Energy and Material Recovery from Wastes by Thermal Treatment in Fluidized Bed Systems

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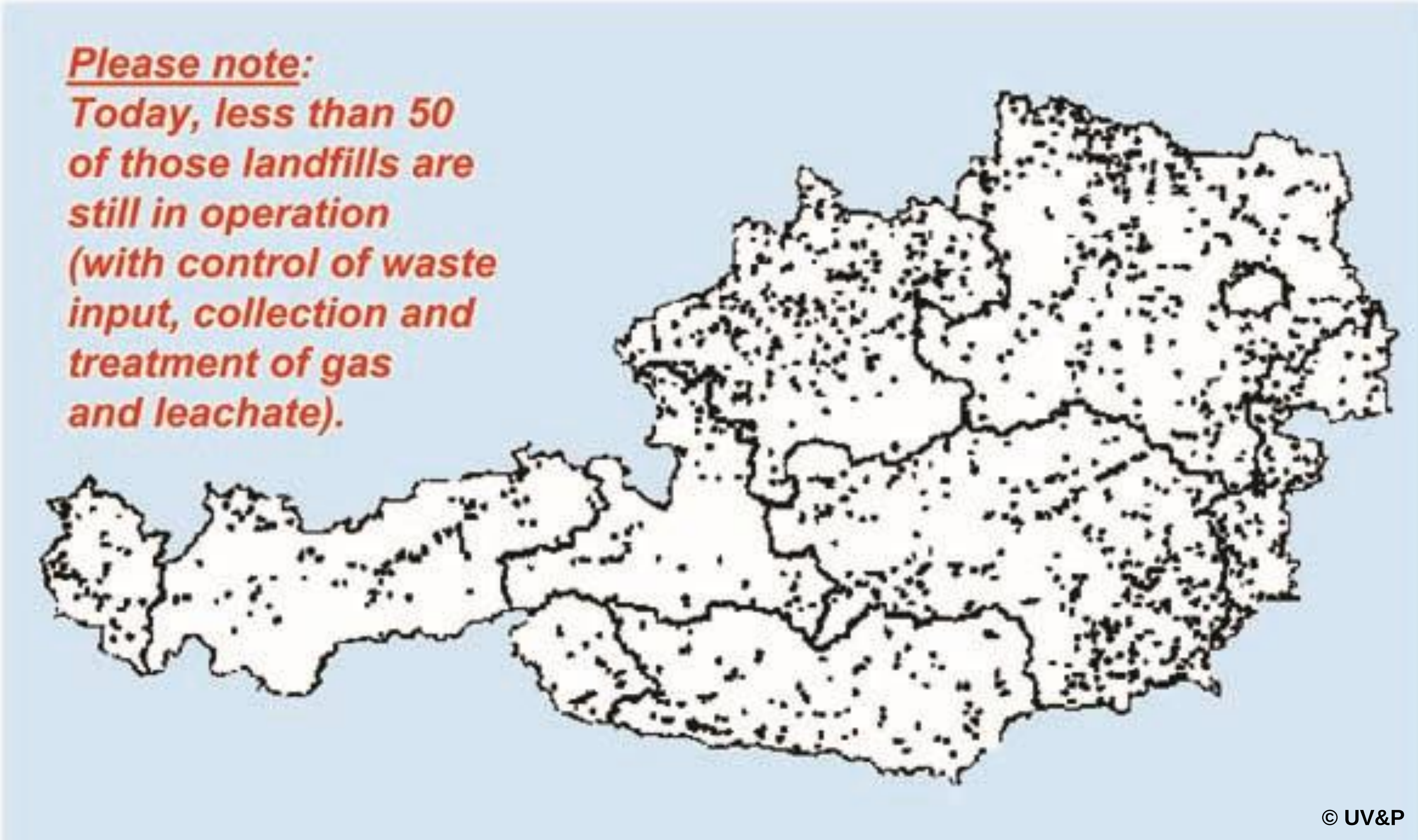
Keywords:

Energy & Material Recovery from Wastes by Thermal Treatment in Fluidized Bed Systems

Content of presentation:

- Development of Waste Management and Thermal Treatment of Wastes
- Technical Requirements – Mass and Energy Balances, "Zero-Emissions"
- Mechanical Processing and Recovery from Municipal Solid Wastes
- Recovery Inorganic Materials from Fluidized Bed Systems
- Intermediate Storage of Wastes for Future Recovery
- Conclusions & Recommendations

Historic View: Legally Registered Landfills in Austria in 1984 (approx. 1.800 Sites / 7 Mio. Inhabitants)

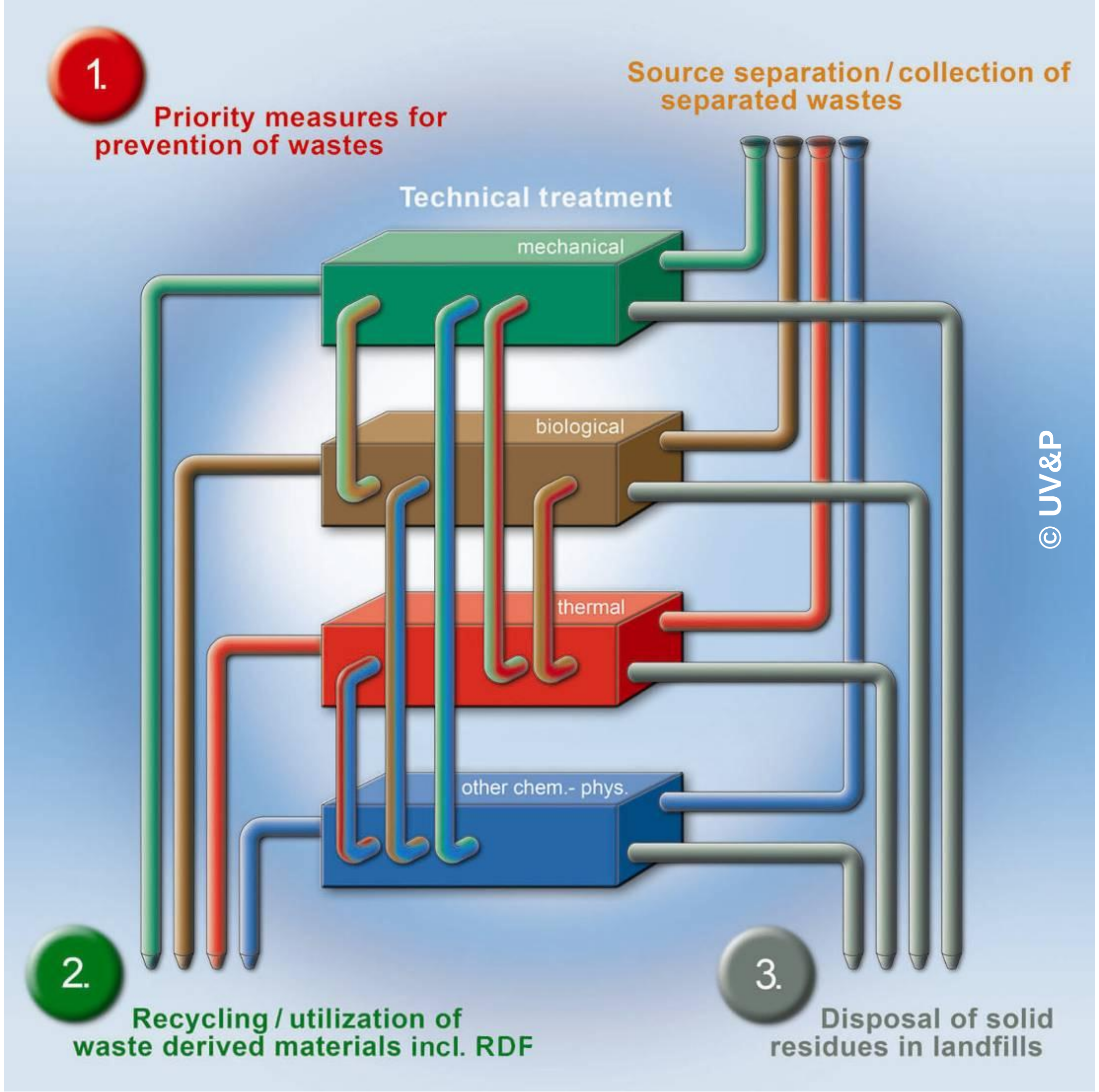


Municipal Waste incineration plants only in Vienna (Flötzersteig, Spittelau, Simmering) and Wels

Historic Development of Waste Management Policy and Legislation in Austria

Integrated waste management began in Austria about 30 years ago with increasing public awareness, environmental regulations and subsidies:

- Technical guidelines for control of waste dumps 1977
- Hazardous and Special Waste Management Act 1983
- Federal legislation on the Environmental Protection Fund, 1983
- Guidelines for waste management in Austria 1988
- Federal legislation on clean-up of landfills and contaminated sites, 1993 (including a disposal tax on landfill operations for clean-up activities)
- Ban on disposal of hazardous wastes in landfills (except of inorganic wastes encapsulated in closed salt formations) by July 2001
- Decree on landfills including the ban on disposal of wastes exceeding 5 % TOC (Total Organic Carbon) for new landfills by the beginning of 1997 and limitation for existing landfills until beginning of 2004 (limited legal exemptions until end of 2008, and limited exemptions for stabilized residues from MBT Mechanical Biological Treatment).



Different technologies are needed for specific wastes in an integrated treatment system, also taking into consideration specific regional conditions.

Successful project design must be based on the 1st and 2nd Law of Thermodynamics!

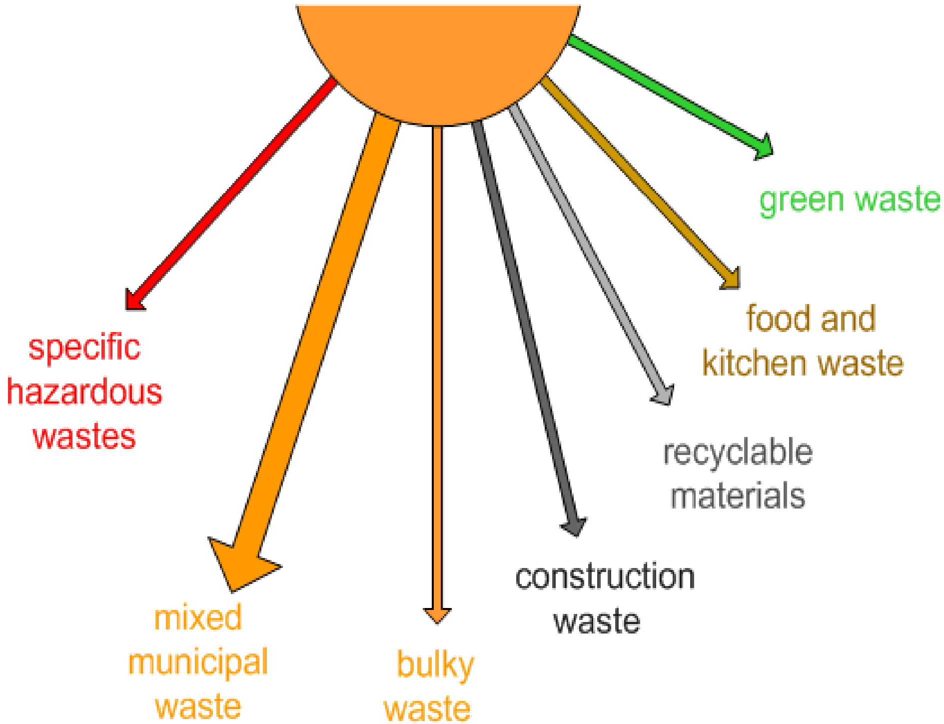
Our project designs are profitable for our clients and protect the environment.

(UV&P, since 1991)

www.uvp.at

Source Separation & Separate Collection of Municipal Wastes for Recovery of Materials and Energy

Separated collection of

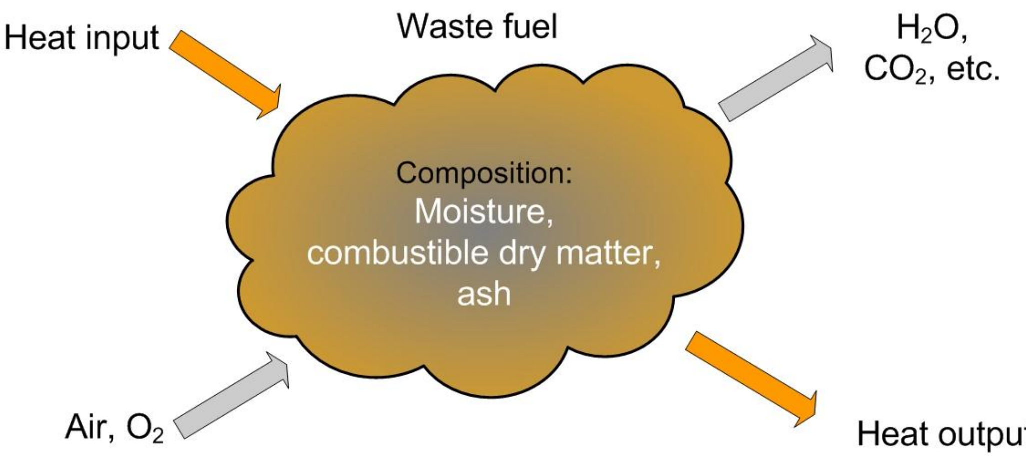


Separate collection and recycling must be complemented by waste-to-energy

Type of waste fraction	Incineration in % weight	Comments
Paper, Cardboard	approx. 5 – 15	Sorting and processing
Plastics, Composites	approx. 30 – 70	„Plastic Packaging Bag“, „Oekobox“
Packaging glass, Laminated glass	approx. 2 – 10	Plastics, Composite films
Construction waste	approx. 10 – 40	Wood, shavings, plastic pipes, foils, packaging, carpeting
Biological waste	approx. 5 – 10	Plastics, non-biodegradable materials
Bulky waste, scrap tires	approx. 70 – 90	without metals and recyclable fractions
Non-recyclable garbage	approx. 45 – 98	without metals, due to biological processes (MBT)

The Process of Incineration: Drying, Degasification, Gasification, Combustion

Mass- and heat transfer



1 Drying

2 De-gasification (pyrolysis)

3 Gasification of carbon:

$C + CO_2 \rightarrow 2\,CO$

$C + H_2O \rightarrow H_2 + CO$

$2\,C + O_2 \rightarrow 2\,CO$

4 Oxidation of gases at high temperature:

$2\,CO + O_2 \rightarrow 2\,CO_2$

$2\,H_2 + O_2 \rightarrow 2\,H_2O$

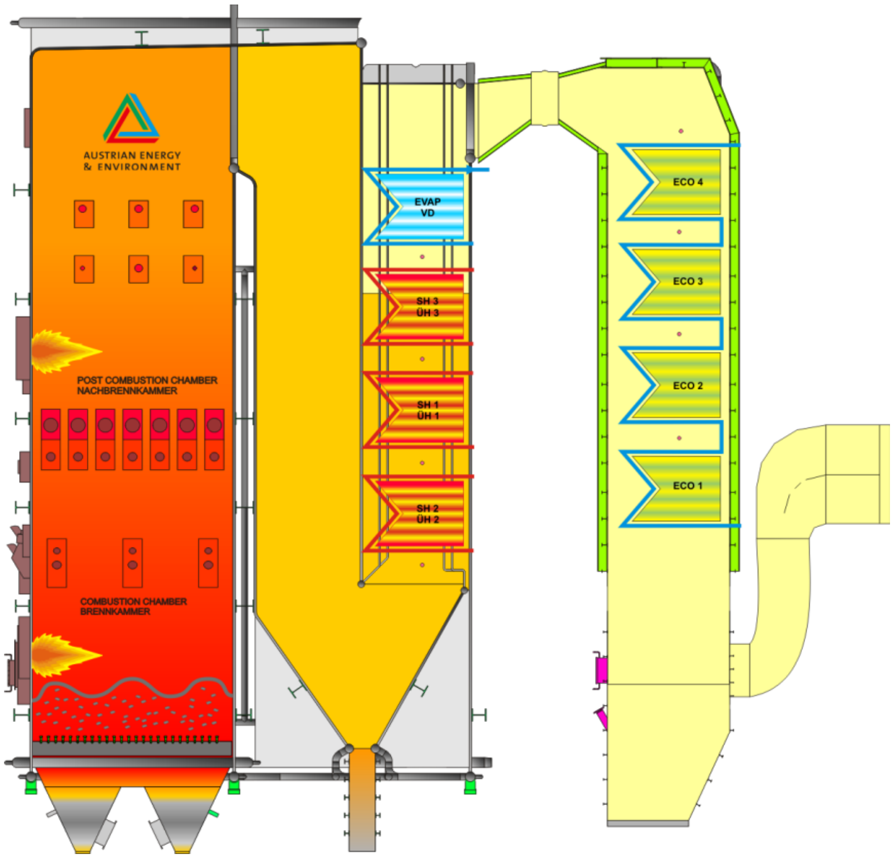
"3 T" – Criteria for controlled combustion:

Turbulence + Temperature + Time

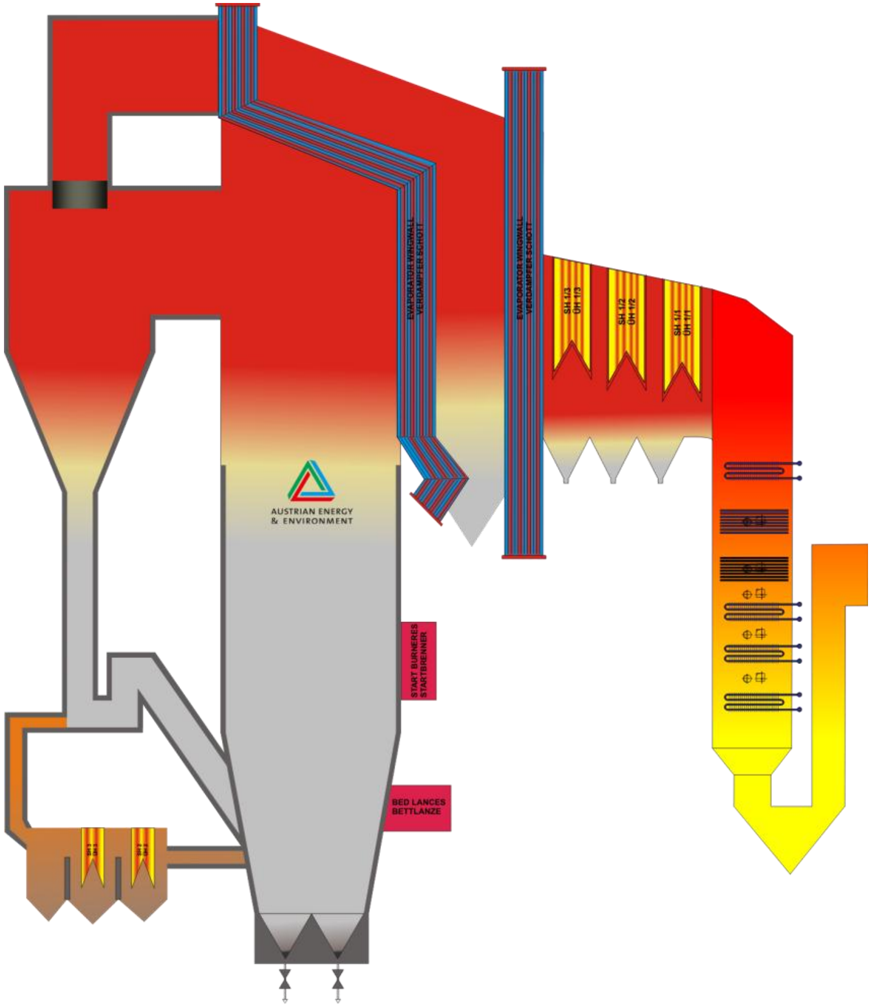
+ complete burn-out of ashes (TOC << 3%)

Examples of Fluidized Bed Systems for Thermal Waste Treatment

Bubbling Fluidized Bed "MULTIFUEL DESIGN"



Circulating Fluidized Bed "MULTIFUEL DESIGN"



Source: Austrian Energy & Environment AG (now ANDRITZ)

Allocation of Specific Wastes to Incineration Technologies

Type of waste	Incineration technology		
	Grate	Fluidized-bed	Rotary kiln
Residual municipal solid waste	well suited	pre-treatment required	suitable
Sewage sludge	limited in terms of quantity	well suited	suitable
Screening wastes from sewage	suitable	pre-tratment required	limited suitability
Shredded plastic wastes	limited in terms of quantity	well suited	limited suitability
Scrap tires	limited suitability	unsuitable	limited suitability
Shredder wastes (from scrap recycling)	limited in terms of quantity	well suited	limited suitability
Shredded waste wood	well suited	well suited	suitable
Lacquer and paint sludge	unsuitable	suitable	suitable
Hazardous wastes in small containers (e.g. laboratory waste)	limited suitability	unsuitable	suitable

Large Waste Incineration Facilities in Austria 2012

Austria (approx. 8 Mio. people)

USA (approx. 308 Mio. people)

Large facilites for thermal treatment of waste in Austria:

- **16 fluidized bed incinerators**
- **14 grate systems**
- **3 rotary kilns (for hazardous wastes)**
- **9 cement kilns with co-firing of waste fuels**

Subtotal: 42 facilities in operation

Planned projects:

- **4 fluidized bed incinerators**
- **1 grate system**

Subtotal: 5 facilities planned

Total: 47 large waste incineration facilities in Austria

Fundamentals: 1st and 2nd Law of Thermodynamics!

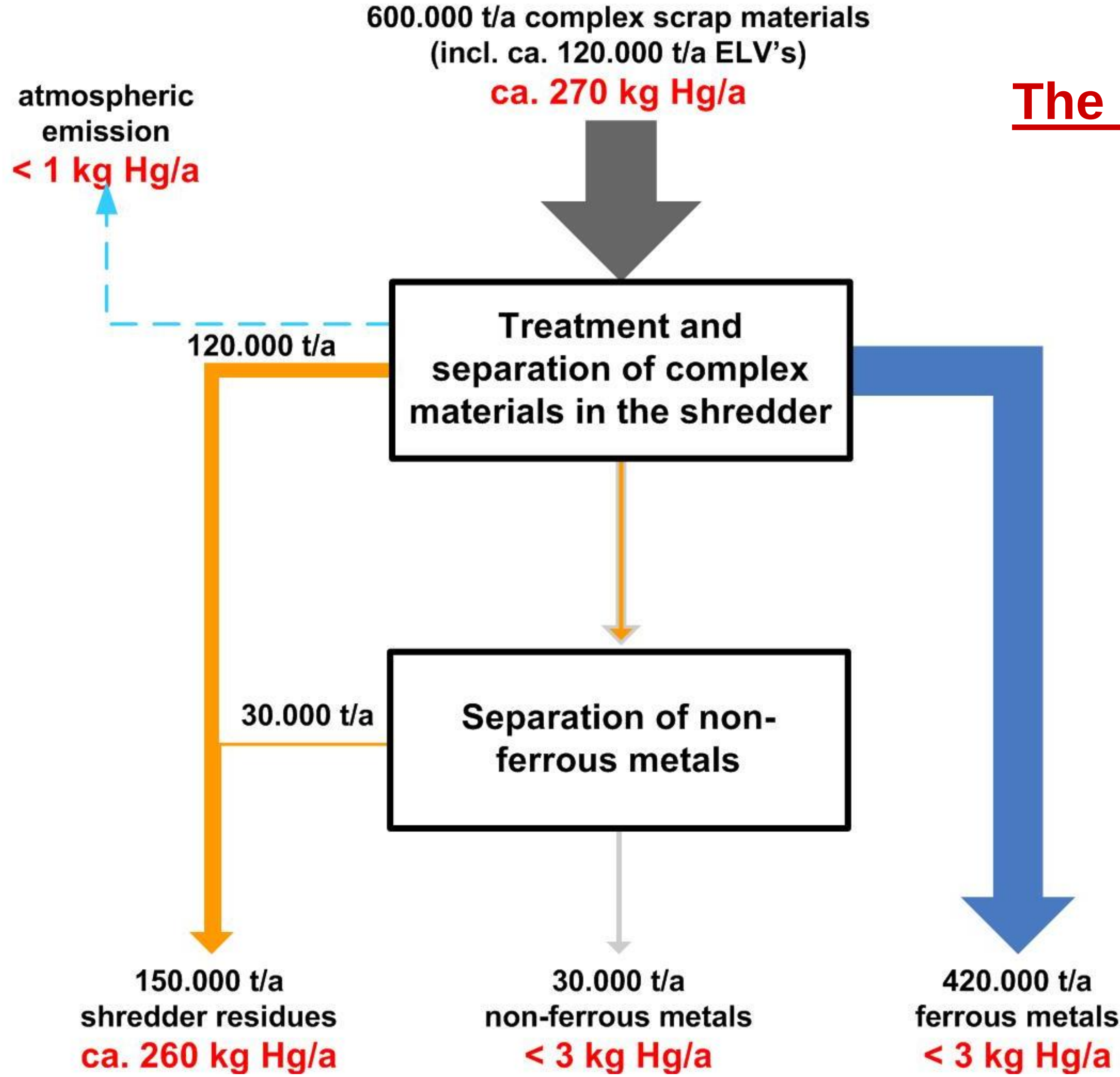
Austrian Standard ÖNORM S 2108-1 (2006-05-01)

Thermal Treatment of Wastes - Part 1

Requirements and boundary conditions:

- Overall mass balances / emissions at minimum for **S, Cl, F, Cr, Cd, Hg**; which is fundamental for treatment of flue-gas and options for recovery and treatment of residues
- Necessary flue-gas treatment (for different wastes according to waste code), i.e. **fine particulate matter, SO_x, Halogens, POPs, Hg, NO_x**
- Suggestion for utilization of specific waste in industrial production **processes** (e.g. main burner cement clinker kiln)
- Suggestions for **recovery of (inorganic) material** from thermal treatment process (e.g., recovery of metals from shredder residues)

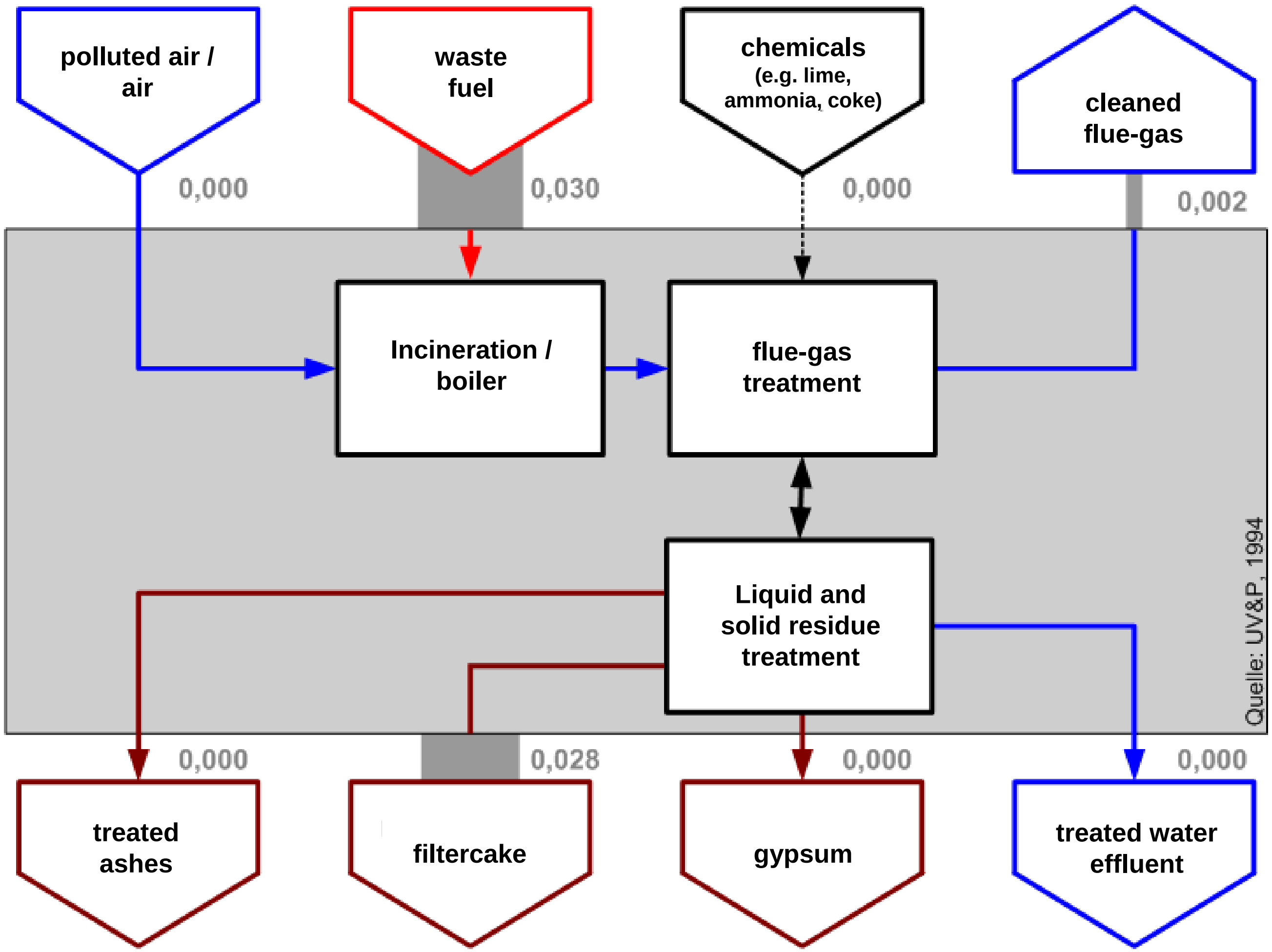
Example: Material Balance for Scrap Processing
Mass Balance for Mercury (Sweden, 2001)



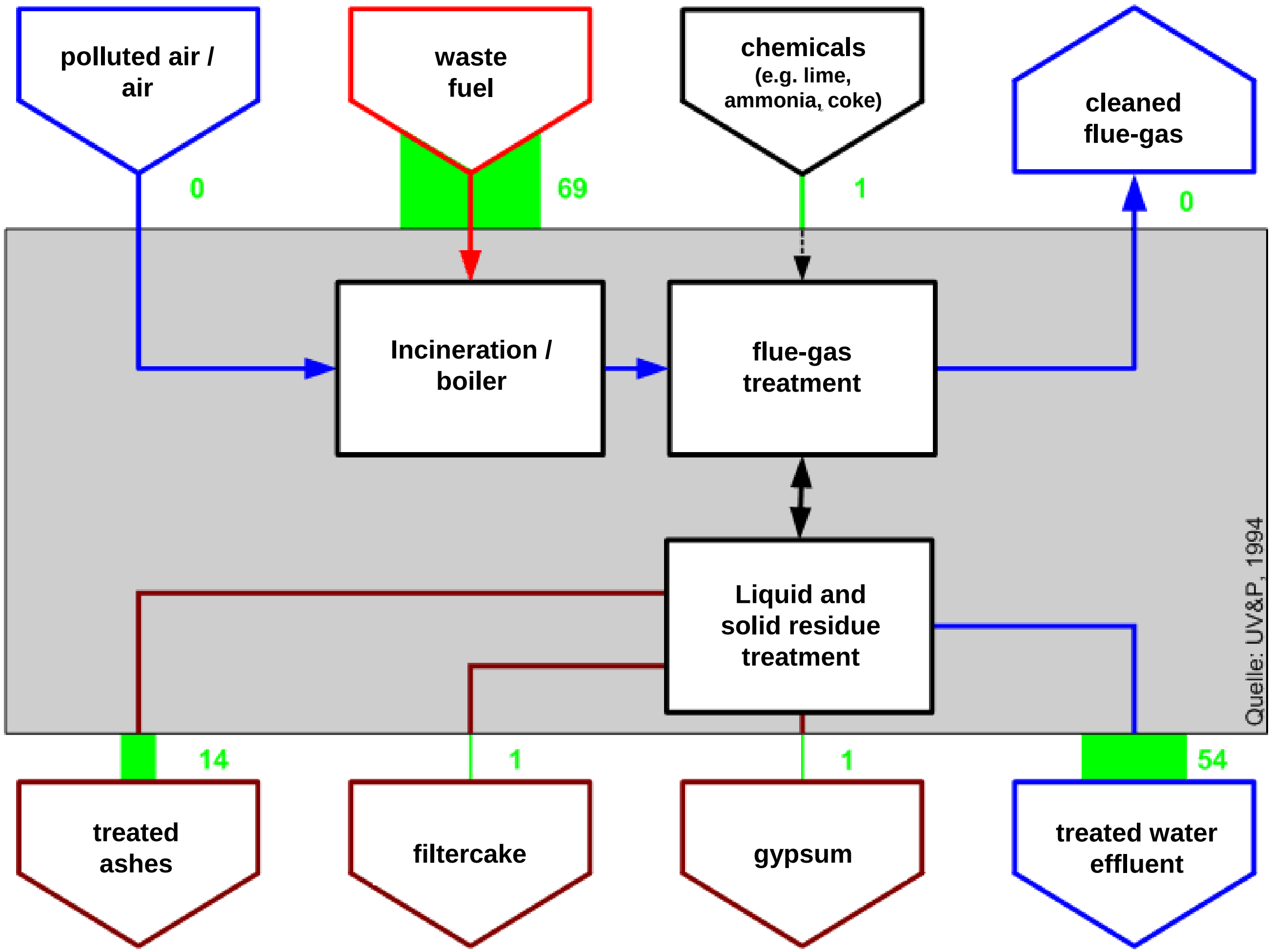
The shredder process ensures:

- Product quality in steel recycling (minimization of Cu influx, etc.)
- Recycling of non-ferrous metals, e.g. Cu, Al, Mg, Ag
- Minimization of hazardous air pollution from the pyro-metallurgical recycling processes (e.g. emissions of POPs and other hazard. organic substances, and of heavy metals such as Cd and Hg).

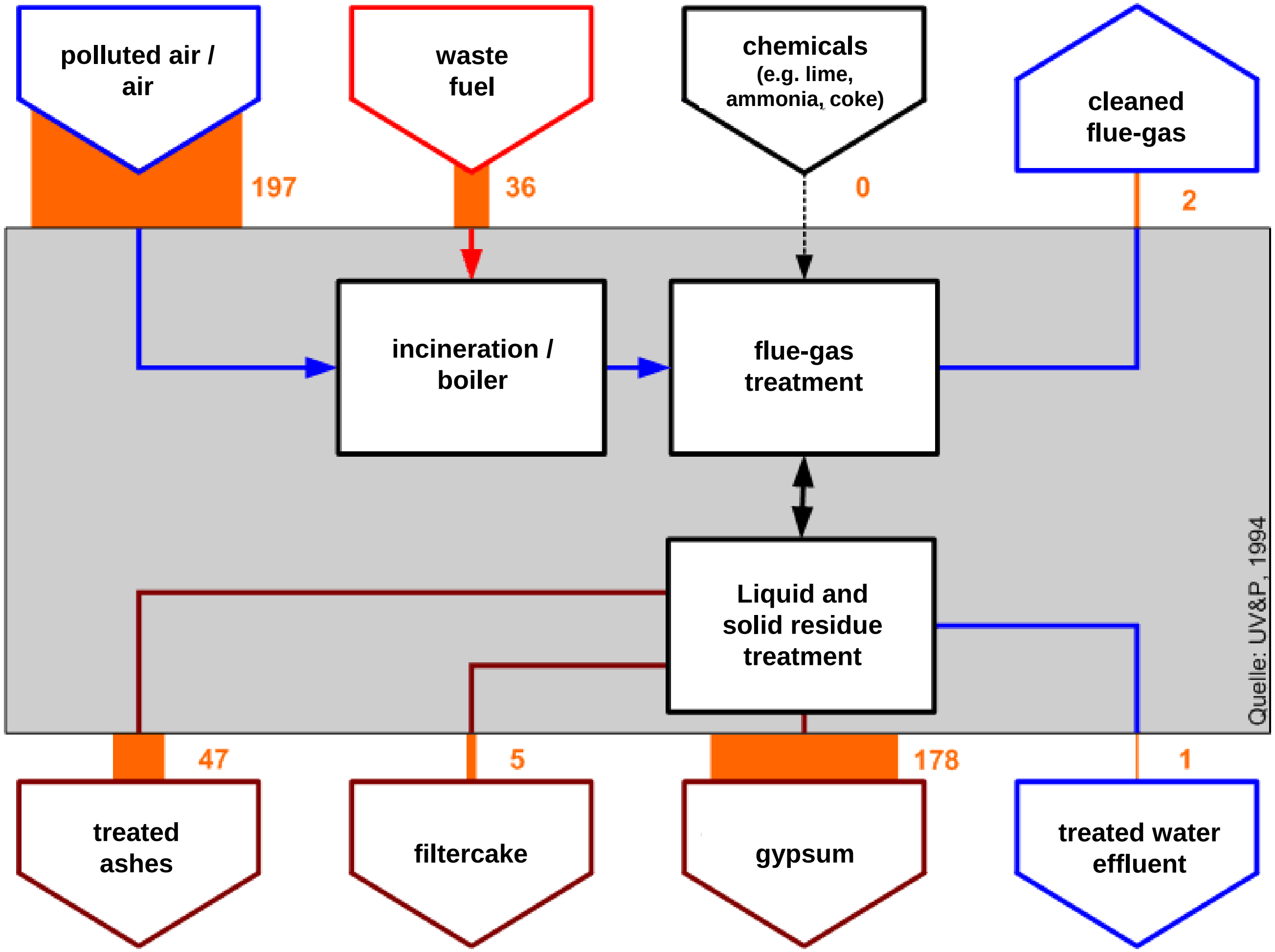
Example for Overall Balance of Hg in a Waste-to-Energy Plant [Numbers for Hg in kg / h]



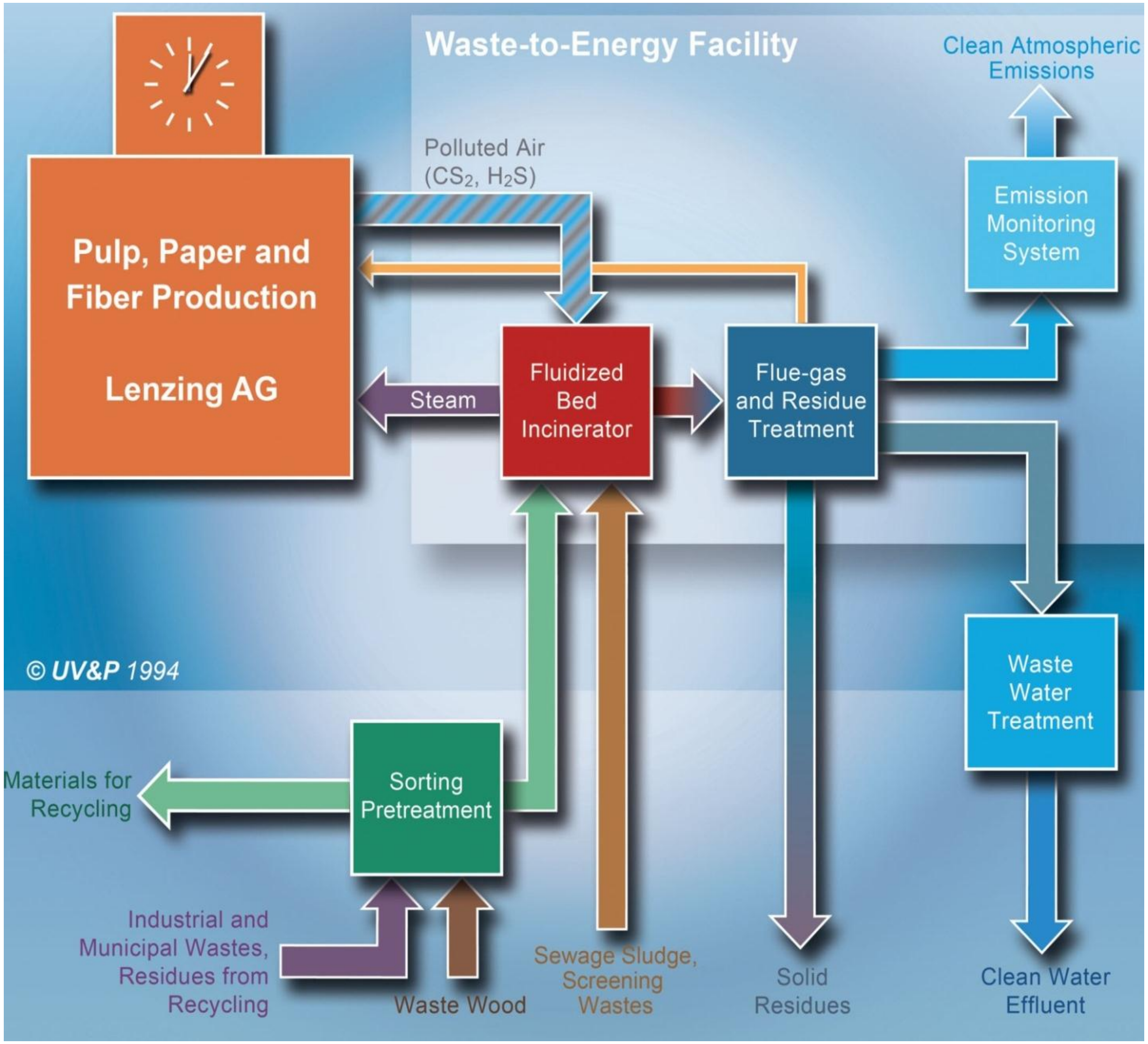
Example for Overall Balance of Cl in a Waste-to-Energy Plant [Numbers for Cl in kg / h]



Example for Overall Balance of S in a Waste-to-Energy Plant [Numbers for S in kg / h]



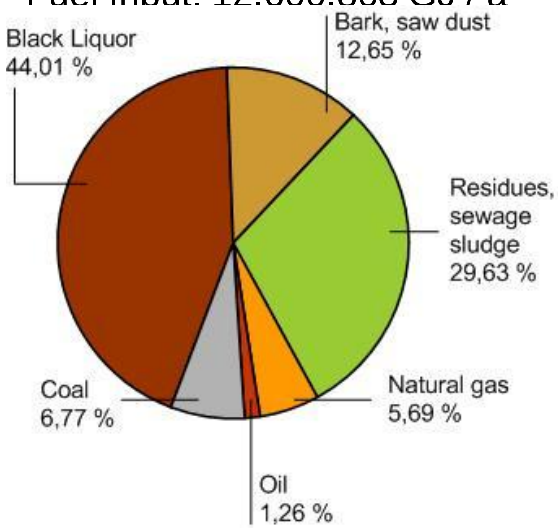
Example for Integrated Waste-to-Energy in Industrial Production: RVL Lenzing, Upper Austria



Planning (UV&P):	**1993/94**
Start Up:	**1998**
Technology:	**Fluidized bed**
Fuel capacity:	**110 MW**
	(approx. 400 mmBtu)
Steam production:	***285.000 lb/h***
	(1160 Psi, 930°F)
Waste throughput:	***up to 1.100 tons / d***

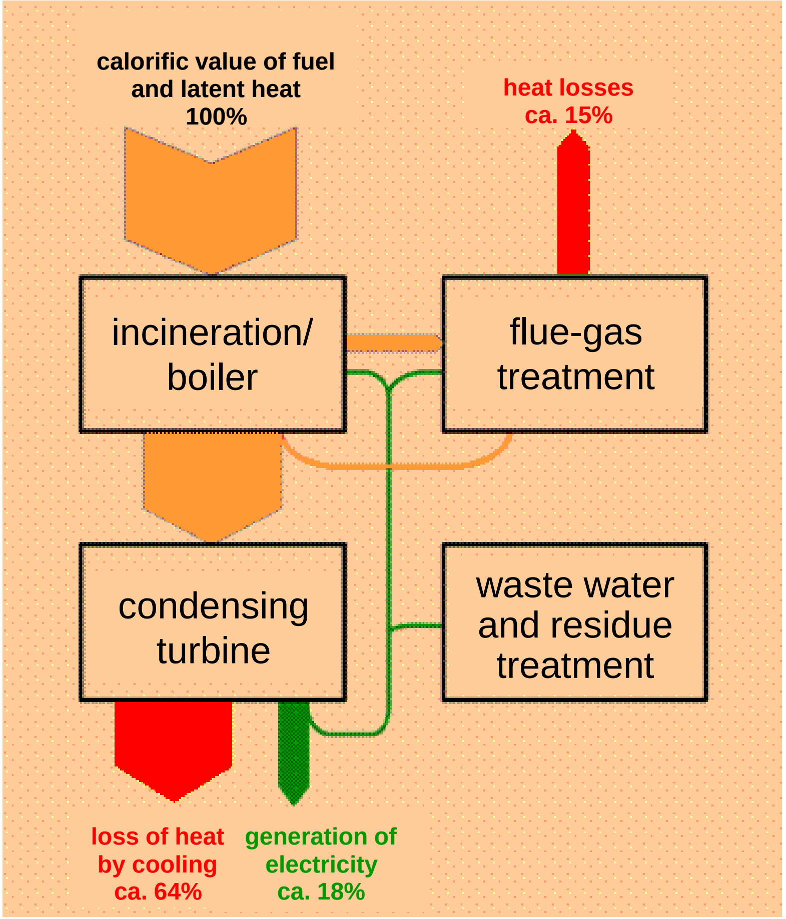
Fuel Mix in 2007 at Lenzing AG:

Fuel Input: 12.600.863 GJ / a



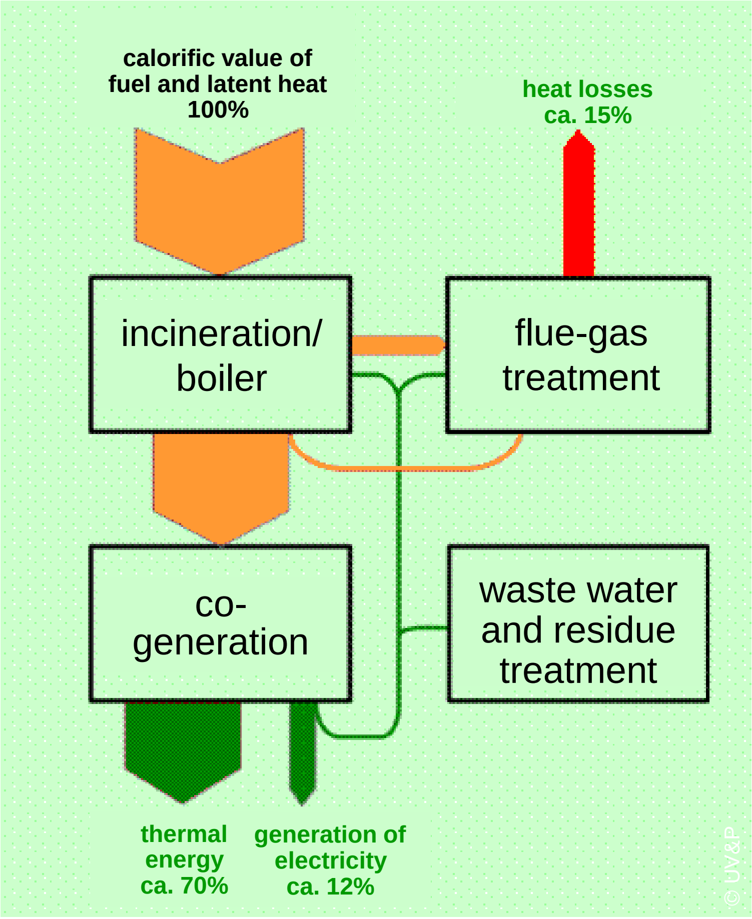
Site-specific Options for Utilization of Energy - Selection of Sites

Condensing Turbine (electricity only)



Energy utilization approx. 20 %

Co-Generation (electricity + heat)



Energy utilization approx. 80 %

Industrial Site of Lenzing in Salzkammergut, Upper Austria

The waste-to-energy plant RVL is integrated in the industrial site of Lenzing Austria – with advanced environmental technology to protect the natural environment in the famous tourist region around Lake Attersee.

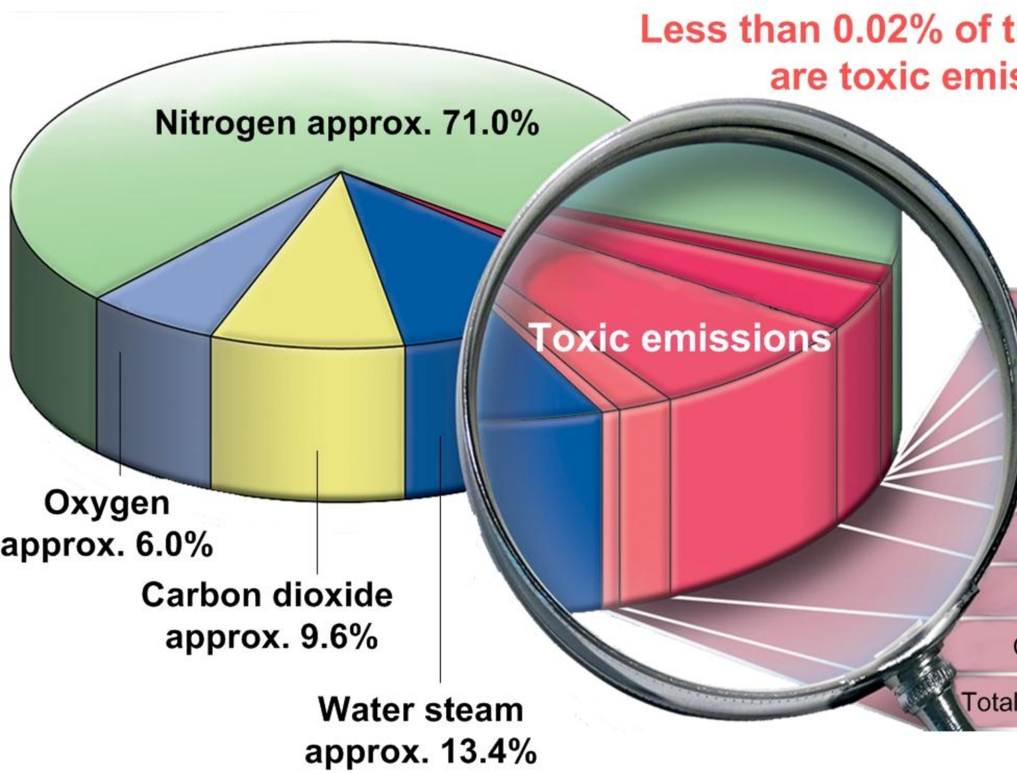
The 3 arguments:

1. Energy demand

2. Reduction of odour

3. No landfilling

Control of Cleaned Flue-Gas from Waste Incineration (Example: RVL Lenzing, in operation since 1998)



Comparison of emission limits: Figures in mg/Nm^3 (11 % O_2, dry)

	EU-Directive 2000/76	AVV BGBl. 389/2002	RVL Lenzing Project 1994	RVL Lenzing Measured values 2002
Particulates	10	10	8	0.6
Mercury Hg	0.05	0.05	0.05	0.007
Hydrogen chloride HCl	10	10	7	0.8
Hydrogen fluoride HF	1	0.7	0.3	0.02
Sulfur dioxide SO_2	50	50	50	4.1
Nitrogen oxides NO_X	400	100*)	70	41.6
Carbon monoxide CO	100	100	50	2.3
Total organic carbon TOC	10	10	8	0.6

* if > 6 tons waste per hour

Development of Emissions from Thermal Waste Treatment

Atmospheric Emissions for thermal waste treatment in Austria and Switzerland:

Values given in mg/m^3_N (11% O_2, dry; for PCCD/F in ng/m³)

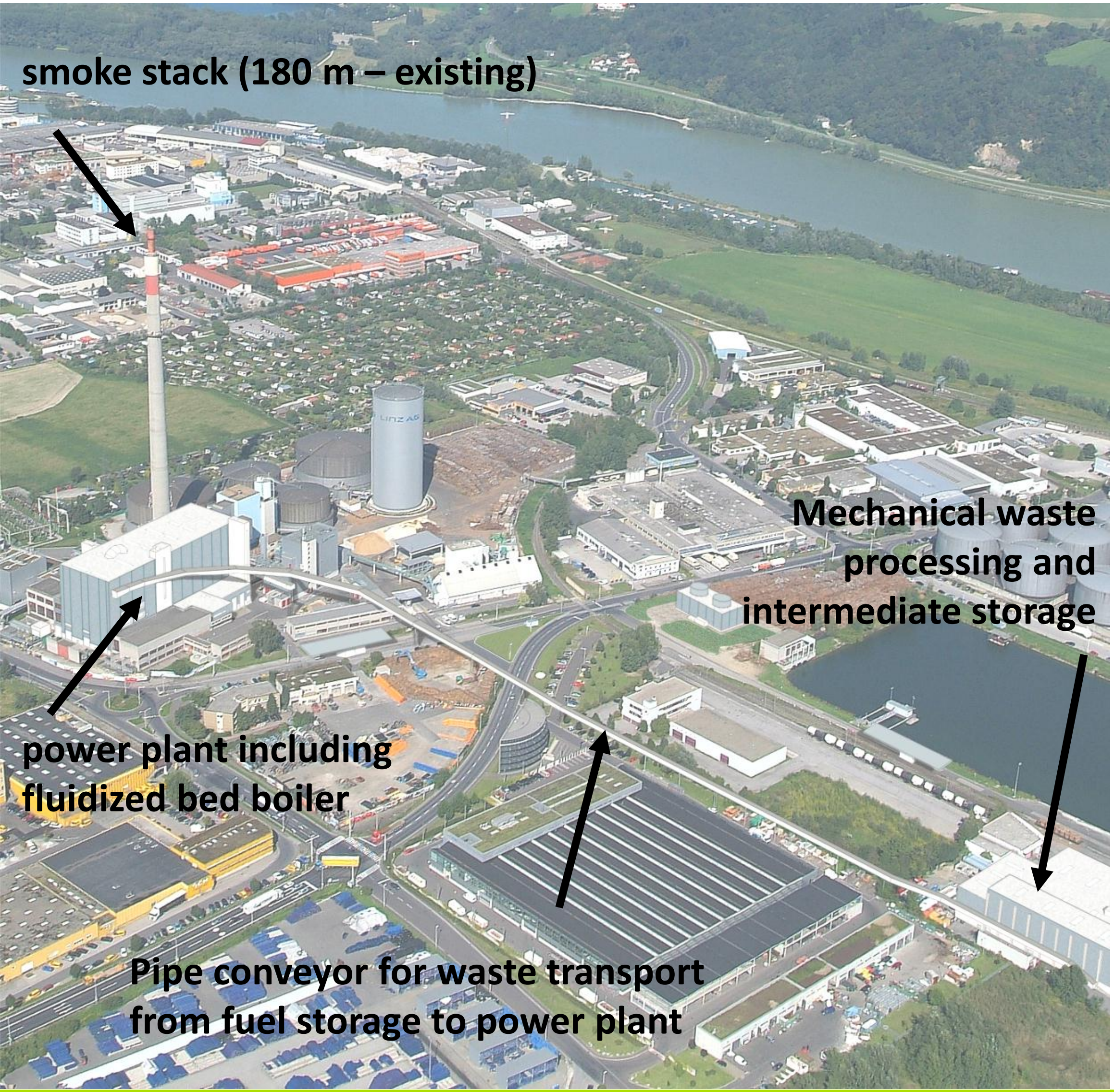
	Dust	Cd	HCl	SO_2	NO_x	Hg	PCDD/F*
1970	**100**	**0,2**	**1.000**	**500**	**300**	**0,5**	**50**
1980	**50**	**0,1**	**100**	**100**	**300**	**0,2**	**20**
1990	**1**	**0,005**	**5**	**20**	**100**	**0,01**	**0,05**
2000	**1**	**0,001**	**1**	**5**	**40**	**0,005**	**0,05**

Source: Vogg (values for 1970 - 1990); RVL (values for 2000)

Legal Emission Standards 1994 in Austria compared to September 2011 Emission Guidelines for MSW in British Columbia:
(Bold numbers for ½-Hour Average, *cursive numbers for Daily Average values*)**:**

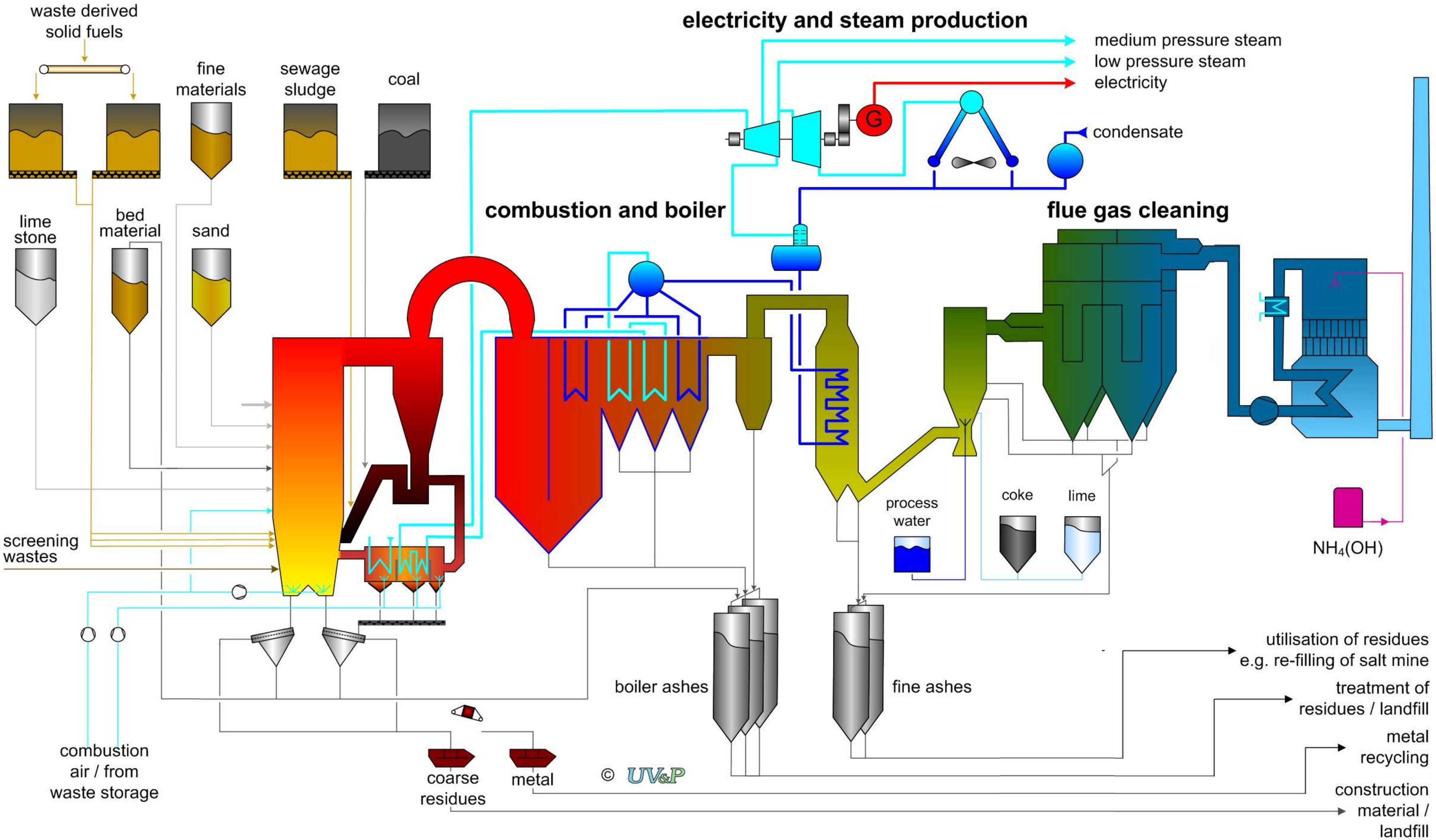
AT 1994	**8**	**0,05**	**7**	**50**	**70**	**0,05**	**0,1**
BC 2011	**9**	**0,007**	*10*	*50*	*190*	*0,02*	**0,08**

Example RHKW Residual Waste Heat and Power Plant Linz: Co-Generation Project based on Waste Derived Fuel



Planning (UV&P):	2006/07
Start Up:	2011
Technology:	Fluidized bed
Fuel capacity:	66 MW *(approx. 250 mmBtu)*
Efficiency:	ca. 80 % (co-generation)
Steam production:	*170,000 lb/h (610 psig, 760°F)*
Average waste throughput:	up to 880 tons / d
Fuels:	Municipal and commercial waste, sewage sludge, screening wastes, shredder residues

Example for a Fluidized Bed System and for an effluent-free flue gas cleaning



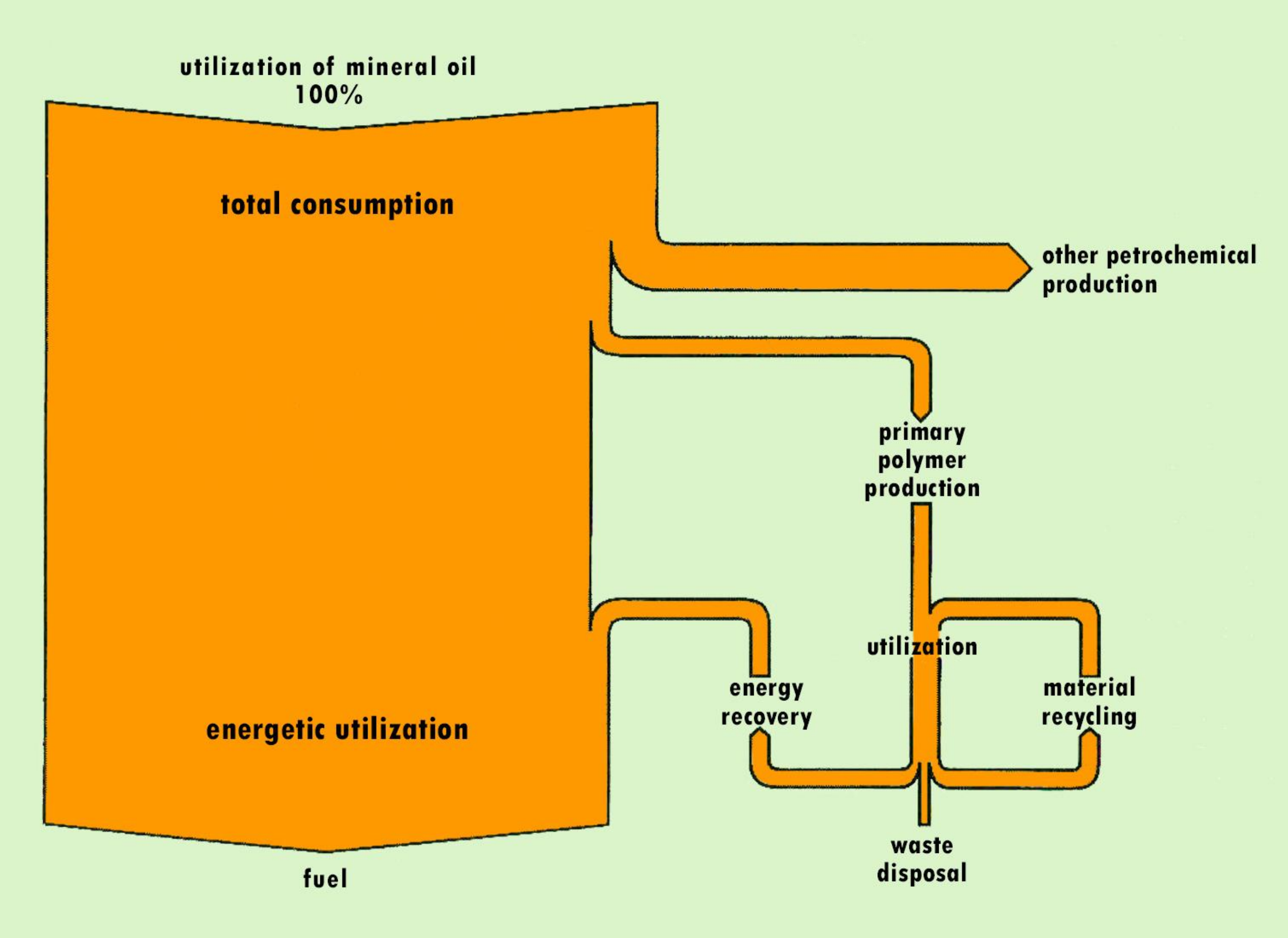
Complete „Burn-out“ of Solid Residues from Combustion in a Fluidized Bed - Ideal for Material Recovery!

Material Recovery:

Residues from Waste Incineration in a Fluidized Bed

Source: Panowitz / Metran

Efficient Use of Non-renewable Resources
Example Mineral Oil

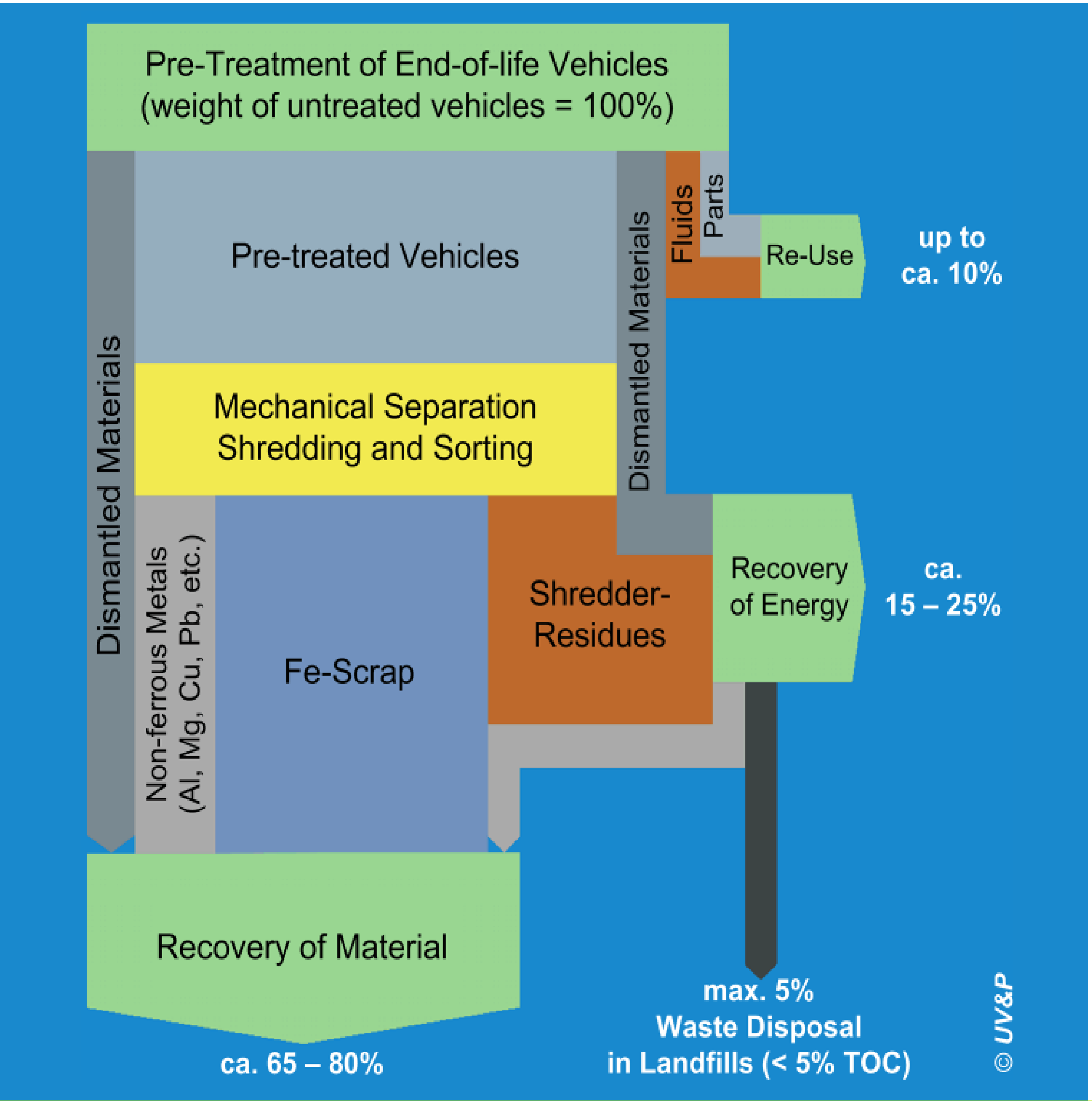


More efficient use of crude oil for production of valuable materials, including recycling and recovery of energy from waste

100 kg difference in weight of vehicle may change fuel consumption by 0,3 l / 100 km

Zero disposal! (despite Landfill Directive 1999/31/EC)

Treatment of End-of-life Products: e.g. Vehicles (Directive 2000/53/EC)



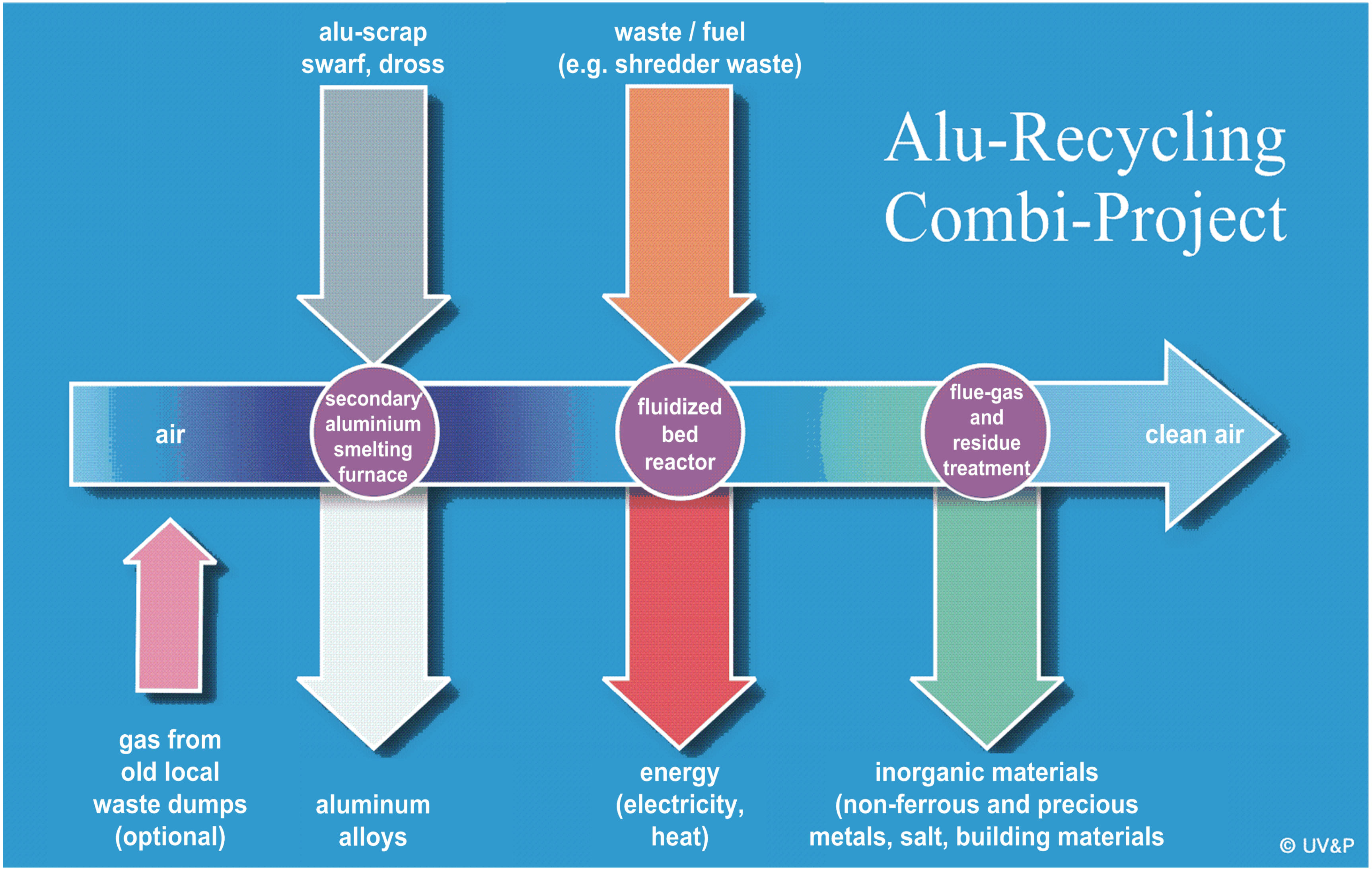
EU environmental policy:
Increasingly oriented towards mandatory requirements for take-back of all sorts of specific products by the producers (referred to as "producer's responsibility").

End-of-life vehicles (Austria):

1. Reuse of parts in (approx. 4.000) automobile workshops and do-it-yourself activities
2. Pre-treatment to recover hazardous and special materials (approx. 200 sites)
3. Mechanical shredding and material separation (6 sites)
4. Treatment of shredder residues for recovery (6+2+18)

EU Target for 2015:
95% recovery (by weight!)

Example for Integrated Technology: The „Missing Link“ towards 100% Recovery - Metal-Recycling Combi-Project (Patented 1991)



Transport Routes of various „End-of-Life Products " and Scrap

Examples for Questionable Thermal Waste Treatment
(Source of pictures: SPIEGEL TV MAGAZIN)

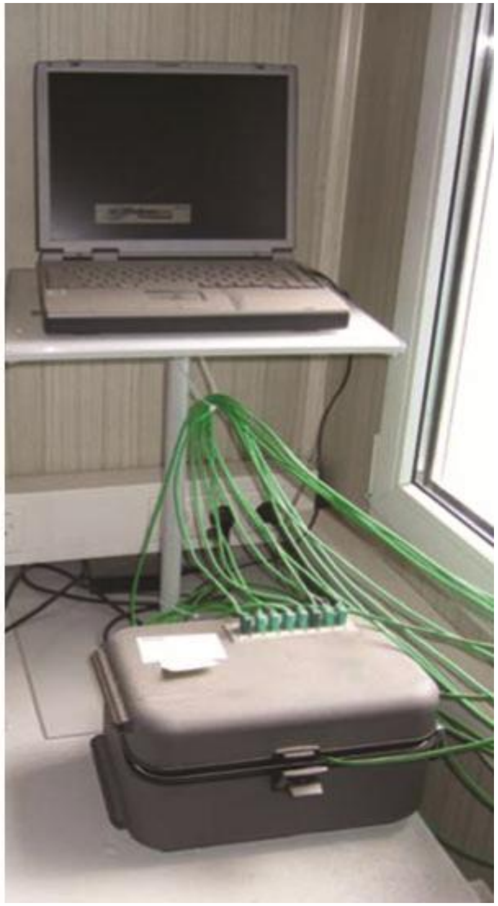
Example Ghana, near Accra:
Scrap and cable treatment

Example for State-of-the-Art Intermediate Storage of Wastes in Plastic-wrapped Bales: Thermal Capacity (MW) = (MJ/kg)*(kg/s)

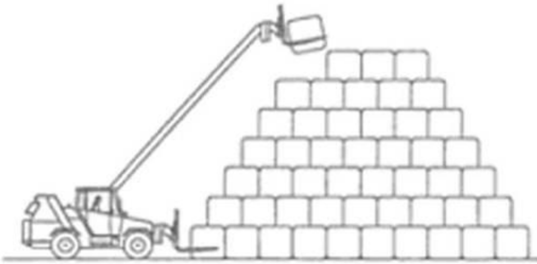
Foto: W. Kletzmayr, 2006

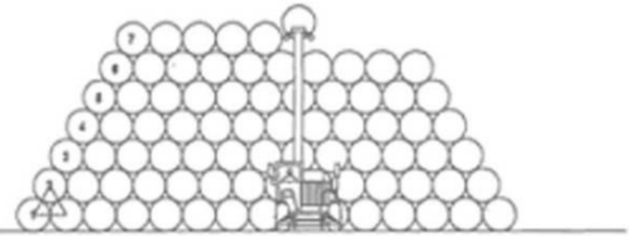
Calorific value of 1 bale of waste equals 2 to 3 barrels of crude oil.

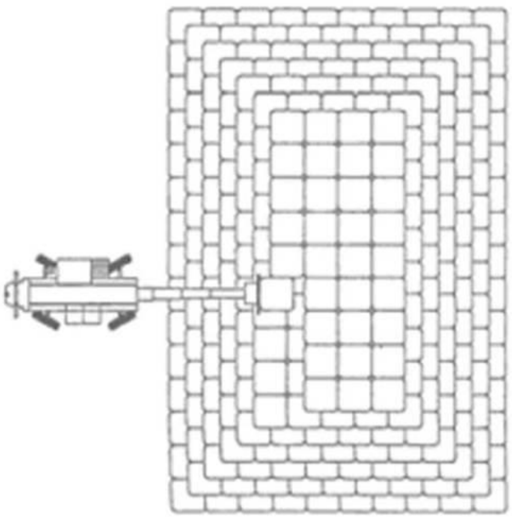
Temperature Monitoring for Plastic-wrapped Bales with Shredder Residues from Scrap Processing

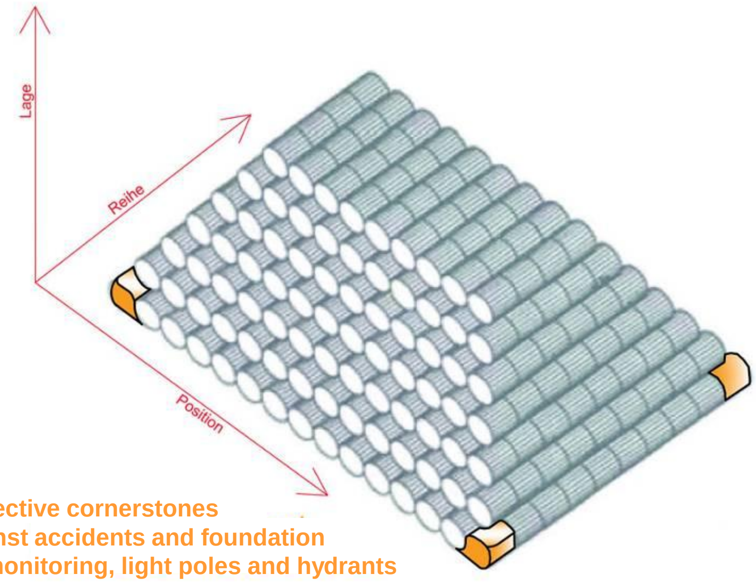


System for Safe and Clean Storage of Waste-Derived Fuel (Patent PCT/EP2009/058157, PCT/EP2009/050238)









State-of-the-art: cylindrical bales with approx. 1,2 m diameter and 1,2 m height
Capacity per packing machine approx. 30 bales/h, 3.000 to 4.000 h/a => ca. 60.000 to 120.000 t/a
Storage quantity dependent on height of pile and density of waste: up to 60.000 t/ha storage area

Conclusions and Recommendations

- Sustainable waste management requires **different** technologies integrated in an overall waste treatment infrastructure; - including also fluidized bed systems
- **Fluidized bed systems** (with competent design and operation) are proven technologies for co-combustion of wastes with coal and biomass, as well as **for energy and material recovery** from different **specific** wastes (e.g. shredder residues from scrap processing)
- In specific cases **recovery of energy from waste** can be more **resource efficient** than recycling by recovery of materials - e.g. by factor 4 when comparing saving in natural gas (which could also be used for synthesis of methanol) by the fluidized bed waste-to-energy boiler in Lenzing to a high-pressure gasification of the same quantity of wastes with recovery of methanol according to practice in East-Germany
- Improvement in energy recovery and resource efficiency will require thermal treatment in **fluidized bed systems for specific wastes** (e.g. residues from shredder processes for end-of-life vehicles and WEEE wastes)
- Intermediate **storage** of wastes for future recovery should be considered, also because it is economically profitable by securing **just-in-time supply** (with consideration of shut-down times for maintenance and repairs and possible delays in start-up of additional new capacities)
- Unproven (sometimes "**miraculous**") technologies should be viewed with **caution** and must be carefully evaluated and compared to efficiency based on state-of-the-art.

Thank you !
Comments & Questions ?

Think Globally • Act Locally

Precaution against New & “Miraculous“ Technologies

The technical concept should be based on:

- **State-of-the-art technology (BAT) for such type of waste**
- **Prove of successful technical operation of a similar type and size of facility (e.g. > 80% of requested thermal capacity) over a minimum period of 3 years**

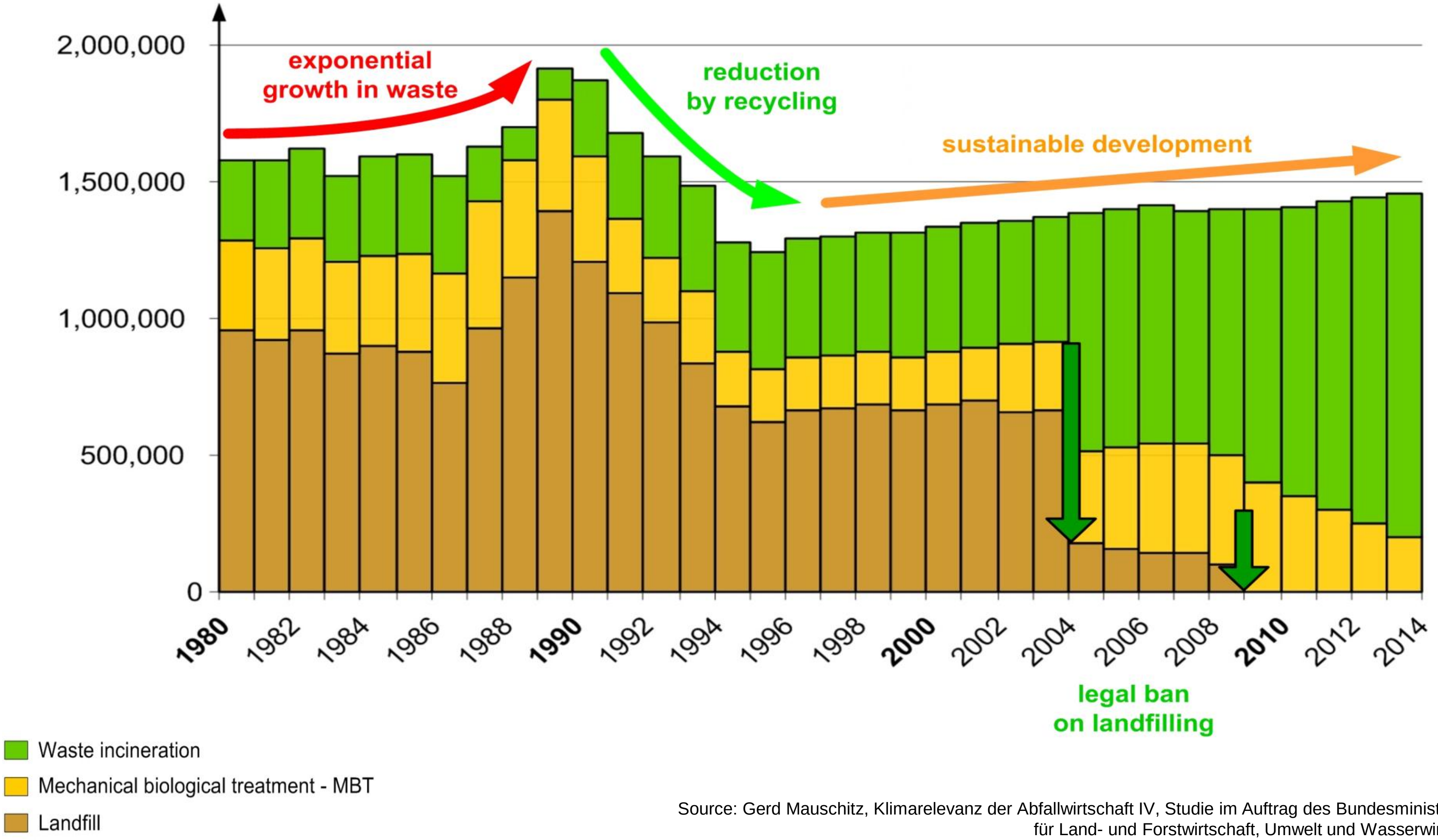
The financial risks for installation of un-proven technology are significant and have to be legally well-defined and financially secured.

The following scenarios must be considered:

1. **Costs for immediate upgrading in case of insufficient performance**
2. **Costs for installation of a system according to state-of-the-art in case of a continuous failure**
3. **Costs for alternative treatment of waste during incomplete or malfunctioning of the overall system.**

Treatment Methods for Residual Municipal Solid Waste Development from 1980 to 2013 in Austria

Figures expressed in tons per year

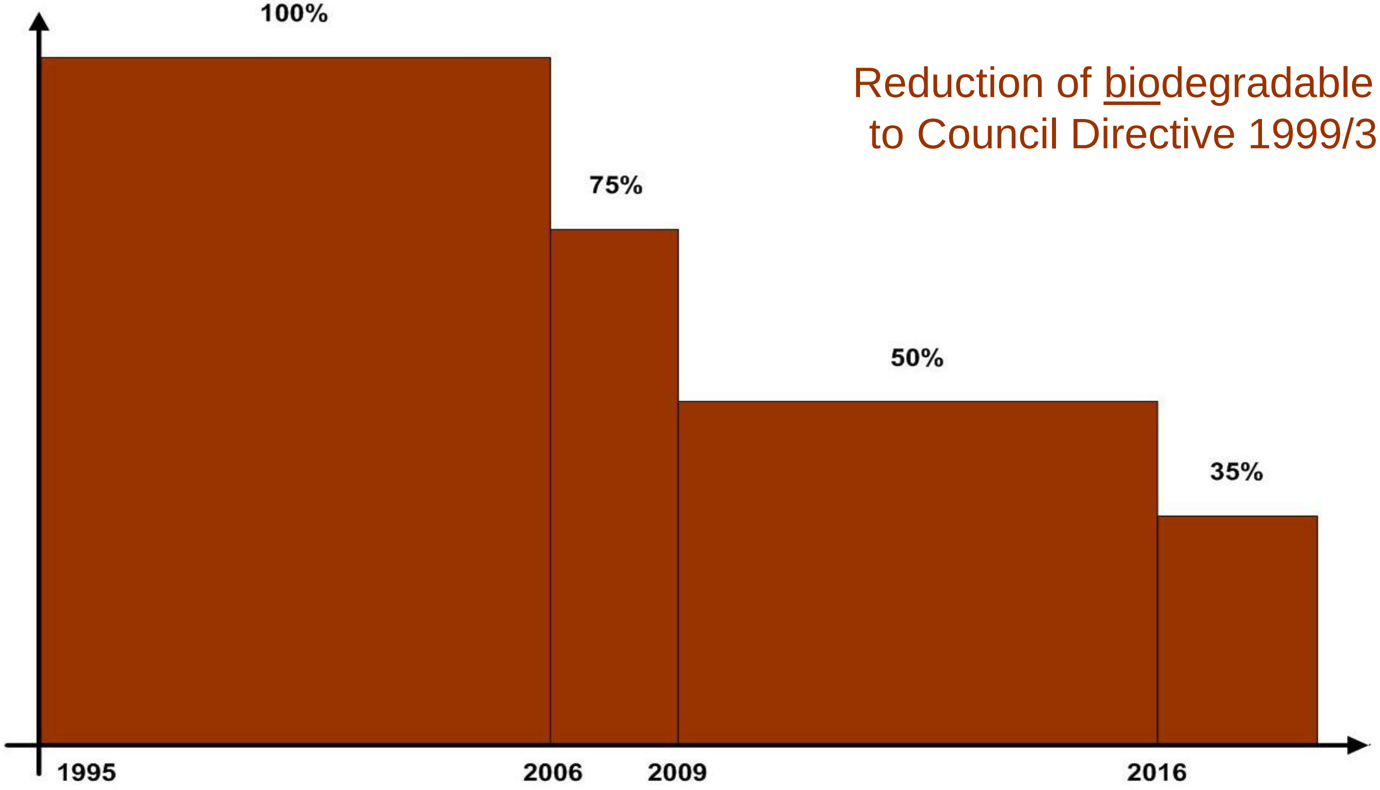


Source: Gerd Mauschitz, Klimarelevanz der Abfallwirtschaft IV, Studie im Auftrag des Bundesministeriums für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft

EU - Limitation for Waste Disposal in Landfills

DIRECTIVE 2008/98/EC of 19 November 2008 on waste:

… that waste prevention should be the first priority of waste management, and that re-use and material recycling should be preferred to energy recovery from waste, where and insofar as they are the best ecological options.

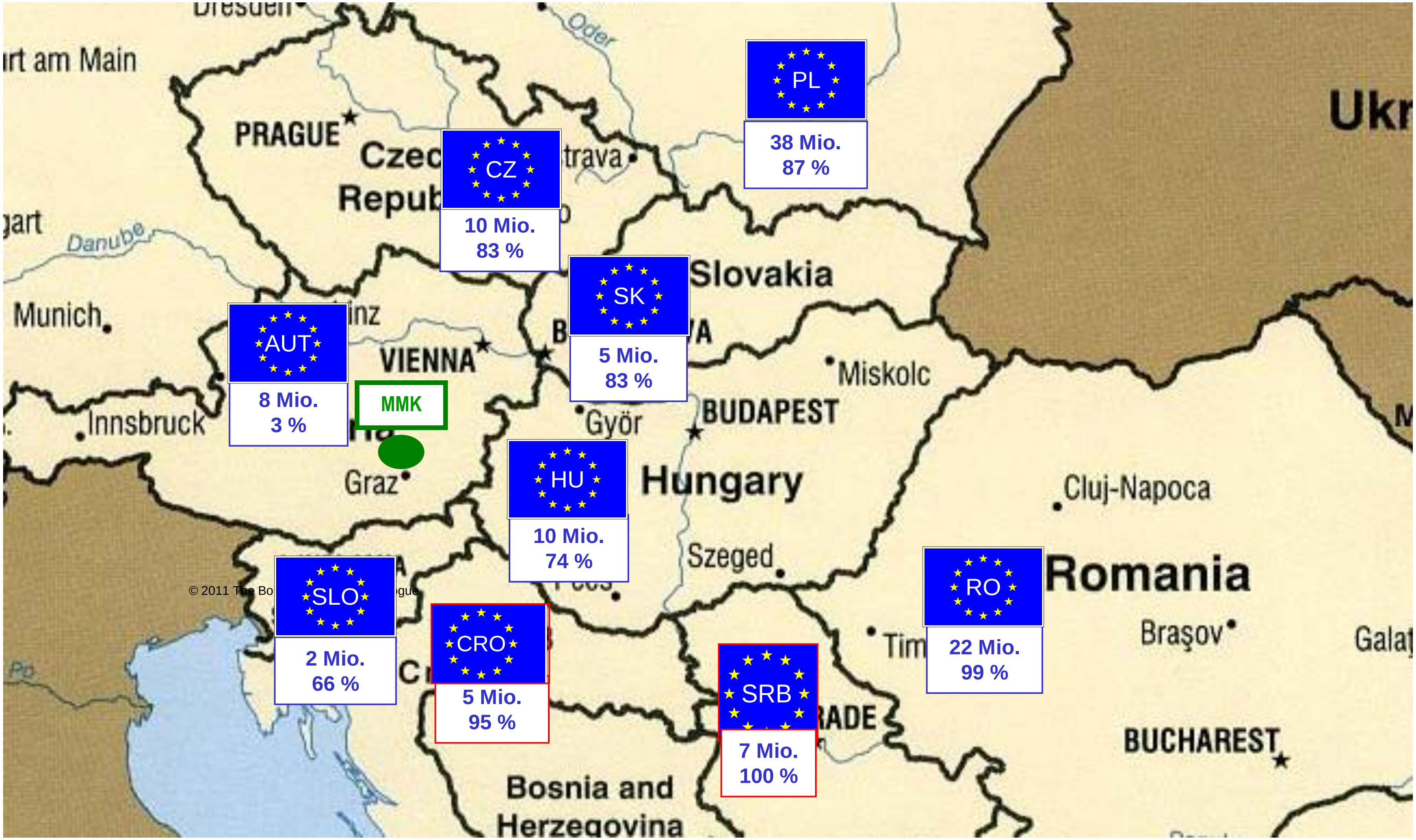


Reduction of biodegradable wastes according to Council Directive 1999/31/EC Art. 5 on the Landfill of Waste

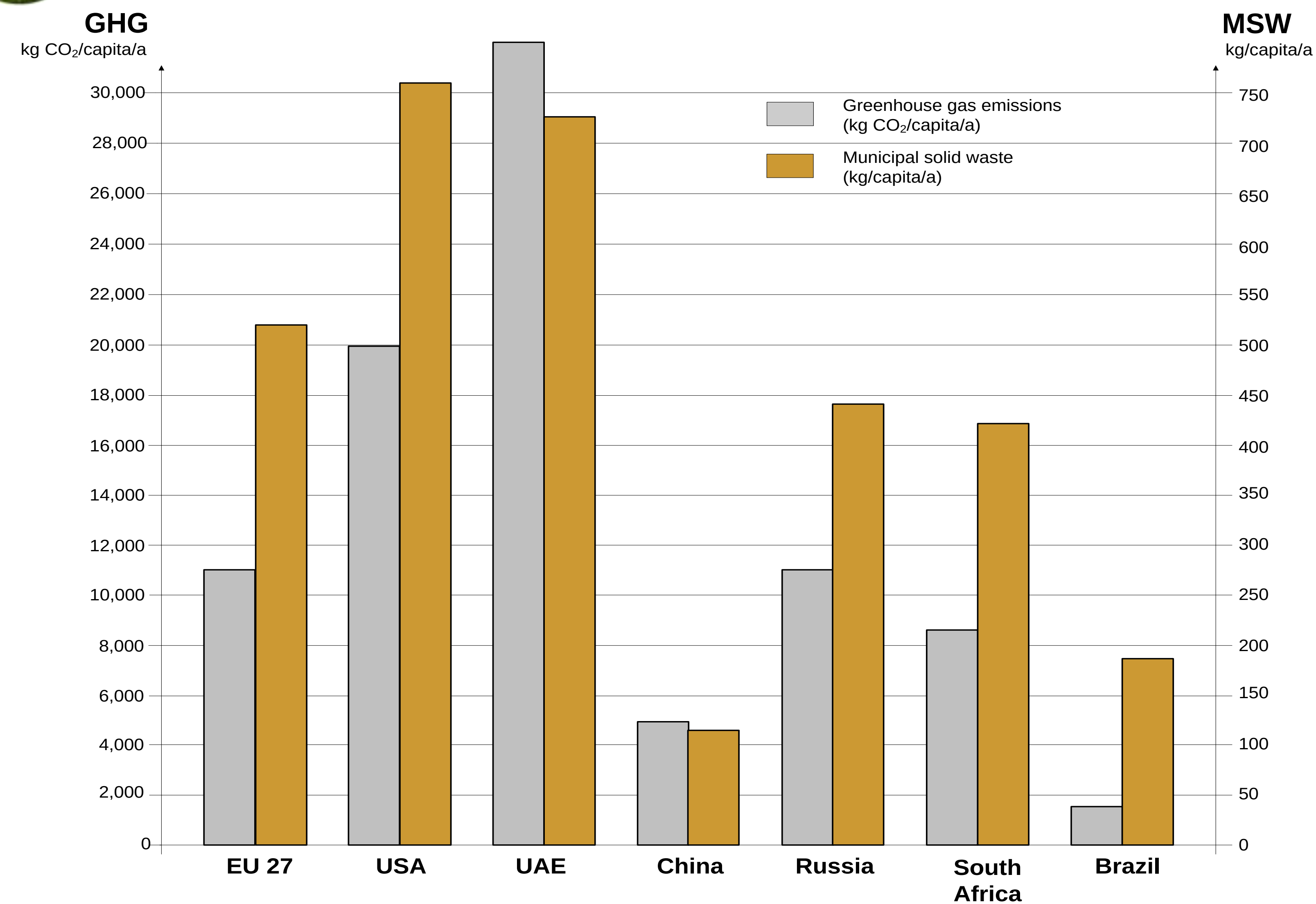
Example for future Perspective: MMK Cardboard Industry with New Energy Center, Frohnleiten, Styria

Planning (UV&P):	2005/07
Technology:	Fluidized bed
Fuel capacity:	2 x 80 MW (approx. 2 x 300 mmBtu)
Efficiency:	ca. 80 % (co-generation)
Steam production:	420,000 lb/h (1015 psi / 880 °F)
Average RDF throughput:	up to 1,500 tn / d
Fuels:	Refuse derived fuel, residues from paper recycling, waste wood, sludge from waste water treatment (biomass, coal)

Central- and South–Eastern Europe Region:
Inhabitants / Land filling in % of MSW (EUROSTAT, 2008)



Global Outlook: Greenhouse Gas Emissions and Collection of Municipal Solid Waste per Capita in various Regions



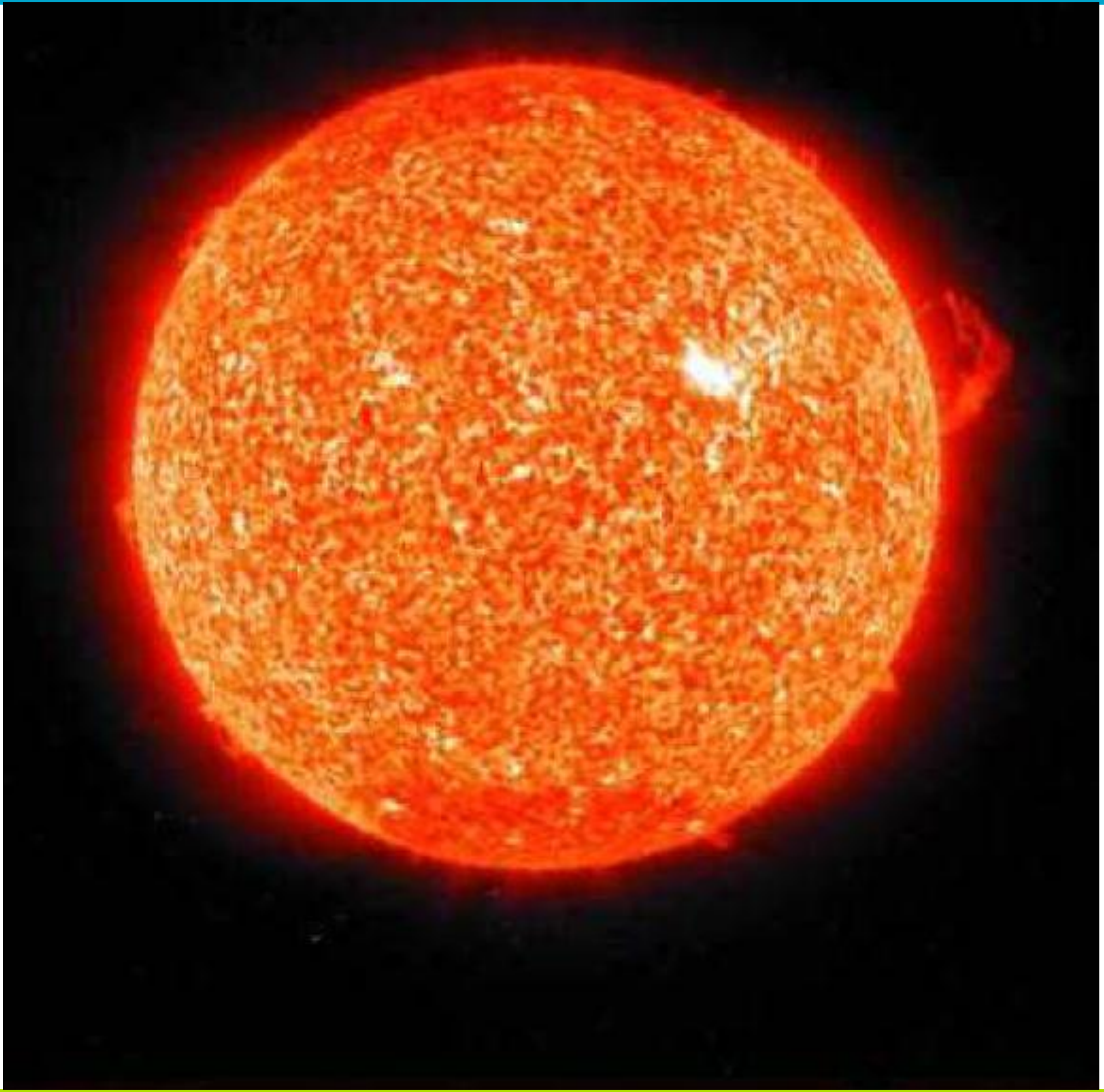
Source: „Waste-to-Energy in Austria: Whitebook – Figures, Data, Facts – 2nd Edition", 2010; Figures in kg per capita and year

Energy Need and Recovery: Heat or Power? How much?

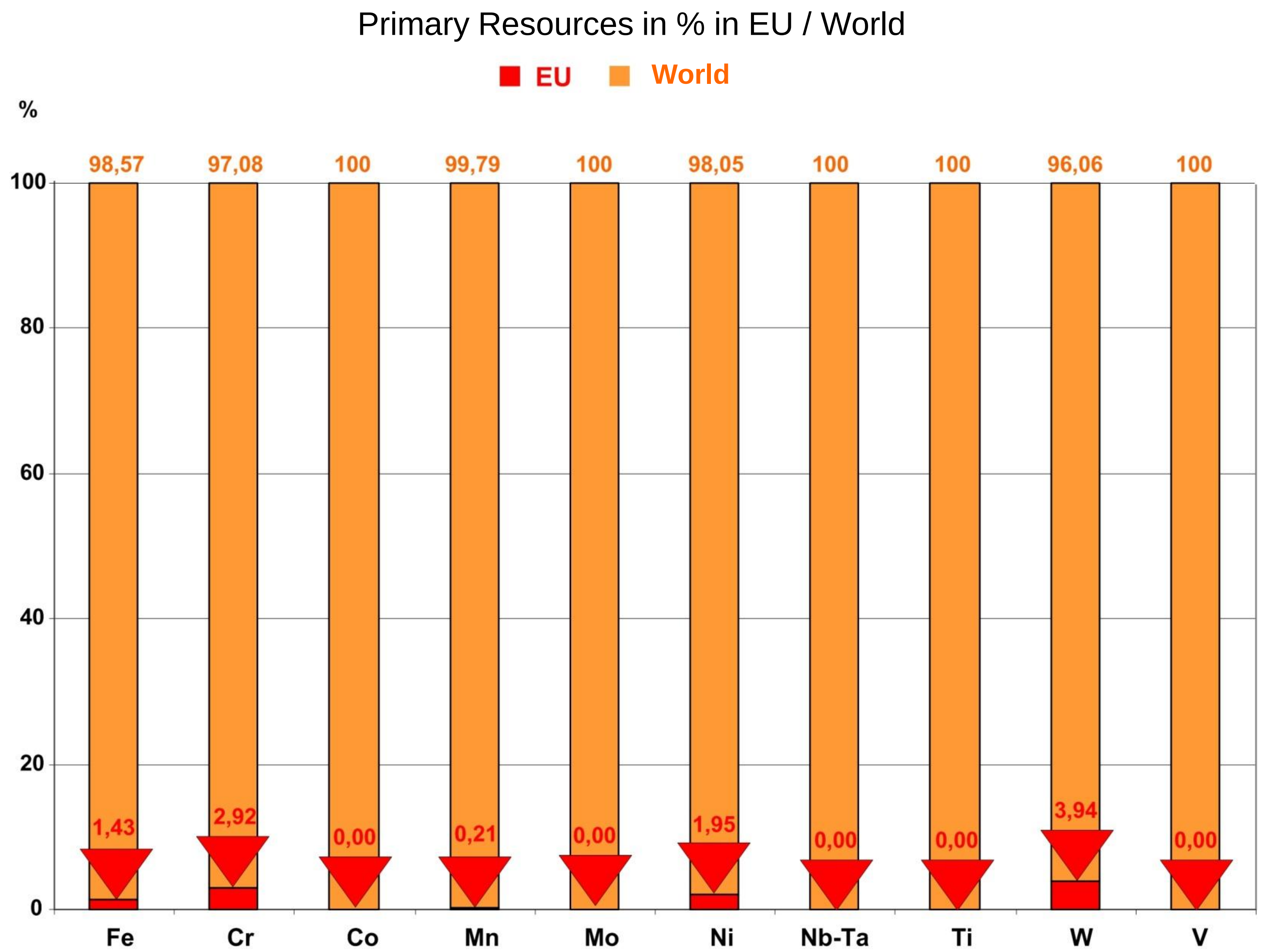
Solar energy absorbed by the earth in <u>1 hour</u> …

… exceeds the world's consumption of primary energy in <u>1 year</u>

Source: Gohlke, O. (Martin GmbH), Waste & Climate Conference Copenhagen, December 3 - 4, 2009



“Metal Poverty“ of the EU: Limited Metal Resources (2008)



How large is the "Loss" of Metals by Questionable Exports?

There is no reliable data from the EU due to the complexity of the problem and the vast variety of metal wastes, e.g. EEE.

The macro-economic losses for the EU are enormous (e.g. according to „European second-hand car market analysis", Freiburg, Germany: European Commission – DG Climate Action):

The "loss" of approx. 100 million (end-of-life) vehicles within 10 years (since 2002) is equivalent to the loss of:

- ***75,000,000* tons of steel and ferrous scrap**
- ***2,500,000* tons of non-ferrous metals**
- ***300,000* kg of precious metals (Platinum etc.)**

Technical Standards for the Intermediate Storage of High-calorific Wastes (Ministry of Environment, Austria, 2007)

http://publikationen.lebensministerium.at/publication/publication/view/3058/28567