlast:	15,2	18,3	t/h	(nach Leistungs-erhöhung)
Min. Dauerlast:	9,2	9,2	t/h	
Gesamtbetriebsdauer bis Juli 2000:		15.000	h	
Laständerungsgeschwindigkeit (bez. auf Momentanlast):	-	8	%/min	
Wirkungsgrad:	85,5	85,5	%	
Emissionen: bez. auf 11 % O_2 im Rg. tr.				
CO:	50	16,3	mg/Nm³	
SO_2:	50	< 1,8	mg/Nm³	
NO_x:	70	45,2	mg/Nm³	


TRANSFERKOEFFIZIENTEN
der Elemente
IM REFERENZVERSUCH
IN DEN FILTERSTAUB
Cr
Co
Ni
Cu
Zn
Cd
Pb
100.0
ANLAGE
RENI
95.0
82.0
97.0
98.0
GESAMT-INPUT
GESAMT-OUTPUT

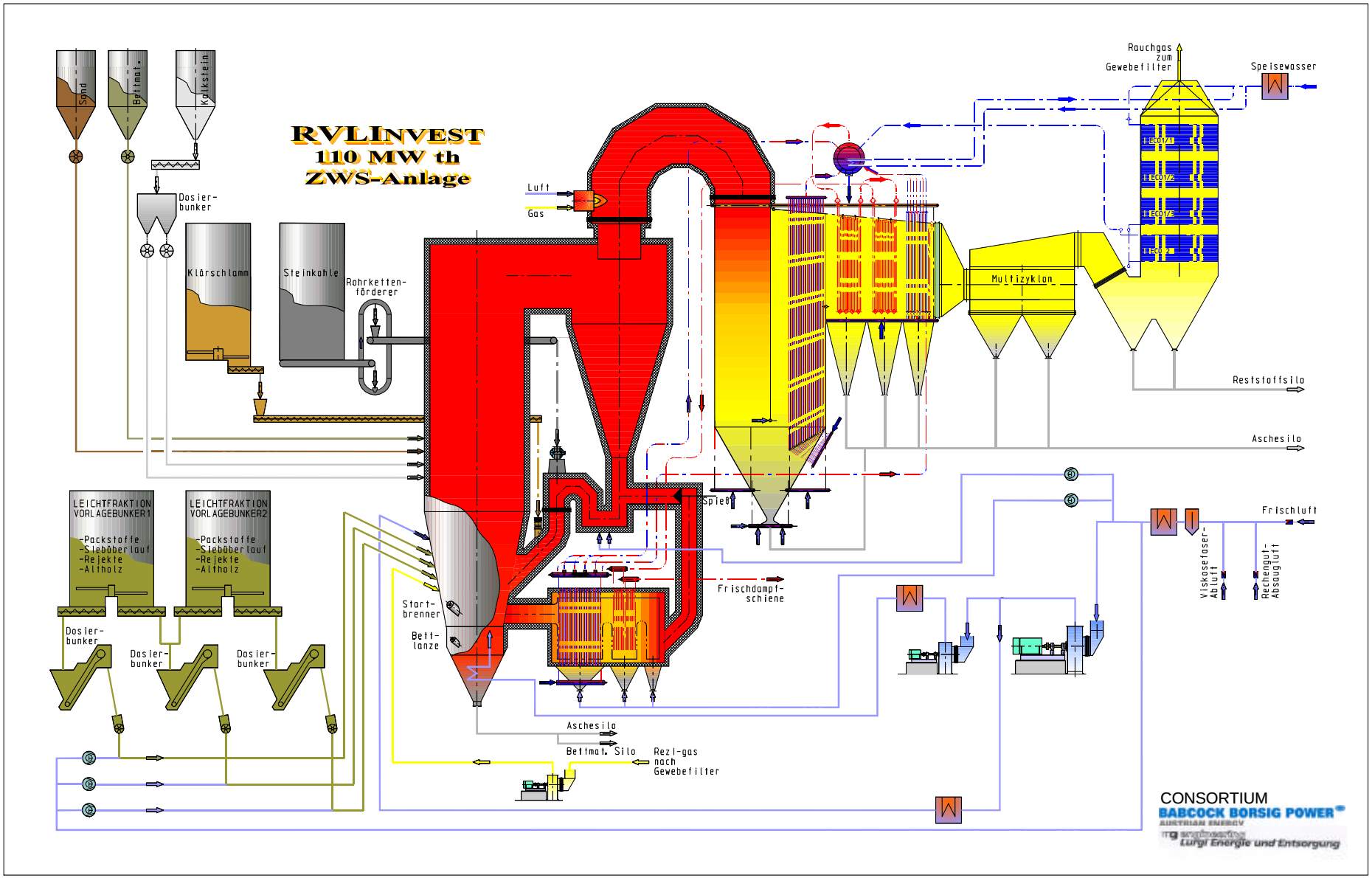
Quo vadis - Abfallwirtschaft?

Gewichteter Mittelwert der **S**toff **K**onzentrierungs **E**ffizienzen für Cd, Hg, Pb und Zn



Waste incineration plant RV-Lenzing:

- Over 20.000 operating hours firing 100% waste fuels
- Range of LHV: 6,5 - 31 MJ/kg, extremely high flexibility on various waste materials
- Use of exhaust air (fibre production) for combustion
- Extremely good emissions
- High thermal efficiency due to integration in energy supply system of Lenzing AG


RVLINVEST
110 MW th
ZWS-Anlage
Sand
Bettmat.
Kalkstein
Dosier-bunker
Klärschlamm
Steinkohle
Rohrketten-förderer
Luft
Gas
Rauchgas zum Gewebefilter
Speisewasser
Multizyklon
Reststoffsilo
Aschesilo
Spieß
Frischdampf-schiene
Start-brenner
Bett-lanze
LEICHTFRAKTION VORLAGEBUNKER1
-Packstoffe
-Siebüberlauf
-Rejekte
-Altholz
LEICHTFRAKTION VORLAGEBUNKER2
-Packstoffe
-Siebüberlauf
-Rejekte
-Altholz
Dosier-bunker
Dosier-bunker
Dosier-bunker
Aschesilo
Bettmat. Silo
Rezi-gas nach Gewebefilter
Frischluft
Viskosefaser-Abluft
Rechengut-Absaugluft
CONSORTIUM
BABCOCK BORSIG POWER
AUSTRIAN ENERGY
mg engineering
Lurgi Energie und Entsorgung

CFB-Plant RVL Lenzing (Austria)

Steam data:	129 t/h; 79 barü, 500 °C
Main fuels:	packing material, screen overflow, waste wood, rejects, sewage sludge
Additional fuels:	bituminous coal, heavy fuel oil, natural gas
Combustion air:	polluted with H_2S and CS_2

	Guarantee values
Max. continuous rating using residual matter:	110 MW_{th}
Max. continuous rating using coal:	110 MW_{th}
Min. continuous rating using residual matter :	55 MW_{th}
Availability:	92 %
Range of low heating powers:	6,5 -31 MJ/kg
Emissions: ref. to 11% O_2 in the flue gas, dry	
CO:	45 mg/Nm³
Corg:	5 mg/Nm³
SO_2:*)	50 mg/Nm³
NO_x:*)	70 mg/Nm³
HCl:*)	7 mg/Nm³
PCDD: (TE acc. to ITEF) *)	0,1 ng/Nm³

*) after flue gas cleaning

Fuels RV-Lenzing

	LHV	Capacity	Bulk density	Flow by volume (design)
	MJ/kg	t/h	kg/m³	m³/h
Packing mat. / Screen overflow	9 - 28	2 - 36	80 - 150	450
Waste wood	13	6 - 30	150	200
Sewage sludge	1.5 - 2	4 - 18	900 - 1000	20
Bituminous coal	31	1 - 15	800	19

Flue Gas Emissions RV-Lenzing

(mg/Nm³, related to 11% O_2, dry)

Maximum 0.5 h mean value at all load cases		limit boiler exit	act. emission boiler exit	limit total plant	act. emission total plant
Dust (rel. to 11% O_2, dry)	mg/Nm³	3000	< 3000	8	< 1
NOx (rel. to 11% O_2, dry)	mg/Nm³	300	70 - 150	70	< 40
CO (rel. to 11% O_2, dry)	mg/Nm³	45	< 1 - 10	50	< 1 - 10
$C_{org.}$ (rel. to 11% O_2, dry)	mg/Nm³	5	0.5	8	0.5
SO_2 (rel. to 11% O_2, dry)	mg/Nm³	2000	0 - 200	50	< 5
SO_3 (rel. to 11% O_2, dry)	mg/Nm³	40	5	-	-
HCl (rel. to 11% O_2, dry)	mg/Nm³	-	700 - 1600	7	1
PCDD / PCDF (rel. to 11% O_2, dry) 2h mean value	ng/Nm³	10	< 10	0.1	< 0.1

Fuels fired in the BBP - Commercial plants

Fossil Fuels:

Bituminous coal
Brown coal
Coal dust (undried &dried)
Fuel oil (light, heavy)
Lignite
Natural gas
Oil ashes
Anthracite
Pet coke

Renewable Fuels:

Bark
Chicken droppings
Straw
Wood chips

Residues & Wastes:

Bagasse (sugarcane etc.)
Various fibreboard wastes
Garbage
Ginding dust
Industrial & Municipal sewage sludge
Paper sludge
Petrol coke
Refuse derived fuel (RDF)
Rejects (various sources)
Residues from leather production
Saw dust
Waste plastics (sorted)
Waste tires (steel and textile cord)
Waste wood

Fuels investigated in the AE-Pilot Plants

- Waste wood
- Car shredder material (various sources)
- Bagasse (sugarcane etc.)
- Refuse derived fuel RDF
- Natural gas (start-up and auxiliary fuel)
- Chipboard waste
- Fibre sludge
- Fibre boards
- Fuel oil
- Industrial sewage sludge
- Municipal sewage sludge
- Lignite (Austrian origin)
- Concentrate from fibreboard production
- Petrol coke
- Coal dust (Lausitzer fine coal)
- Visbreaker residues
- Tetra Pack
- Wood chips
- Oil ashes
- Brown coal
- Waste tires (steel and textile cord)
- Rejects (various sources)
- Bark
- RDF
- Bituminous coal (Polish)
- Straw
- Residues from leather production
- Waste plastics (sorted)

Special applications

- Regeneration of casting-sand
- Regeneration of contaminated soil- material (oil, cyanide)

Our References

	BFB	FICB	CFB
No. of installations	26	5	43
largest capacity (t/h)	70	80	400
largest capacity (MWe)	20	20	120
countries	A, S, GER, ROK, SF, UK	A, CH, I, JP	A, CZ, GER, JP, ROK, PRC, RP, S, TH, US

Selected BBP Fluidised Bed Reference Plants

SICET : 80 t/h, wood, bark

WESTFIELD: 47 t/h, chicken litter

FUNDER: 39 t/h, residuals, used wood, etc.

Selected BBP Fluidised Bed Reference Plants

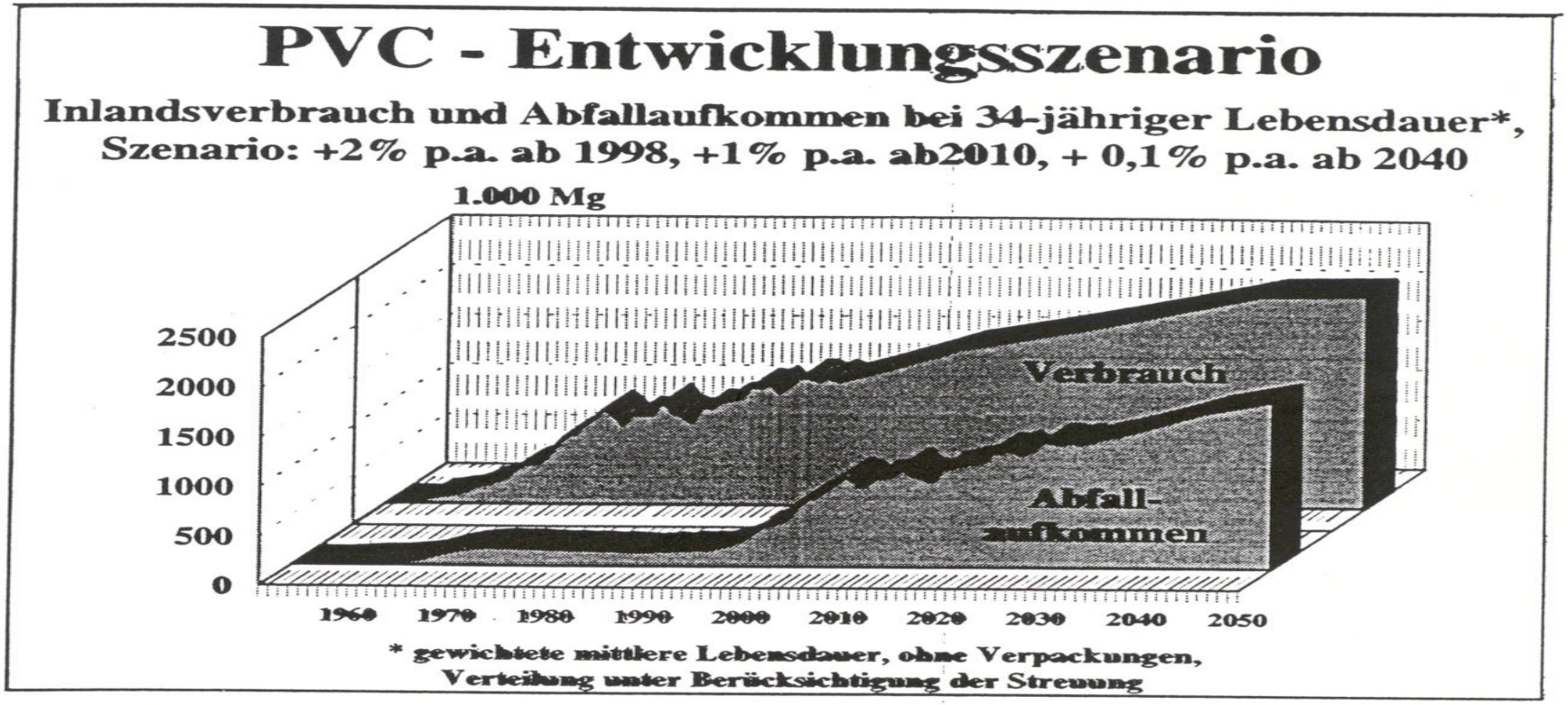
VERA : 3 x 11,2 t/h, sewage sludge

HAINDL : 80 t/h, residuals, waste wood, etc.

RENI : 18 t/h, sewage sludge, waste wood, etc.

PVC-"availability in waste streams" in the near future ….

Abbildung 2: Zukünftige Entwicklung des PVC-bürtigen Chloreintrags in den Abfall

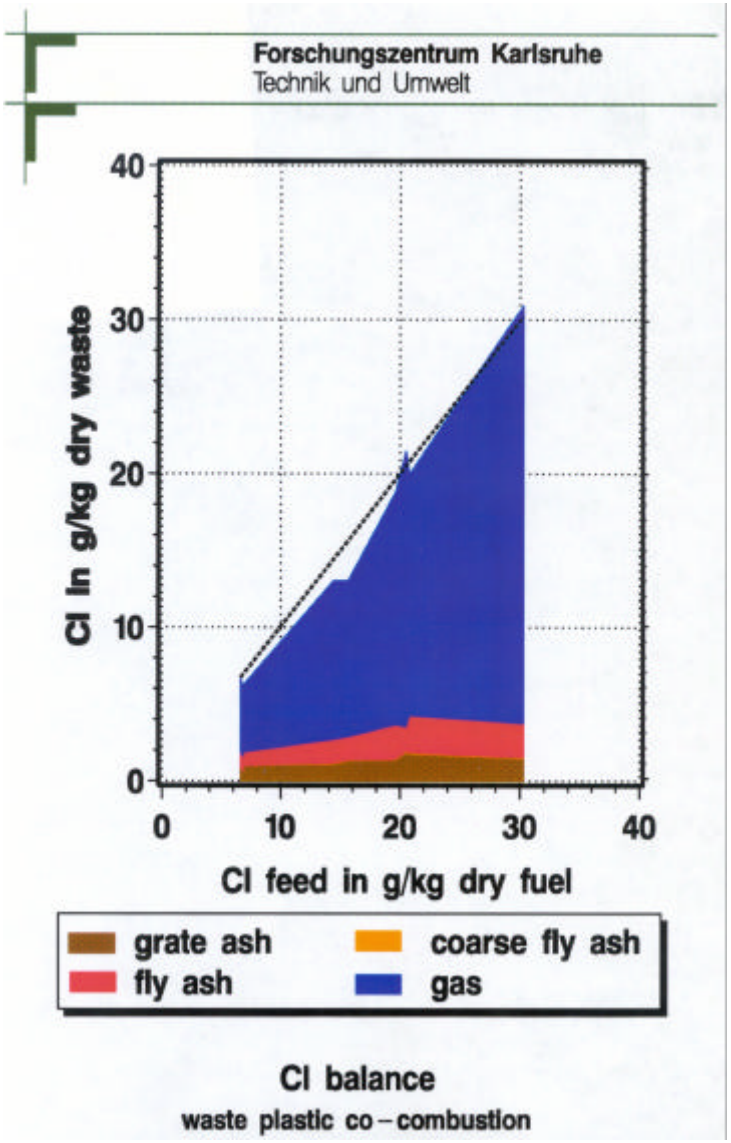


WASTE INCINERATION DIRETIVE 2000/76/EC

Article 11: Measurement requirements

2. The following measurements of air pollutants shall be carried out in accordance with Annex III at the incineration and co-incineration plant:
(a) continuous measurements of the following substances: NOx, provided that emission limit values are set, CO, total dust, TOC, HCl, HF, SO2;
(b) continuous measurements of the following process operation parameters: temperature near the inner wall or at another representative point of the combustion chamber as authorised by the competent authority, concentration of oxygen, pressure, temperature and water vapour content of the exhaust gas;
(c) at least two measurements per year of heavy metals, dioxins and furans; one measurement at least every three months shall however be carried out for the first 12 months of operation. Member States may fix measurement periods where they have set emission limit values for polycyclic aromatic hydrocarbons or other pollutants.

6. Periodic measurements as laid down in § 2© of HCl, HF and SO2 instead of continuous measuring may be authorised in the permit by the competent authority in incineration or co-incineration plants, if the operator can prove that the emissions of those pollutants can under no circumstances be higher than the prescribed emission limit values.



CADMIUM, PLASTICS & indicative CONT INUOUS HCl- Monitoring

ANALYSENERGEBNISSE VON AUFBEREITETEN KUNSTSTOFF-FRAKTIONEN 1997

	Maßeinheit	Mittel	Minimum	Maximum	Anzahl
Chlor gesamt	%	1,20	0,35	2,19	527
Feuchte	%	10,00	1,00	40,00	527
Heizwert	J/g	28.554	14.702	42.491	527
Pb	ppm	88	44	124	11
Cd	ppm	8	4	15	11
Cr	ppm	120	88	167	11
Hg	ppm	0,5	< 0,4	0,7	11

Continuous Indicative Gas Monitoring

SICK | MAIHAK

Cost

Cost Estimation for Raw Gas Monitoring System			
10 years operation, Currency: EURO			
Description	Invest		Cost/year
CEM	70.000		7.000
Installation/Start Up	15.000		1.500
Power/Instrument Air			2.000
Cylinder Gas			1.200
Maintenance Plant Personel			9.000
Maintenance Contract			2.000
Repair	21.000		2.100
Spare Parts			1800
Sum			26.600
Capacity Plant kt/a	50	-	250
Cost per ton waste	**0,53**	**-**	**0,11**

Source: Dr. Breton/ SICK, WTE-GBN Brussels, 1-2002

1st step: FUEL QUALITY GUARANTEE

Environmental Leadership from Cradle to Grave

	Figures in mg/kg fuel					
	S	Cl	sum Me	Cr	Cd	Hg
Referenzwert [R]	250	100	5	100	0,2	0,2
A [< 0,4*R]	< 100	< 40	< 2	< 40	< 0,08	< 0,08
B [< 2*R]	< 500	< 200	< 10	< 200	< 0,4	< 0,4
C [< 10*R]	< 2.500	< 1.000	< 50	< 1.000	< 2	< 2
D [< 50*R]	< 12.500	< 5.000	< 250	< 5.000	< 10	< 10
E [< 250*R]	< 62.500	< 25.000	< 1.250	< 25.000	< 50	< 50
F [> 250*R]	> 62.500	> 25.000	> 1.250	> 25.000	> 50	> 50

Data base: Proposal Austrian standards working group 11-2001

2nd step: FUEL QUALITY BAND-WIDTH

WAS KÖNNTE bez. HERKUNFT & bez. MARKTBEDARF eine sinnvolle und praktische Qualitätsklasse sein ?

	Cal.value MJ/kg	Na+K g/kg	S g/kg	Cl g/kg	Cd mg/kg	Sum HM mg/kg
A	< 5	< 2	< 1	< 2	< 2	< 10
B	5,1 – 9	2 – 5	1,1 – 2,9	2 – 4,9	2,1 - 4	10,1-25
C	9,1 – 14	5,1 –10,0	3 – 5	5 - 8	4,1 - 7	25,1 – 40
D	14,1 – 16,9	10,1 – 25	5,1 – 7,9	8,1 - 12	7,1 – 10	40,1 – 100
E	>17	> 25	>8	> 12	> 10	> 100
	as received	as received	as received	as received	as received	as received