Development and Step-by-Step Implementation of Sustainable Waste Management based on Know-how from Austria

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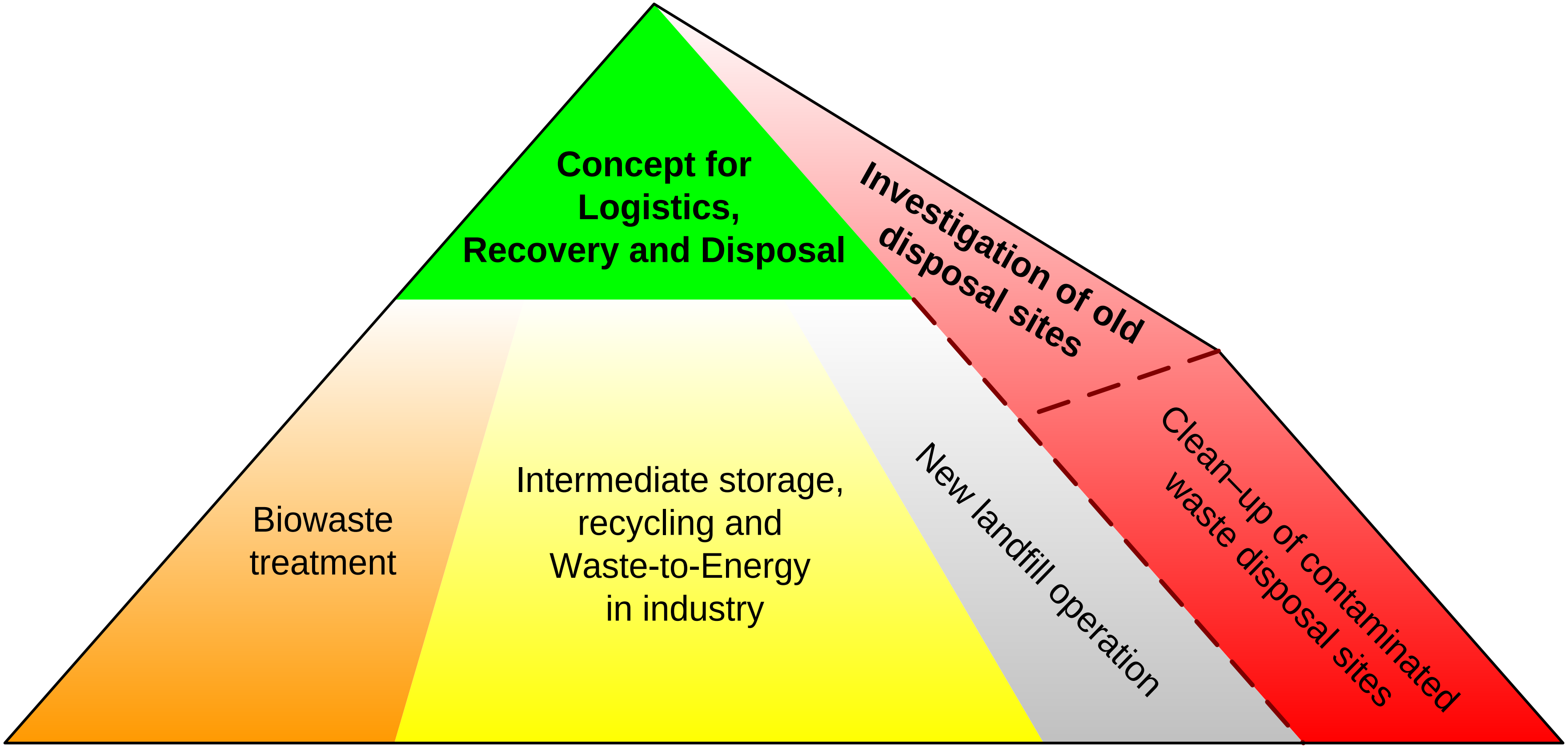
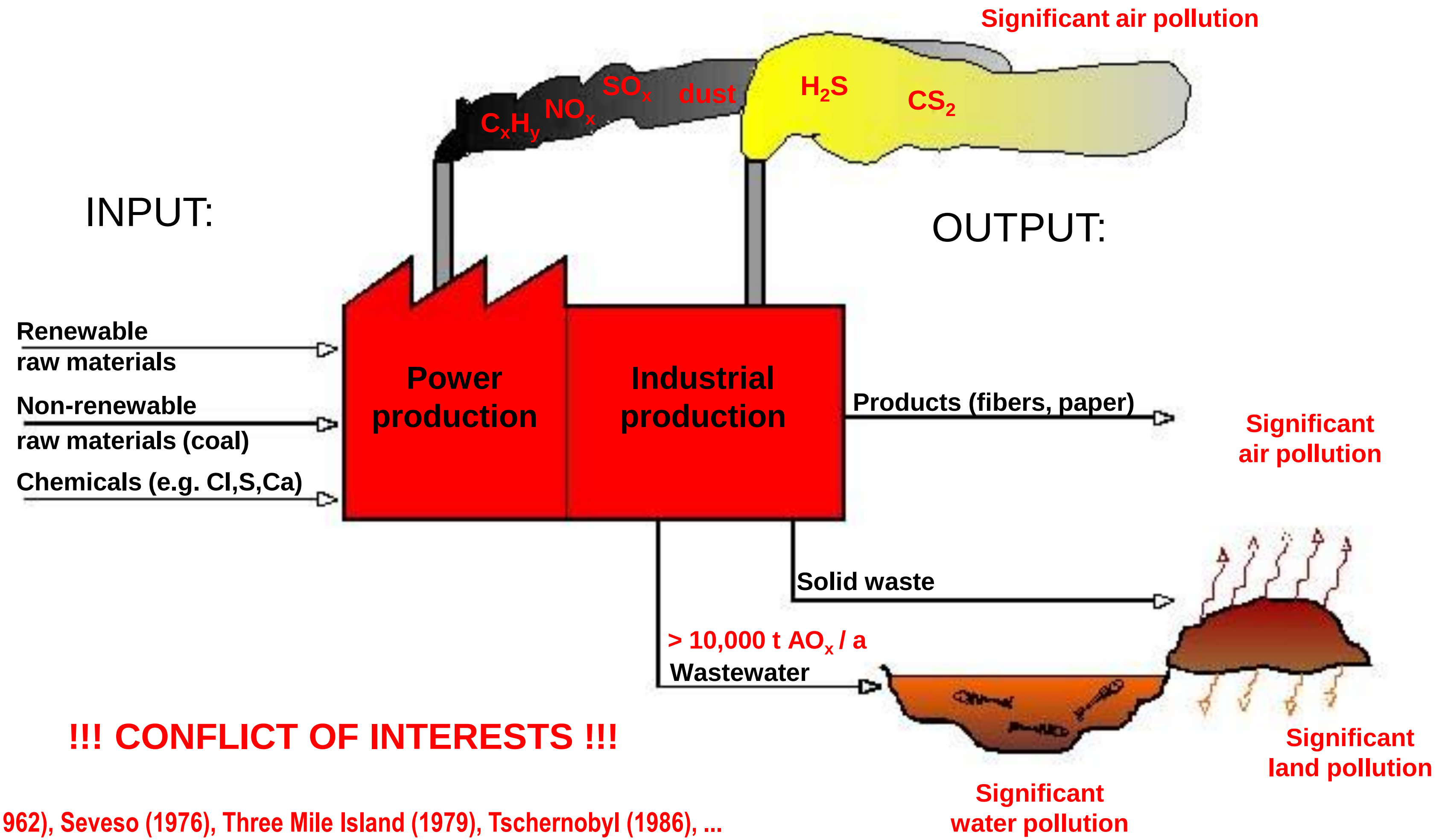


The various expert fields require competent project teams with specific experience

Example for Environmental Pollution in Austria: Fiber and Paper Production (around 1962, until 1980-90)

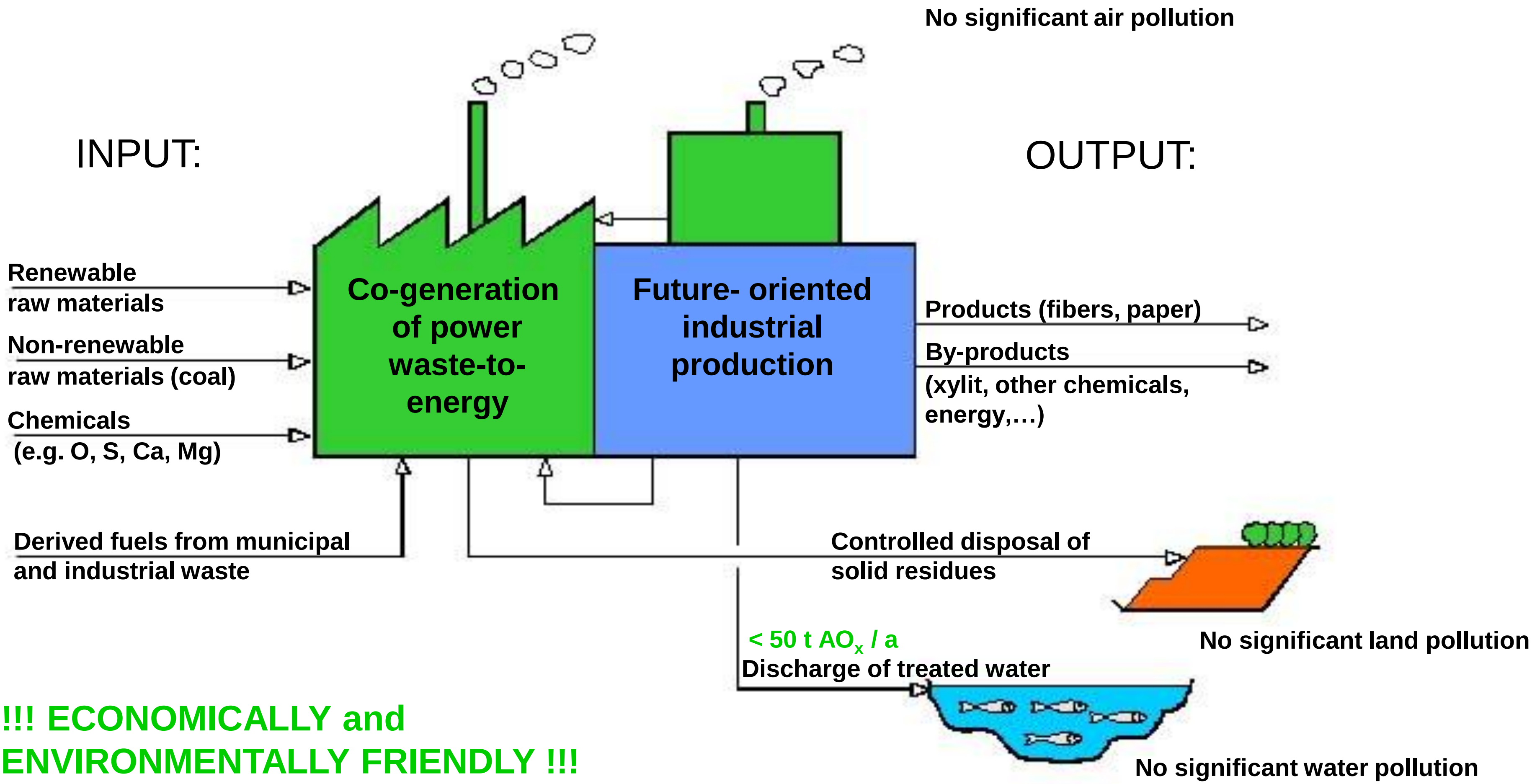
Example: paper and fiber production



!!! CONFLICT OF INTERESTS !!!

Silent Spring (1962), Seveso (1976), Three Mile Island (1979), Tschernobyl (1986), ...

Example: paper and fiber production



!!! ECONOMICALLY and ENVIRONMENTALLY FRIENDLY !!!

Floating Waste in the Danube as observed by Jakob Neubacher Traveling by SU-Paddleboard from Germany to the Black Sea

Paradigm Change: from Disposal to Treatment / Recovery (No more Dumping of Wastes exceeding 5 % TOC!)

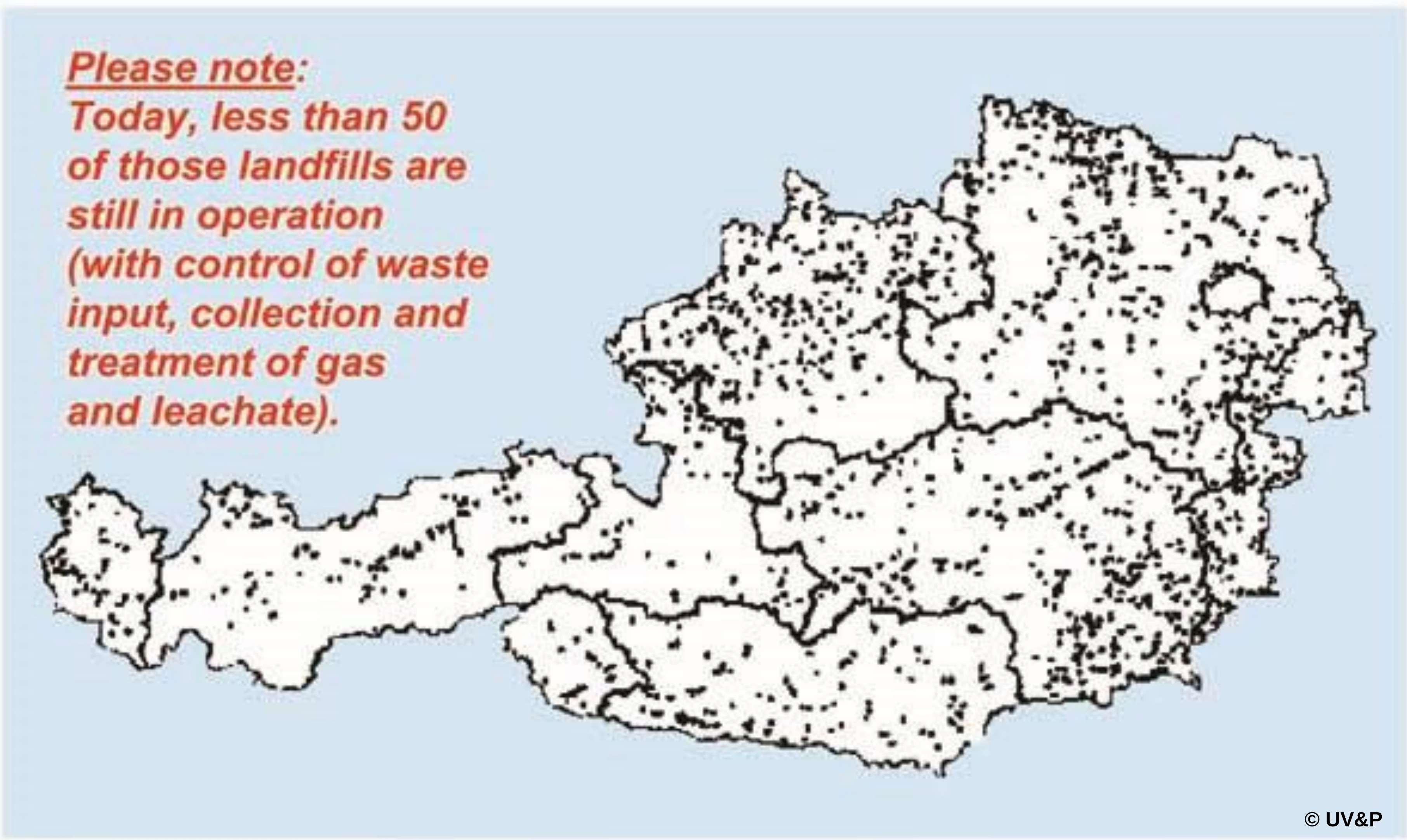
(Addis Ababa, UV&P, 2004)

(Guatemala City, UV&P, 2000)

Worldwide greenhouse gas emissions resulting from waste management sector in 2005 amounted to <u>1.4 Billion tons</u> CO_2-equivalent, incl. approx. 53 % from landfilling of untreated municipal waste (McKinsey).

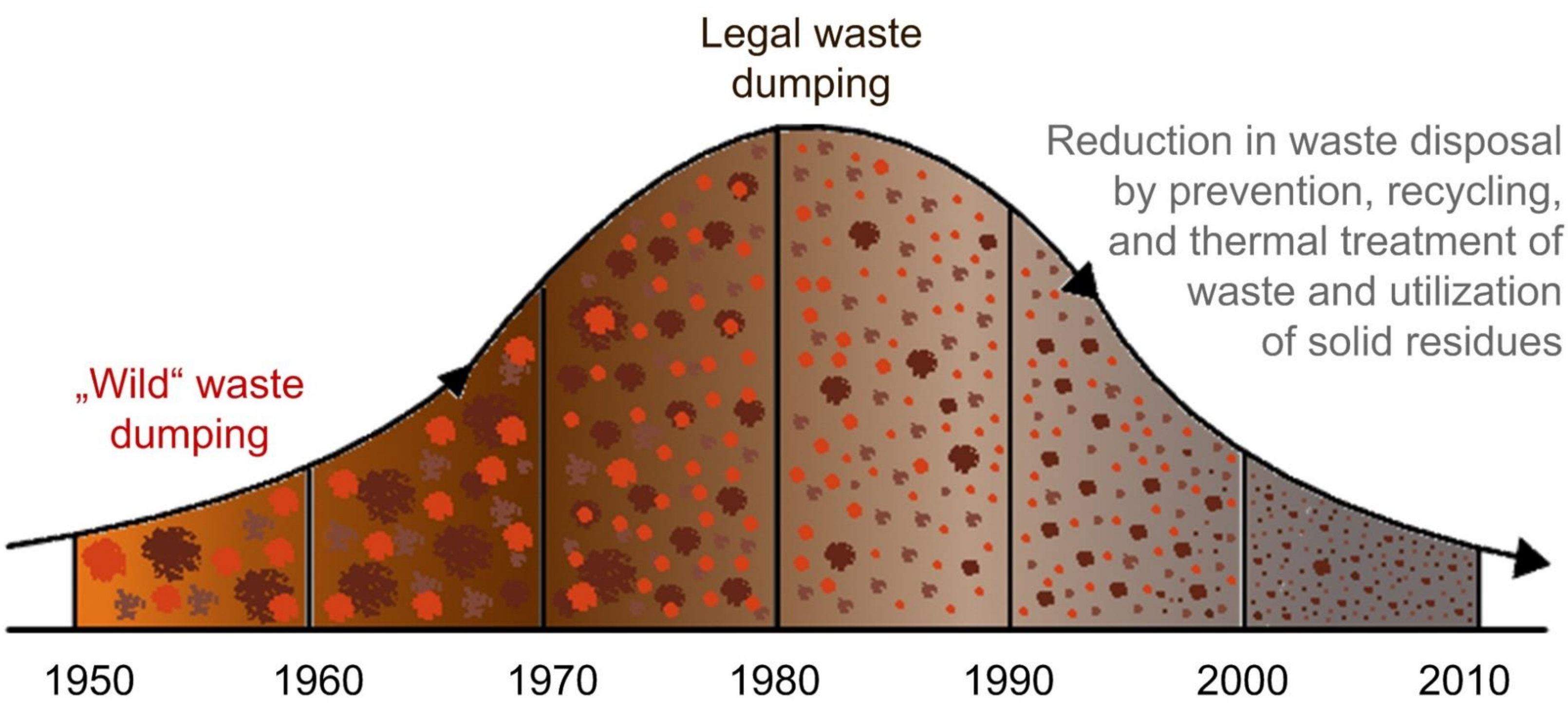
EU-wide ban on landfilling of municipal waste, allows for reduction of <u>110 Mio. tons</u> CO_2-equivalent per year, equivalent to 10 % of total European reduction target! (UNO Climate Summit 2006 in Nairobi)

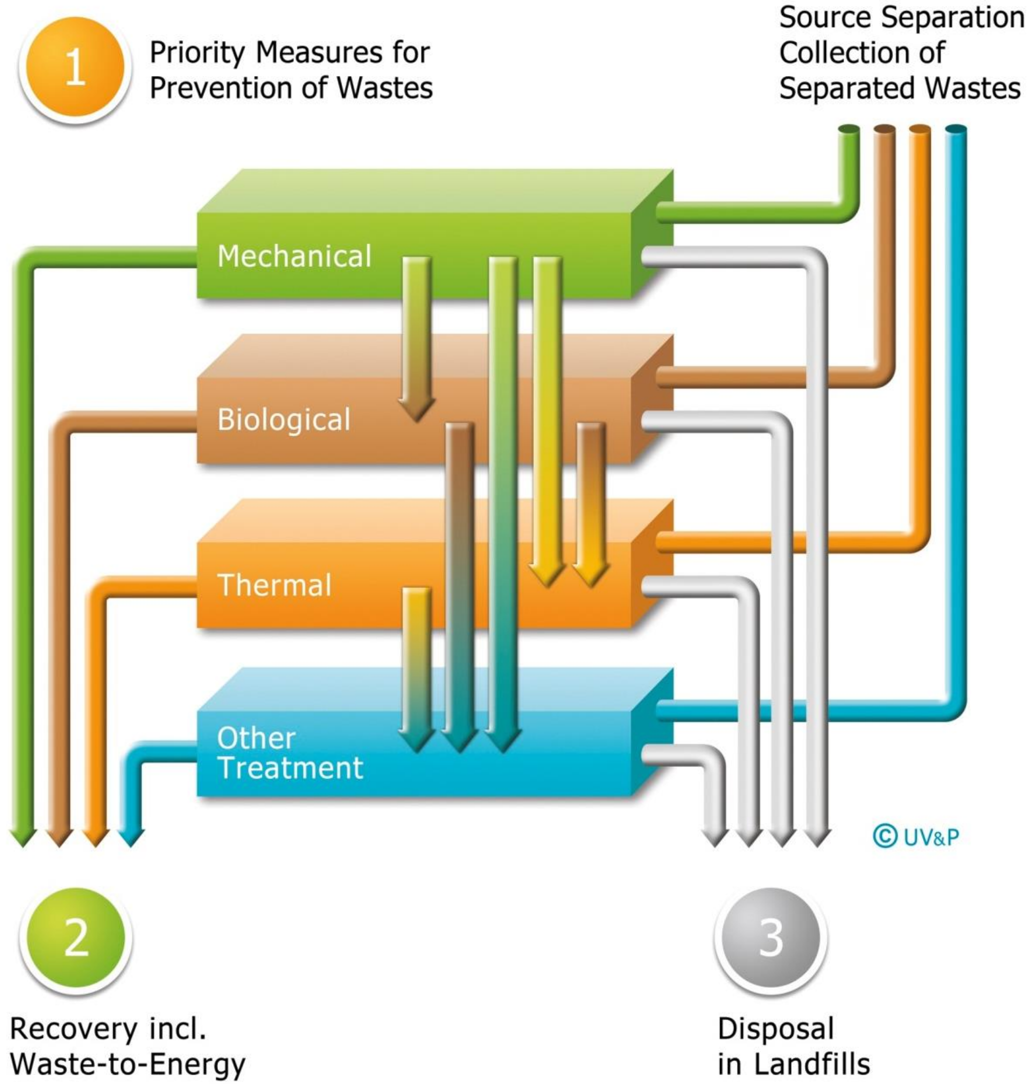
Legally Registered Landfills in Austria in 1984 (approx. 1,800 Sites / 7 Mio. Inhabitants in 1984)



Development of Waste Quantities Landfilled in Austria

Illustration for the development towards sustainable waste management as indicated by the waste volume being dumped in landfills annually





Different technologies are needed for specific wastes in an integrated treatment system.

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

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

(UVP, since 1991)

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

Separated collection of

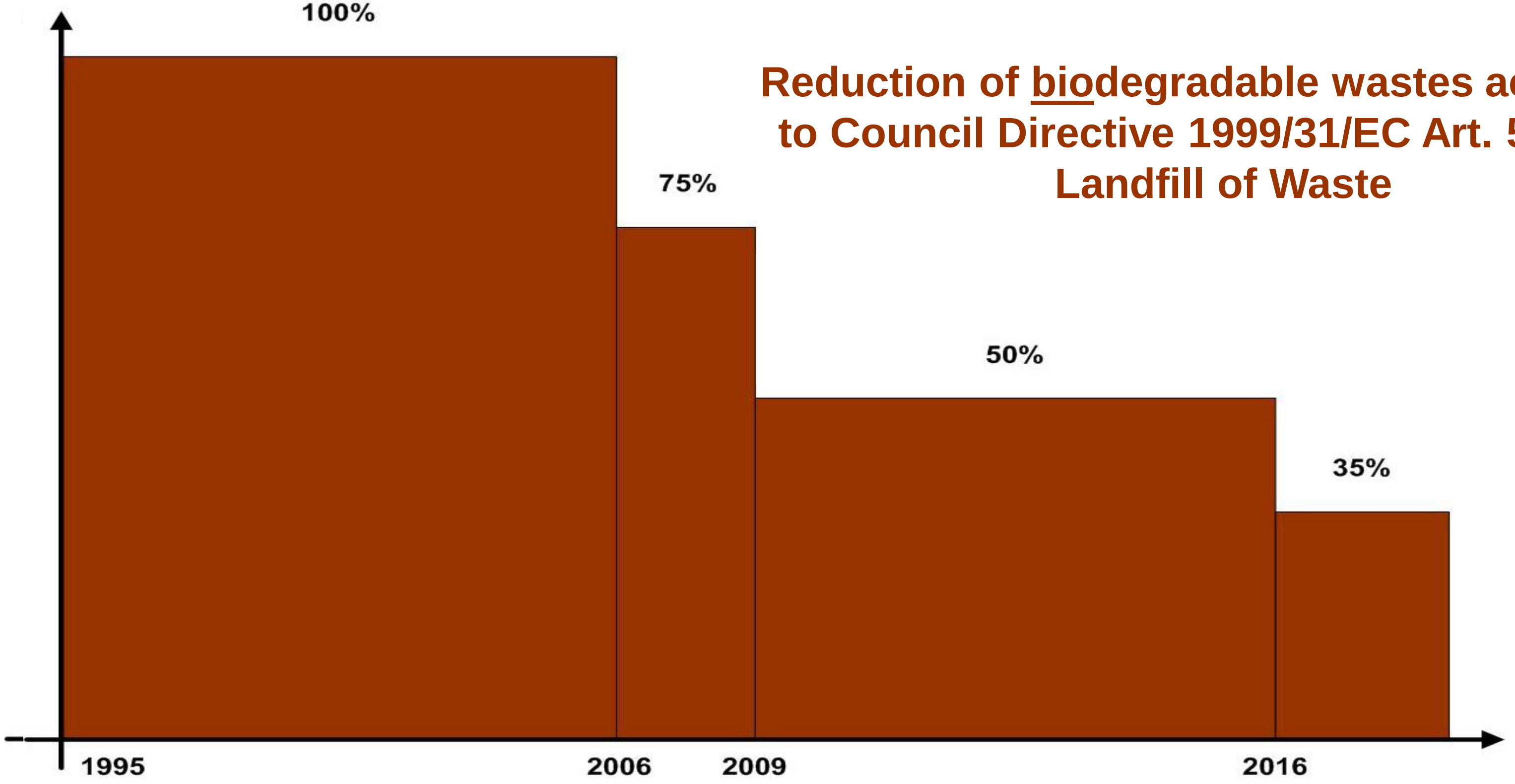
Type of waste fraction	Incineration in % weight	Comments
Paper, Cardboard	approx. 5 – 15	Sorting and processing
Plastics, Composites	approx. 30 – 70	„Plastic Packaging Bag“, „Oekobox“
Packaging glass, Laminated glass	approx. 2 – 10	Plastics, Composite films
Construction waste	approx. 10 – 40	Wood, shavings, 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)

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

EU - Limitation for Solid 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.



Composting Plant Lobau, Vienna, Austria

- Start of operation: 1991
- Open air composting
- Surface 5,2 ha
- Treatment capacity:
  150.000 t/a (input)
- Compost production:
  50.000 t/a (output)
- Favourable location
- High economic efficiency

Source: Wojciech Rogalski, „Biowaste Management in Vienna“, ISWA Beacon Conference 2012

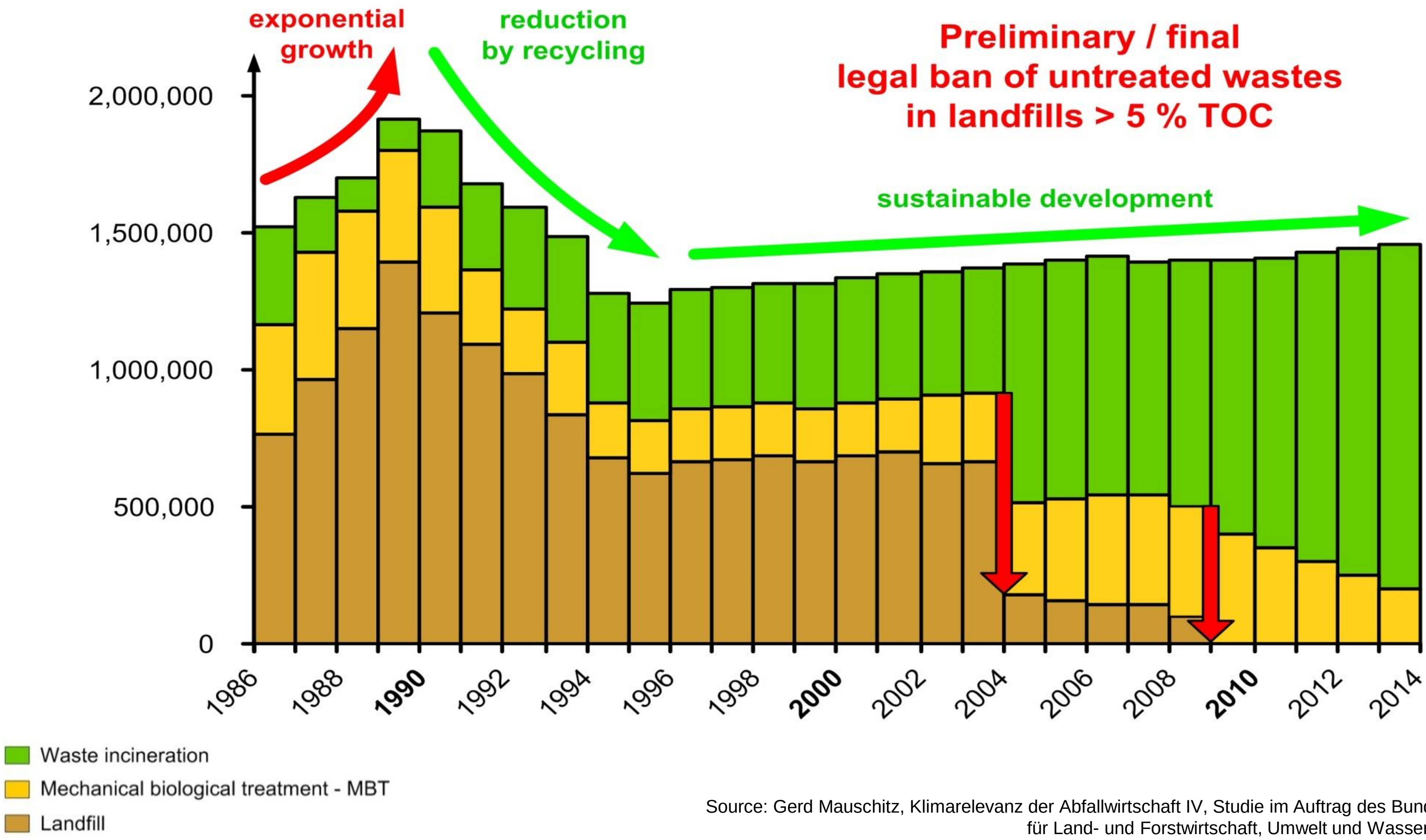
Treatment of Municipal Solid Waste in Different Countires within the European Union

	Municipal solid waste in kg per person	Treatment of municipal solid waste in 2011 (in %)			
		Land filling	Incineration	Recycling	Composting
Austria	552	***3***	**35**	**28**	**34**
Germany	597	***1***	**37**	**45**	**17**
Spain	531	***58***	**9**	**15**	**18**
France	526	***28***	**35**	**19**	**18**
Portugal	487	***59***	**21**	**12**	**8**
Italy	535	***49***	**17**	**21**	**13**
Greece	496	***82***	**0**	**15**	**3**
Bulgaria	375	***94***	**0**	**3**	**3**
Romania	365	***99***	**0**	**1**	**0**
Hungary	382	***67***	**11**	**17**	**5**
Slovenia	411	***58***	**2**	**34**	**6**
Czech Republic	320	***65***	**18**	**15**	**2**
Poland	315	***71***	**1**	**11**	**17**
Denmark	718	***3***	**54**	**31**	**12**

Source: EUROSTAT Press release of 4 March 2013

Energy Recovery and Disposal of Residual Municipal Solid Waste: 30 Years of Development in Austria

Residual Municipal Solid Waste collected in Austria
Figures in tons per year



Source: Gerd Mauschitz, Klimarelevanz der Abfallwirtschaft IV, Studie im Auftrag des Bundesministeriums für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, 2010

Necessary Cooperation and Know-how for Successful Implementation of Waste-to-Energy Projects

Financing (co-Financing incl. Subsidies)
Project Development, Planning, Investments of Equipment and Infrastructure

Know-how

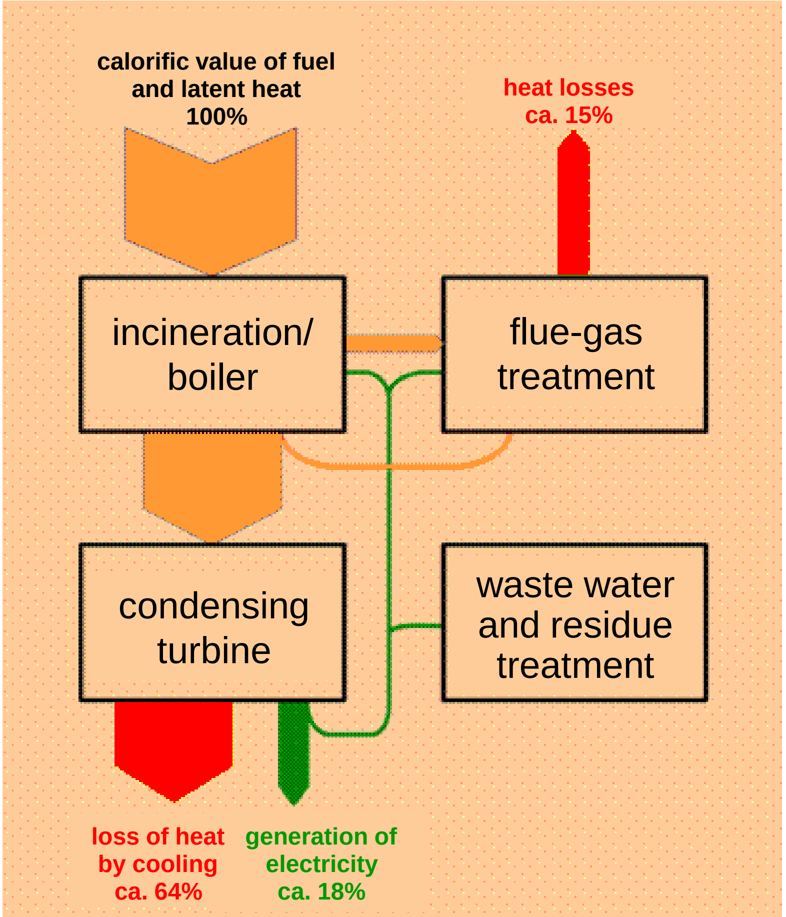
for Project- Development and -Management, Engineering, Erection incl. Supervision, Operation incl. Maintenance, Environmental Audit

Energy Efficiency
Combined Heat and Power / Continuous Heat Demand

Waste Management
Supply of Waste Fuel / Recovery / Disposal of Solid Residues

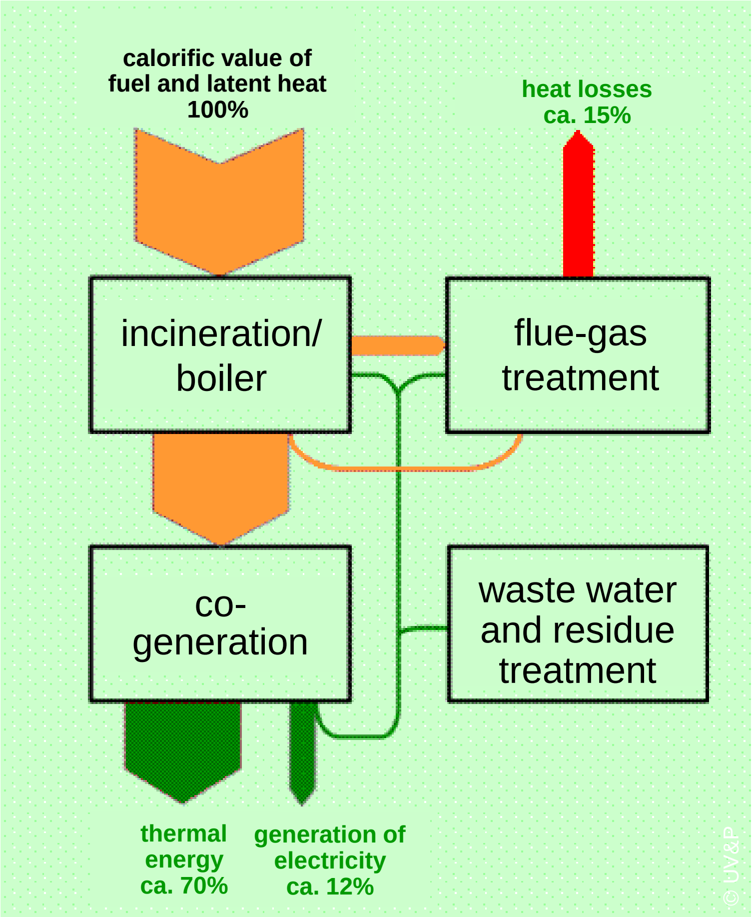
Site-specific Options for Utilization of Energy
The 3 most important Criteria in any Real Estate: Site, Site, Site!

Condensing Turbine (electricity only)



Energy utilization approx. 20 %

Co-Generation (electricity + heat)

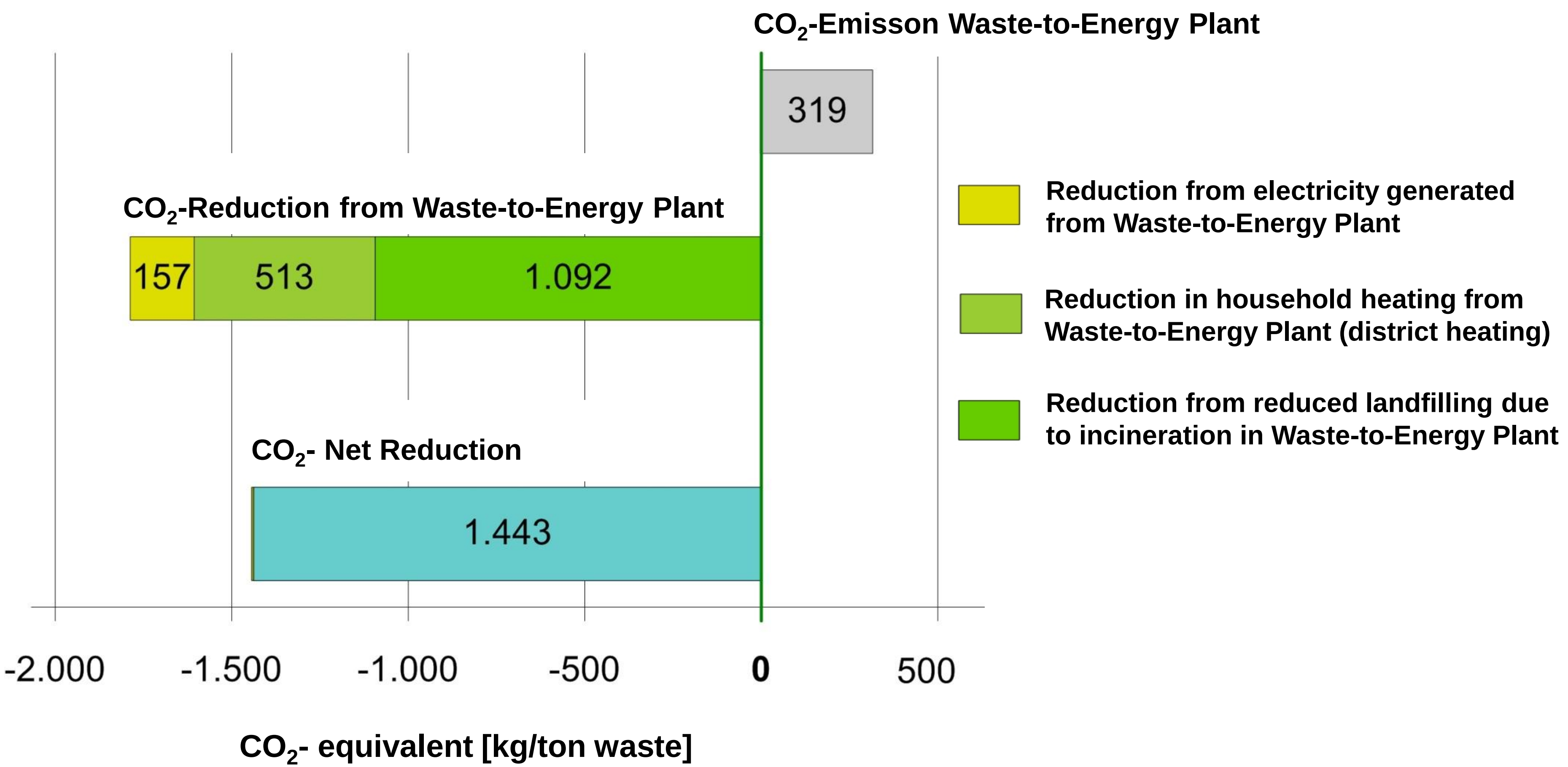


Energy utilization approx. 80 %

Municipal Waste-to-Energy: Positive Example
The Municipal Waste Incineration Plant Spittelau, Vienna

Start:	1969
(Re-) Start up:	1989
Re-vamping boilers:	2013/15
Site:	City of Vienna
Technology:	Grate firing
Fuel capacity:	85 MW
Efficiency:	up to 90 % (co-generation of electricity and district heat)
Steam production:	2 x 50 t / h (32 bar, 240°C)
Average waste throughput:	up to 780 t / d
Fuel:	municipal solid waste

Reduction of Greenhouse - Gas Emissions by Municipal Waste Incineration in Vienna



Source: Kirchner, IIR Conference: Efficient future Waste Treatment Technologies, 2008

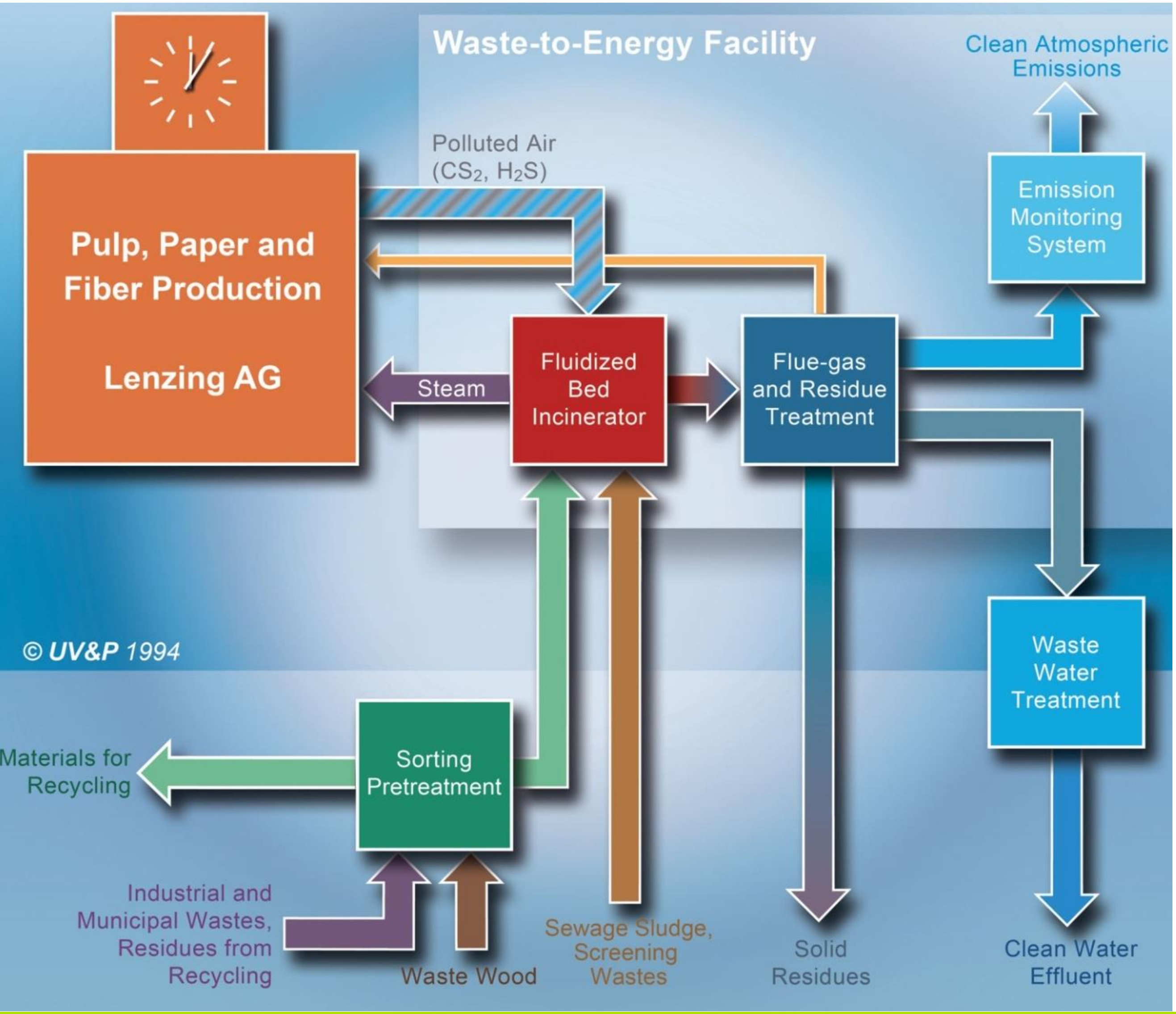
Waste-to-Energy at the Industrial Site of Lenzing in the Tourist Region of Salzkammergut, Upper Austria

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

The 3 arguments in public discussions / acceptance:

1. **Energy demand (90 MW)**
2. **Reduction of odour (H_2S, CS_2)**
3. **No landfilling (300.000 t / a)**

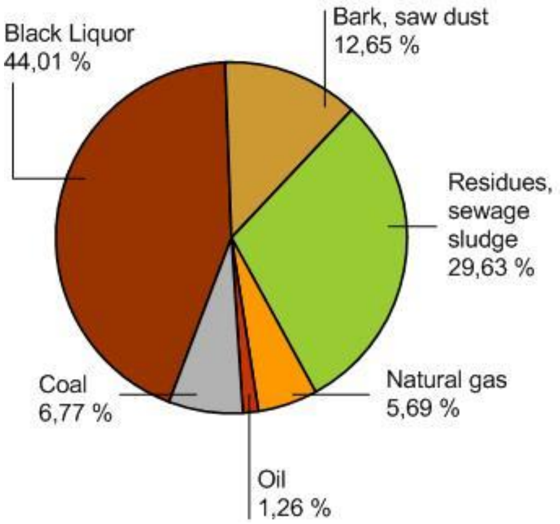
Integration of Waste-to-Energy in Industry
Example: RVL Lenzing, Upper Austria (UV&P, 1993)



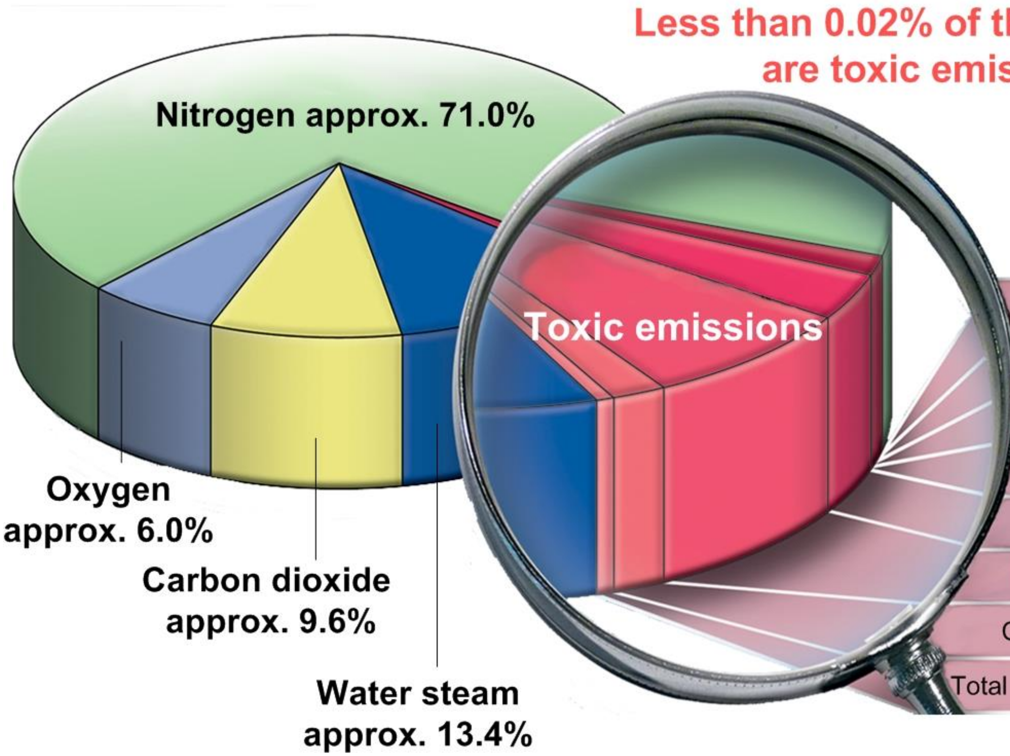
Planning (UV&P): 1993/94
Start Up: 1998
Technology: Fluidized bed
Fuel capacity: 110 MW
Steam production: 120 t / h (80 bar, 500°C)
Waste throughput: up to 1,000 t / d

Fuel Mix in 2007 at Lenzing AG:

Fuel Input: 12,600,863 GJ / a



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



Comparison of emission limits: Figures in mg/Nm³ (11 % O_2, dry)

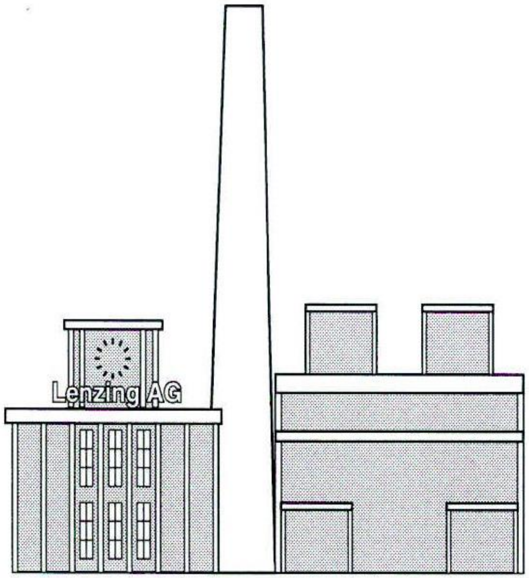
	EU-Directive 2000/76	AVV BGBl. 389/2002	RVL Lenzing	
			Project 1994	Measured values 2002
Particulates	10	10	8	0.6
Mercury Hg	0.05	0.05	0.05	0.007
Hydrogen chloride HCl	10	10	7	0.8
Hydrogen fluoride HF	1	0.7	0.3	0.02
Sulfur dioxide SO_2	50	50	50	4.1
Nitrogen oxides NO_x	400	100*)	70	41.6
Carbon monoxide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

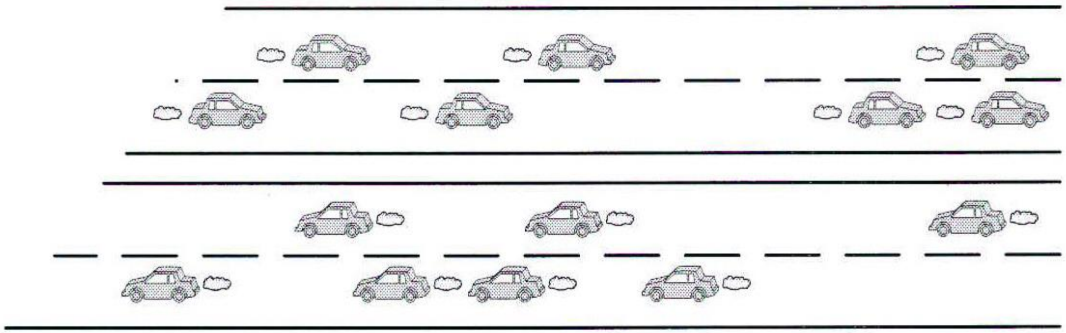
* if > 6 tons waste per hour

Efficiency of Controlled Combustion and Integrated Multi-stage Flue-Gas Cleaning (Example RVL, UV&P 1994)

Comparison of organic compounds from incineration plant / cars on the road

Incineration plant = 14 cars





Calculation:

Car exhaust contains ca. 20 g C-org / kg fuel

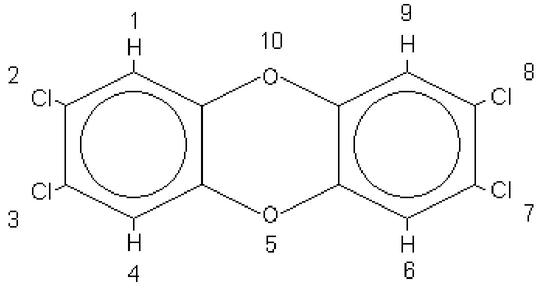
(Source: Schopp G., Ö. Chemz. 1993/9)

Flue gas of the incineration plant with multi-stage flue gas cleaning contains less than 1,980 g C-org / h

(Source: Expertise ZAMG, 22.12.1993)

Cleaned flue-gas of an incineration plant contains less organic compounds than the exhaust of 14 cars

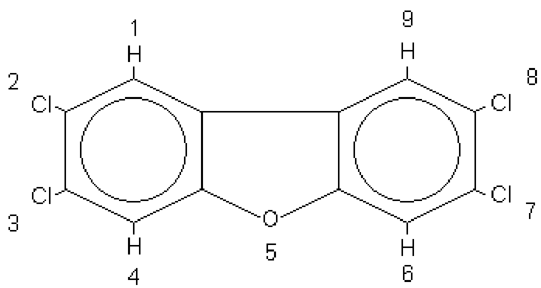
Balance of “Dioxins“ in Waste Incineration according to State-of-the-Art Technology



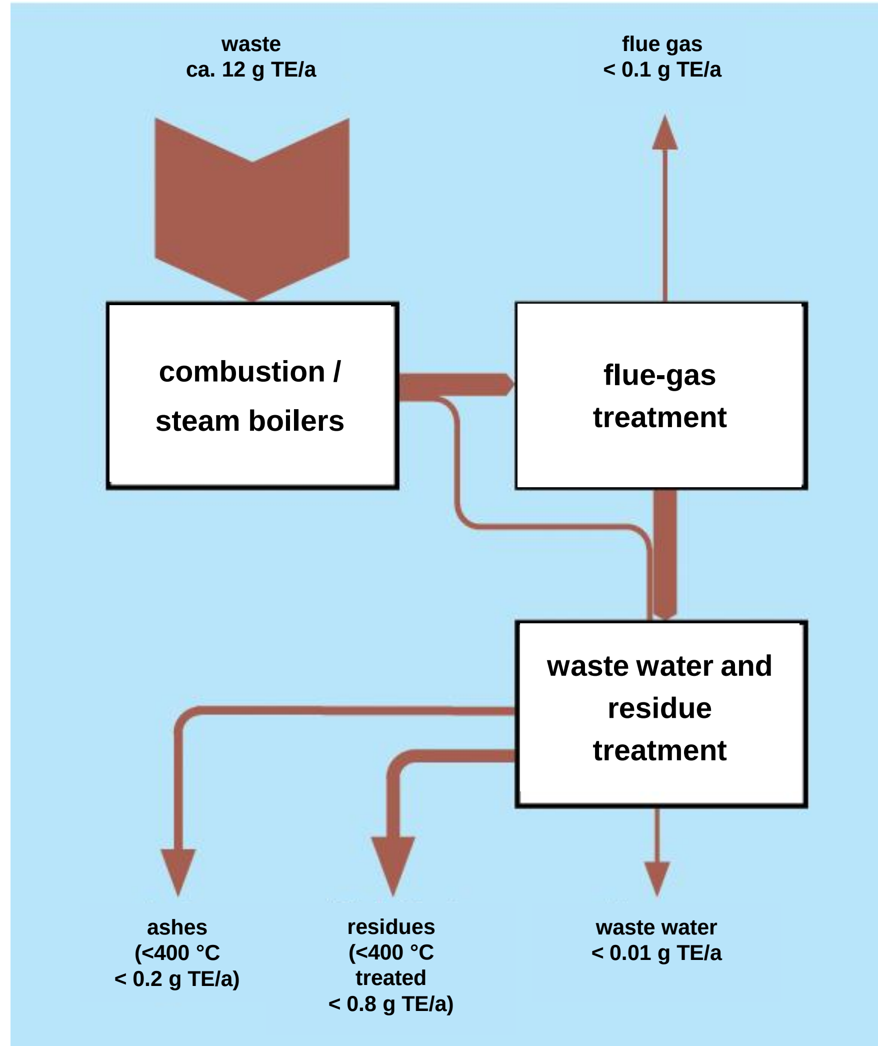
2,3,7,8-Tetrachlordibenzo-p-Dioxin

The emission limit for “dioxins“ is also the essential parameter for higher molecular halogenated organic substances and POPs persistant organic pollutant. The sum of “dioxin-emissions“ of a thermal treatment plant according to state-of-the-art technology is significantly below the amount of dioxins already contained in waste prior to treatment.

g TE / a = g Toxicity Equivalent 2,3,7,8 TCDD per year



2,3,7,8-Tetrachlorodibenzofuran

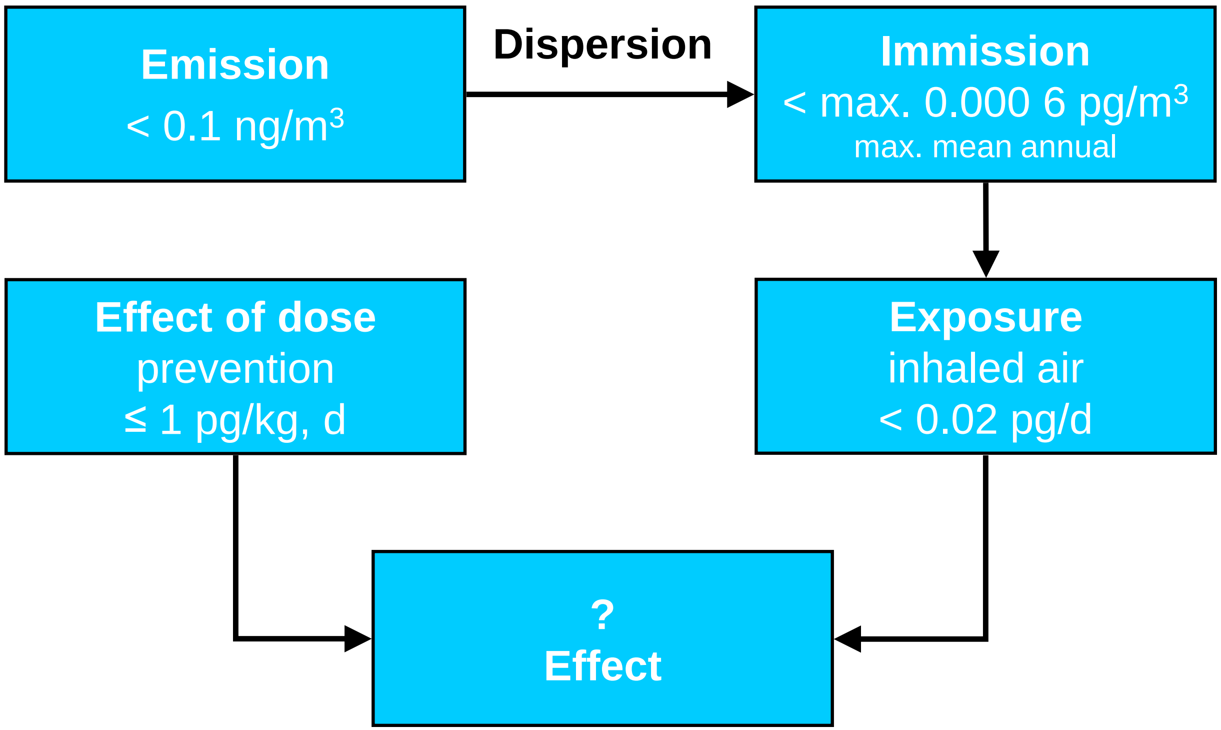


Calculation for an example of a waste incineration project: UV&P, 1996

Risk Assessment for Atmospheric Emission of "Dioxins" (Example: RVL Lenzing, 1994)

1 ng $=10^{-9}$ g = 0,000 000 001 g

1 pg = 10^{-12} g = 0,000 000 000 001 g



Risk assessment:

The precautionary protection standard (federal health bureau, Berlin) is 1 pg / kg weight and day (factor 1,000 safety compared with NOEL - No Observeable Effect Level). In the worst case a person inhales 0,012 pg dioxin with ca. 20m^3 air per day. In comparison the protection standard for a 60 kg person is 60 pg/day. Therefore the inhaled maximum is less than $^1/_{1000}$ of the protection standard. Thus the additional risk can be considered irrelevant.

No increased health risk due to very small concentrations of dioxins in the cleaned flue-gas of the waste incineration facility.

Illustration for Risk Assessment regarding "Dioxins" (Example RVL Lenzing, 1994)

Assumption: **3 cigarettes per day** = marginal value of impact (no effect observable)

Thus the **precautionary** protection standard (=1/1,000) is equivalent to **1 cigarette per year**.

Conclusion : An incineration plant with multi-stage flue gas cleaning is factor 1,000 below the (precautionary) protection standard

thus = equivalent to 1 additional cigarette in 1,000 years

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Long-term monitoring of dioxins and furans near a municipal solid waste incinerator: human health risks

Lolita Vilavert[1], Martí Nadal[1], Marta Schuhmacher[1,2] and José L Domingo[1]

Abstract

Since 1996, a wide surveillance programme has been developed to get overall information on the impact of a municipal solid waste incinerator (MSWI) in Tarragona (Catalonia, Spain). The concentrations of polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs) have been periodically measured in soil and vegetation samples collected at locations in the incinerator surroundings. Furthermore, air PCDD/F levels have been also monitored by using active and passive sampling devices, generating a huge amount of information regarding the environmental status of the zone. In the last survey (2009–2010), mean PCDD/F levels in vegetation, soil and air were 0.06 ng I-TEQ kg^{-1}, 0.58 ng I-TEQ kg^{-1} and 10.5 fg WHO-TEQ m^{-3}, respectively. Both soil and herbage showed a notable reduction in the PCDD/F concentrations in comparison with the baseline study, with this decrease only being significant for soils. In contrast, PCDD/F values in air remained similar during the whole assessment period. Human exposure to PCDD/Fs was evaluated under different scenarios, and the associated non-carcinogenic and carcinogenic risks were assessed. The hazard quotient was below unity in all cases, while cancer risks were under 10^{-6}, which is lower than the maximum recommended guidelines. The current results clearly show that the MSWI of Tarragona does not produce additional health risks for the population living nearby.

Waste-to-Energy Plant ENAGES Integrated within the Site of the Paper Industry in Niklasdorf, Austria

Source: http://www.e-steiermark.com/enages/anlage.htm#

Planning (UV&P):	1994/95
Start up:	2003
Technology:	Fluidized bed
Fuel capacity:	40 MW
Steam production:	46 t / h (40 bar, 400°C)
Average waste throughput:	approx. 100,000 t / a
Fuels:	RDF, municipal, commercial and production wastes, sewage sludge

Waste Incineration Plant EVN integrated to the site of Coal-fired Power Plant in Zwentendorf, Lower Austria

Planning (UV&P):	1999/2001
Start up line 1+2:	2003
Start up line 3:	2009
Technology:	Grate firing
Fuel capacity:	2 x 60 MW
	1 x 90 MW
Steam parameters:	50 bar, 380°C
Efficiency:	ca. 76 - 78 % (co-generation)
Average waste throughput:	approx. 500,000 t / a

Integrated option of steam supply to a turbine of coal-fired power plant (400 MW electricity).

Project includes also a 31 km pipeline for district heating supply to St. Pölten.

RHKW Reststoffheizkraftwerk in the City of Linz, Upper Austria: Co-Generation / District heating based on Waste Derived Fuel

stack (180 m – existing)

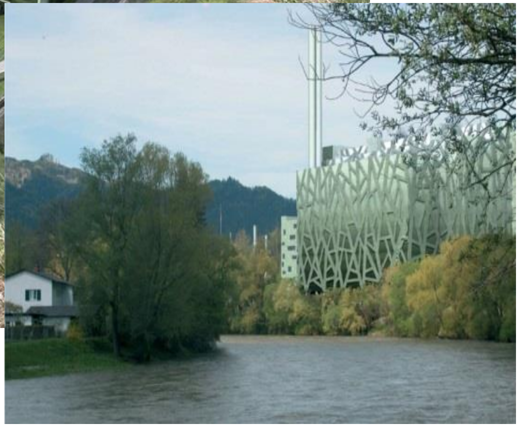
Mechanical waste processing and intermediate storage

power plant including fluidized bed boiler

Pipe conveyor for waste transport from fuel storage to power plant

Planning (UV&P):	2006/07
Start Up:	2011
Technology:	Fluidized bed
Fuel capacity:	72 MW
Efficiency:	ca. 80 % (co-generation)
Steam production:	89 t / h (42 bar, 420°C)
Waste throughput:	up to 800 t / d
Fuels:	Municipal and commercial waste, sewage sludge, screening wastes

Example for Future Perspective: MMK Cardboard Industry with a New Energy Center for Waste-to-Energy, Frohnleiten, Austria

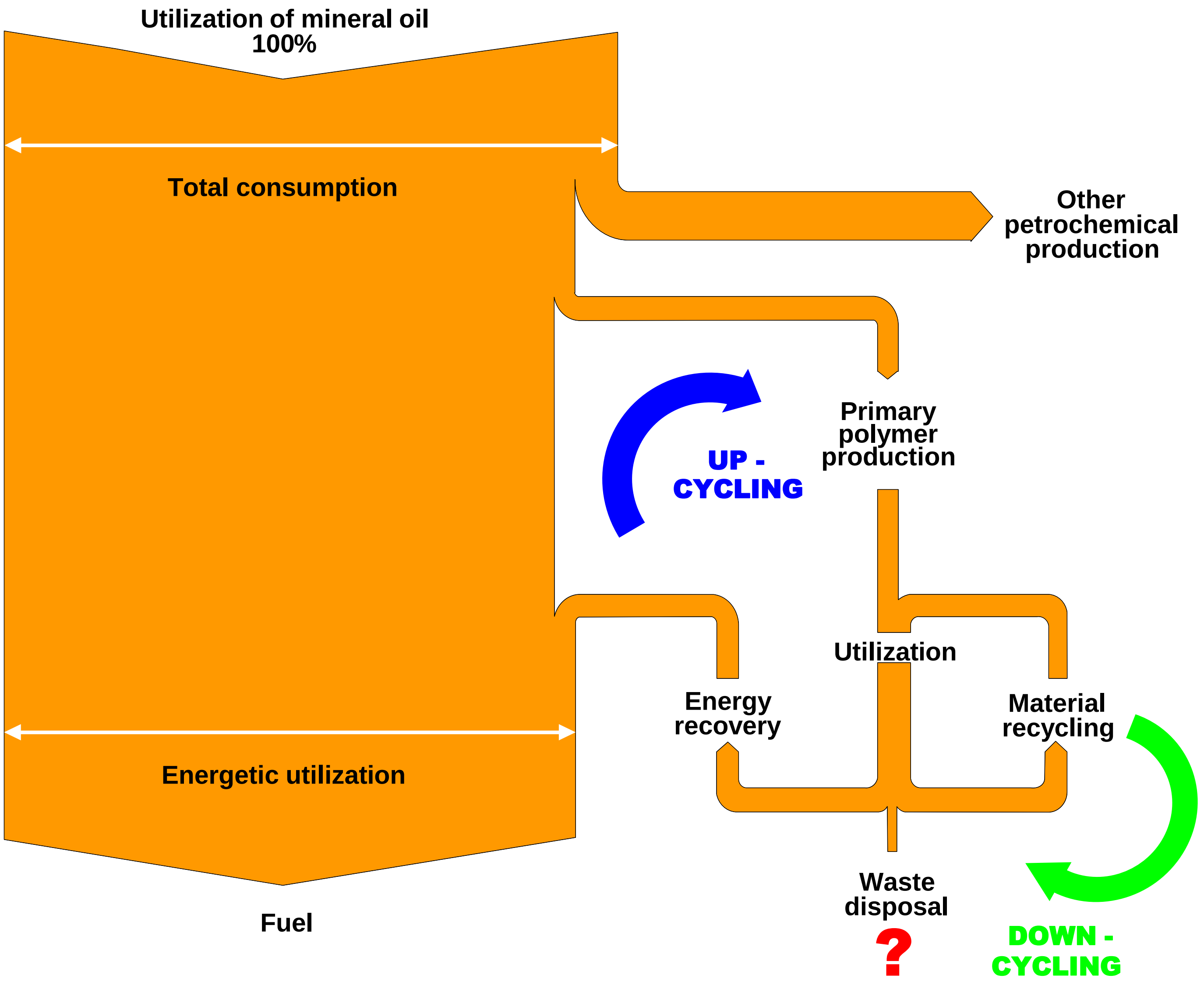


Planning (UV&P):	**2005/07**
Technology:	**Fluidized bed**
Fuel capacity:	**2 x 80 MW**
Efficiency:	**ca. 80 % (co-generation)**
Steam production:	**190 t / h (70 bar, 470°C)**
Average RDF throughput:	**up to 1.360 t / d**
Fuels:	**Refuse derived fuel, residues from paper recycling, waste wood, sludge from waste water treatment (biomass, coal)**

Innovative Concepts for Cement Clinker Production in Austria with highest Environmental Standard and Efficiency

- **Minimum atmospheric emissions (incl. PM 10, VOC, NOx, CO, and continuous monitoring incl. Hg)**
- **Highest energy efficiency due to integration and waste heat export to regional district heating network**
- **Highest resource efficiency due to utilization of waste-derived alternative raw materials and waste-derived hazardous and non-hazardous alternative fuels**

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

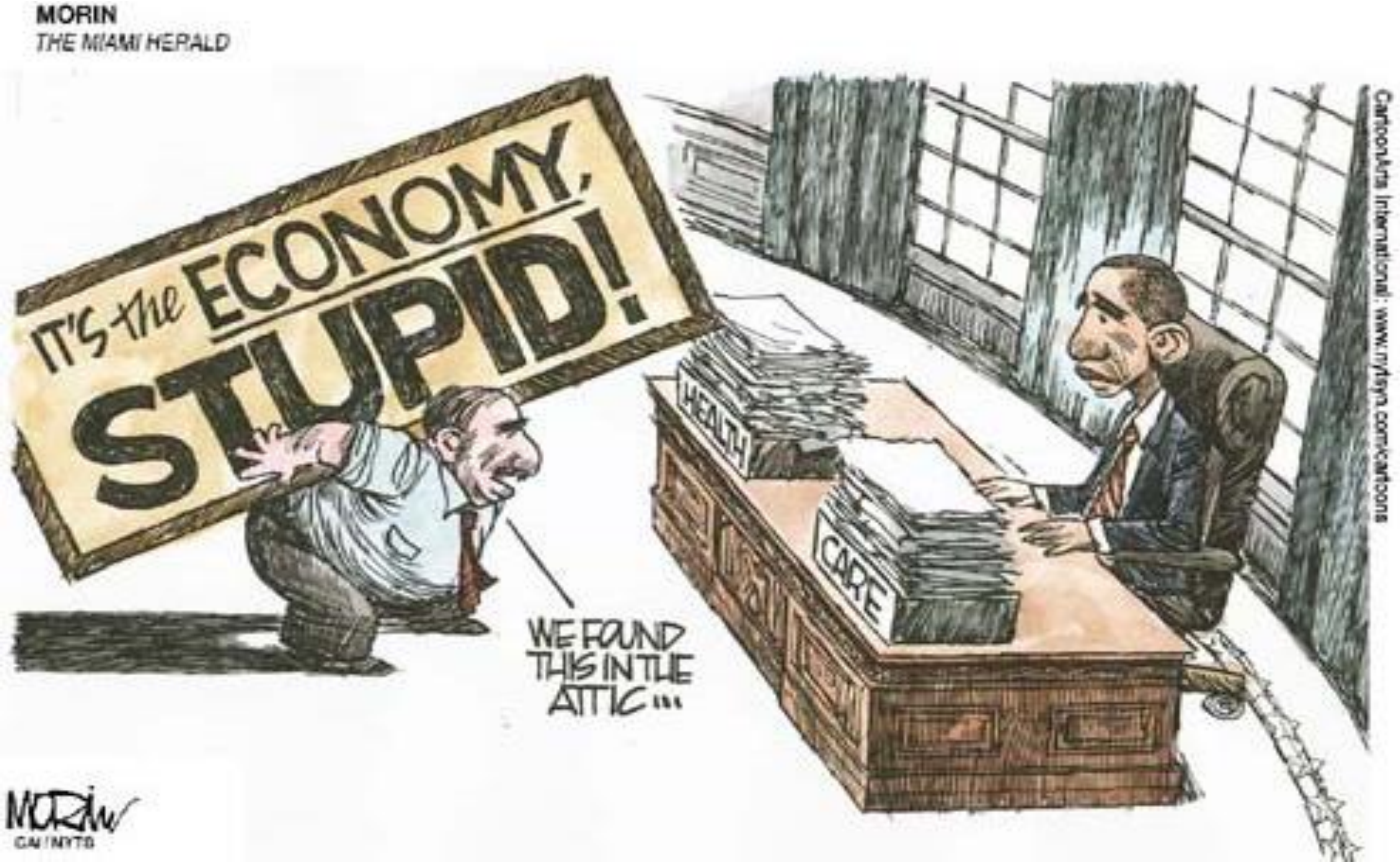
Zero disposal!
(despite Landfill Directive 1999/31/EC)

Practical Examples for Economic Discussions

We have calculated this for you

Source: Martin GmbH, SYNCOM presentation in Arnoldstein, 26-27 April 2006

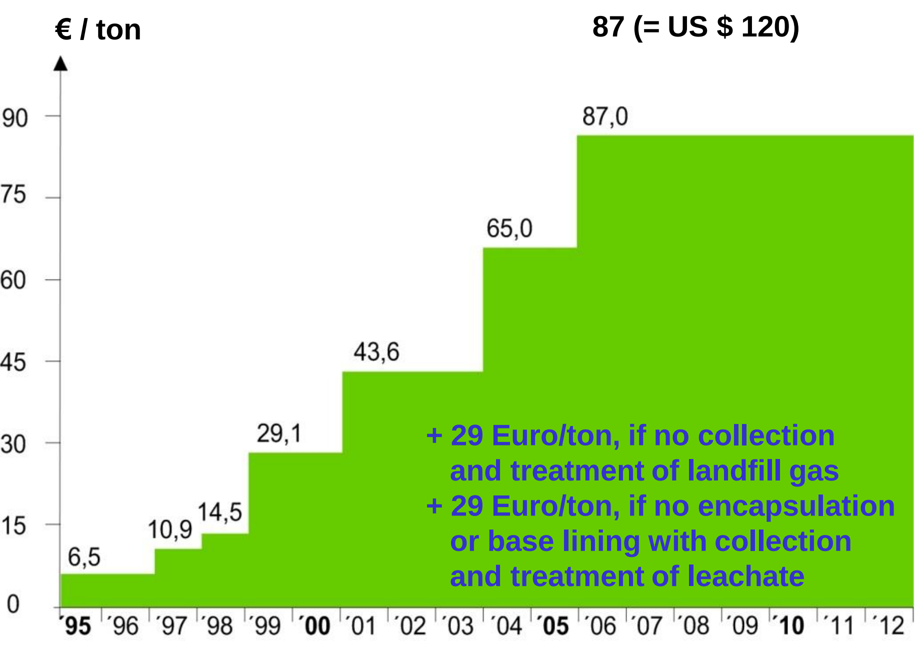
Waste Prevention, Reuse and Recovery: It's Economics …!!!



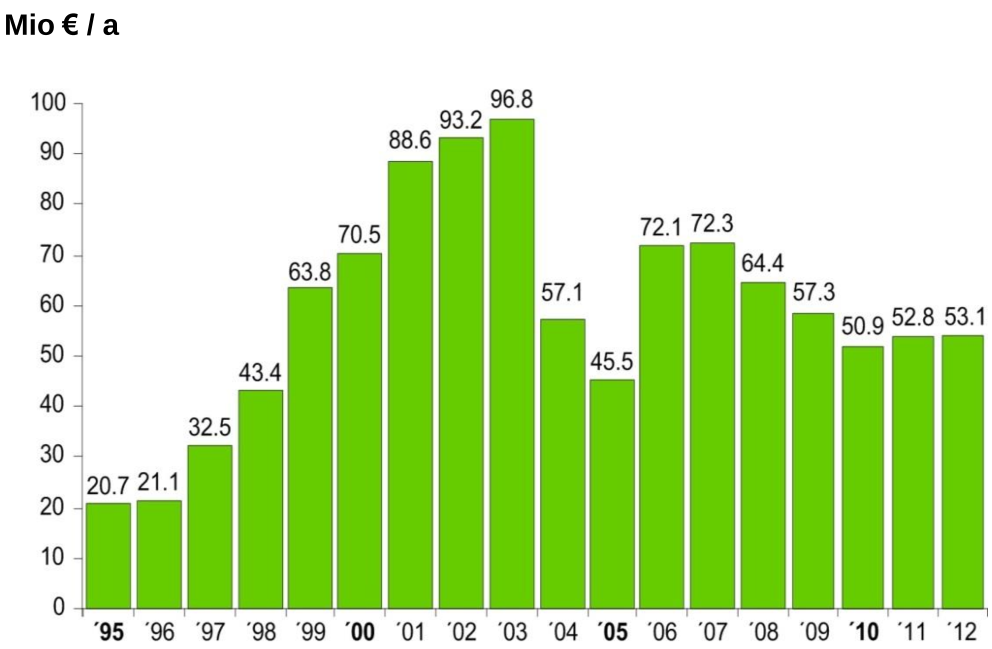
Development of the Special Landfill Tax in Austria

The development of waste management in Austria towards reduction of landfilled waste as well as recycling and recovery has been very effectively supported by a special landfill tax

Landfill tax in € / ton of waste (e. g. municipal waste)



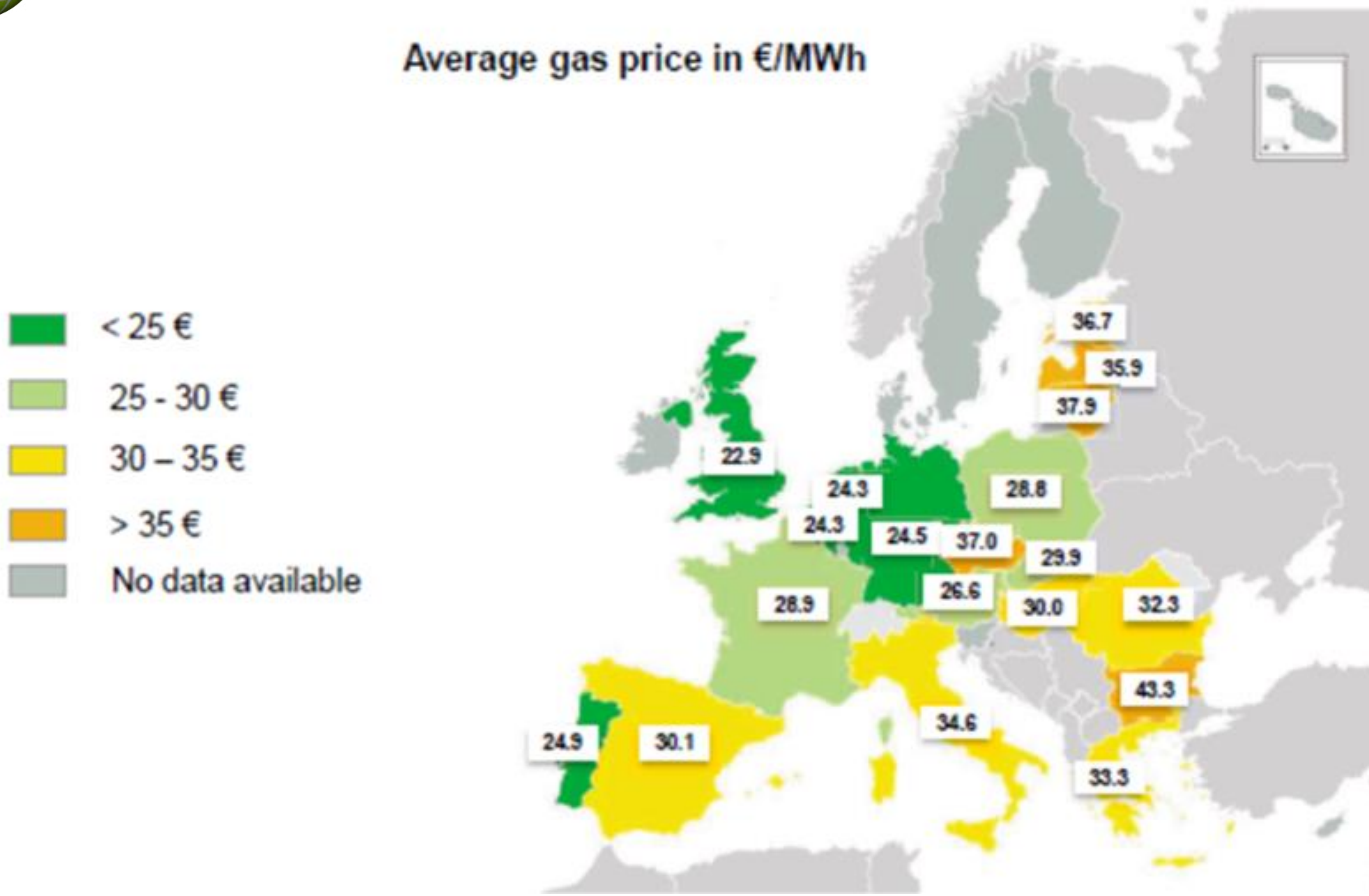
Revenue from landfill tax in Million € / a (total revenue per year)



3 criteria:

- **Foreseeable for (at least 10) 20 years**
- **Environmental standard of the landfill**
- **Quality of waste to be landfilled**

Gas prices vary significantly across the EU region depending on the level of Competition



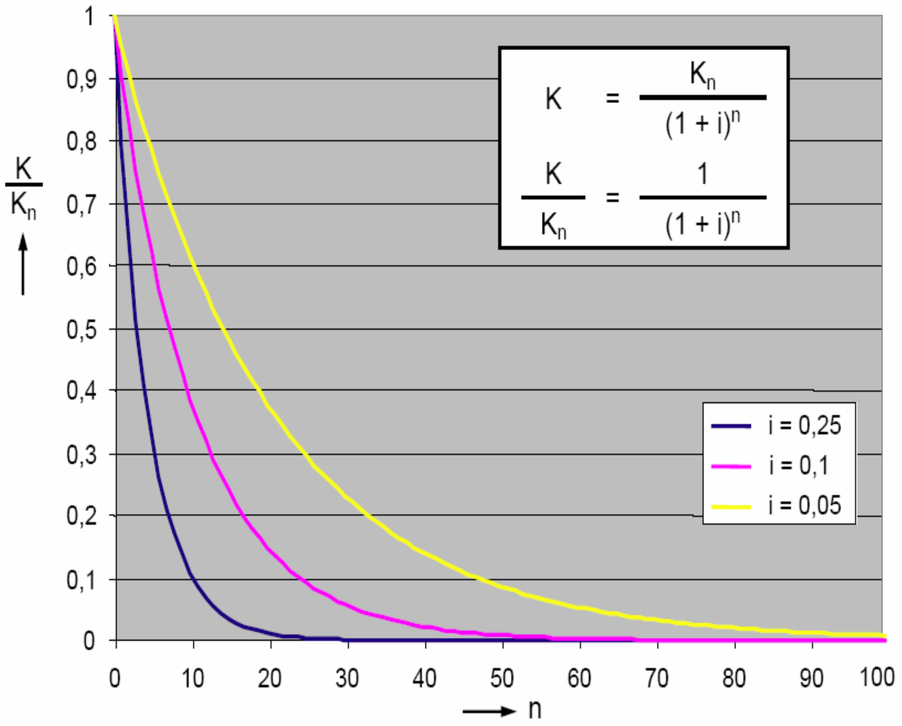
Source: “Energy challenges and policy“, European Commission, May 2013

Discounting of the future (?) - Effect of the interest rates on the Net Present Value for future cash flows

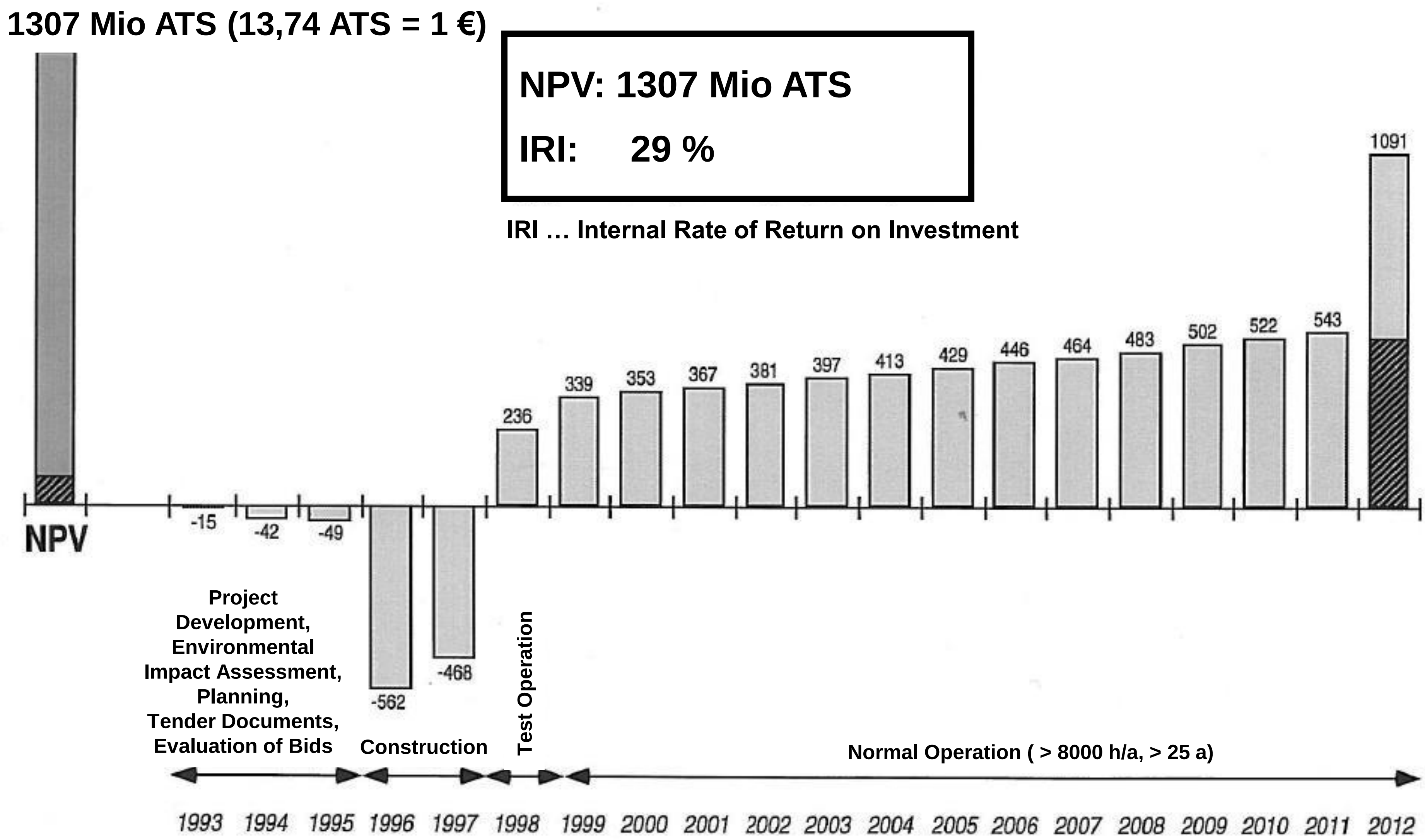
$$K = (R_0 - E_0) + \frac{R_1 - E_1}{(1+i)} + \frac{R_2 - E_2}{(1+i)^2} + \ldots + \frac{R_n - E_n}{(1+i)^n}$$

K ………. **Net Present Value**
R ………. **Revenue**
E ………. **Expense**
i ………. **Interest rate**

Index ….. **Year, calculated from the present (t=0) to the end of economic use (t=n)**

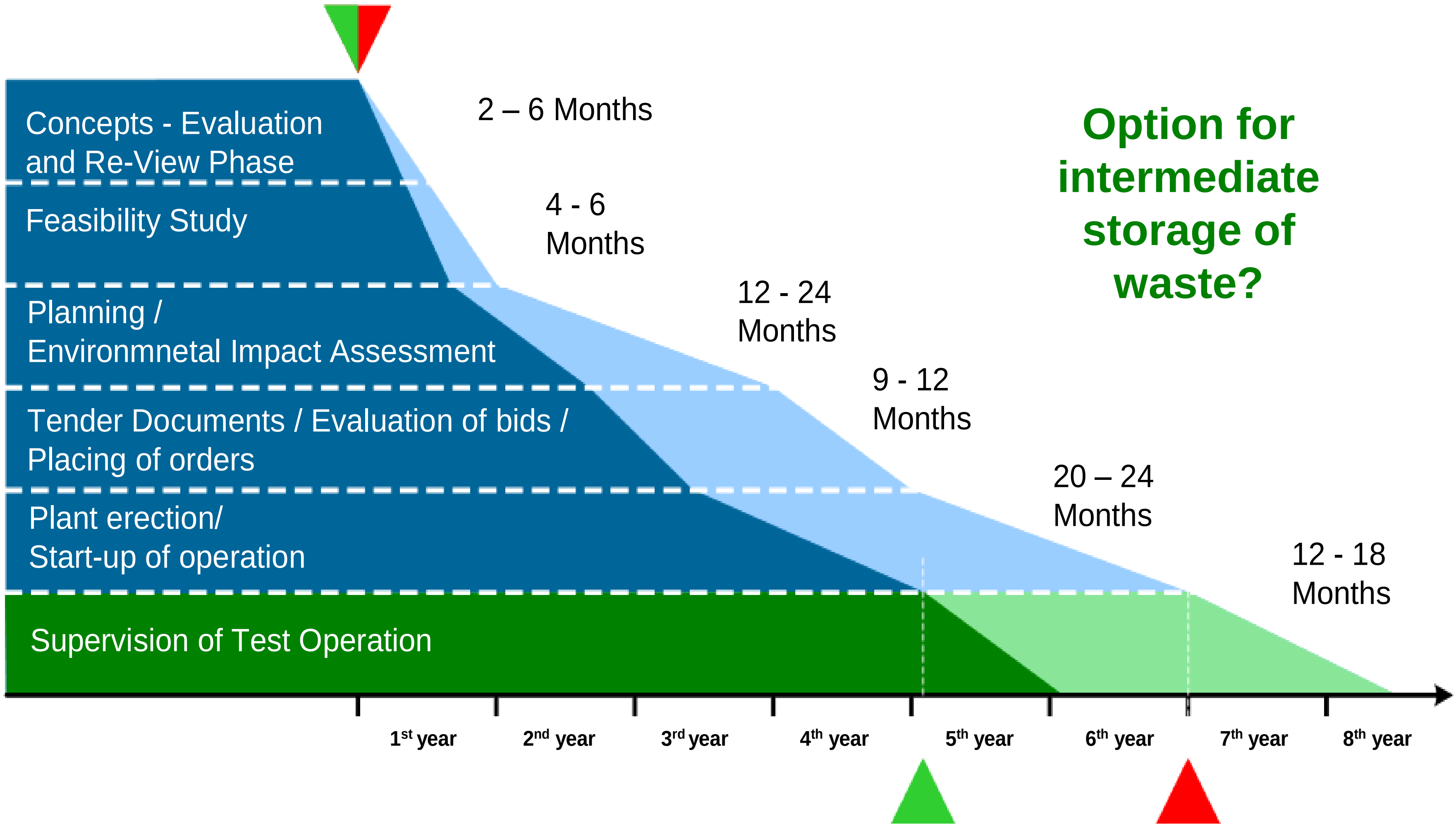


Example for NPV-Analysis – Project Development “LASER“ Waste-to-Energy for Industrial Co - Generation (UV&P 1993)



Activities and Time Schedule for Project Implementation of Large Waste-to-Energy Treatment Projects

Necessary time from project start until start-up of operation: min. 4 to approx. 6 years

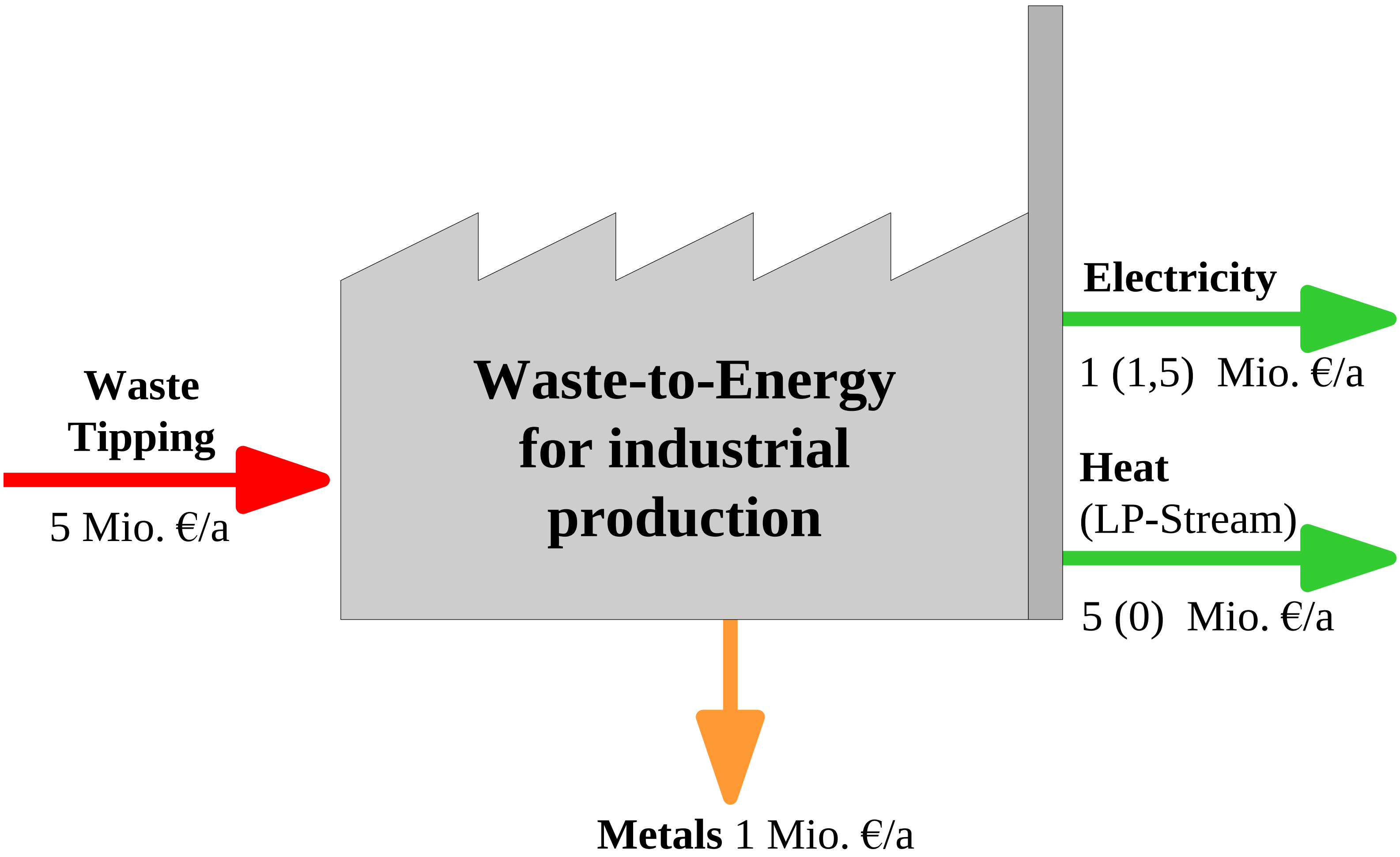


Example for State-of-the-Art Intermediate Storage of Wastes in Plastic-wrapped Bales: Thermal Capacity (MW) = (MJ/kg)*(kg/s)

Foto: W. Kletzmayr, 2006

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

Example for Revenues 2014 for Waste-to-Energy in a small 40 MW BFB – Boiler with Integration to an Industrial Site in Austria



Source: Pusterhofer, October 2014

Precaution against New "Miraculous" Technologies

The **technical concept** should be based on:

- State-of-the-art technology (BAT) for such types of waste
- Proof 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 unproven 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.

And don‘t make the mistake …

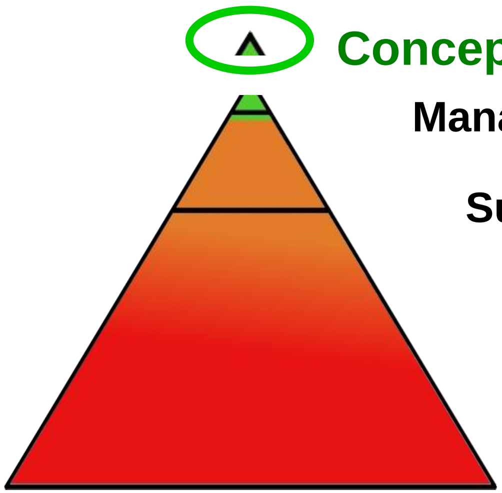
And don’t make the mistake …
Source: Stadtreinigung Hamburg-2008

Typical Mistakes in the Development of Waste Management based on Experience in Europe

	Principle	Practical examples for violation of principles
1	**Awareness**	Ignorance may cause substantial economic losses to present and future generations, health hazards and general environmental degradation (e.g. waste dumps: out of sight – out of mind)
2	**1st Law of Thermodynamics** (balances of mass and energy)	Technologies with technically foreseeable faults (e.g. inappropriate selection of sites with lack of utilization of heat from waste incineration)
3	**2nd Law of Thermodynamics** (increase of entropy)	Technologies with technically foreseeable faults (e.g. stranded investments in waste sorting plants for recycling of municipal garbage)
4	**Economic feasibility of project**	Lack of consideration of waste markets, of economies of scale and of necessary cooperation
5	**Public information** and social acceptance of project	Lack of information and/or investment in public credibility of project applicants may prevent even environmentally friendly projects because of the "NIMBY-syndrome" (Not In My Back-Yard)
6	**Civil law and civil conduct**; **Control and enforcement of law**	Fraud, corruption, overregulation, ignorance, Laissez-faire in enforcement of environmental law and standards by governmental authorities
7	**Foreseeable political development based on sustainability and legal justice**	Increasing bureaucratic costs and stranded investments caused by unforeseen political changes with subsequent frequent changes of regulations and/or of enforcement (e.g. delay of enforcement action; permits for waste export)

Overall Costs for Project Development, Implementation and Operation of a Waste-to-Energy Plant

Typical Cash-flow of large Waste-to-Energy Plants over Lifetime (e.g. in Asutria: RVL Lenzing, EVN Lower Austria, RHKW Linz)



Concept- and Feasibility Studies approx. 0.2 – 0.5 Mio. Euro

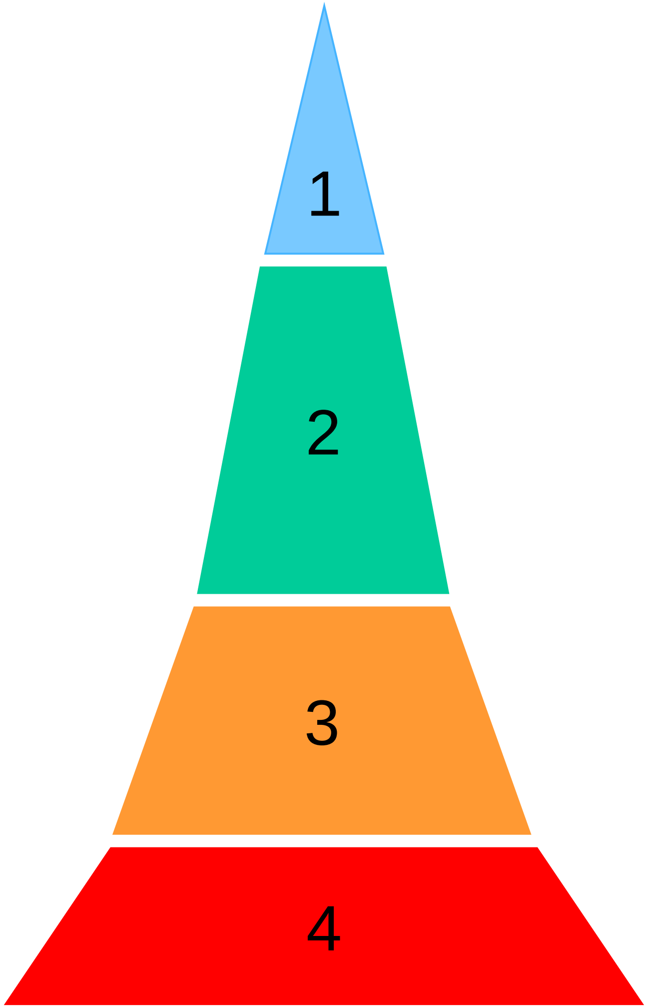
Management, Consulting & Engineering approx. 10 Mio. Euro

Supply and Construction approx. 100 – 200 Mio. Euro

Operation and Maintenance of Plant: Turnover (approx. 40 years lifetime) approx. 600 – 2,000 Mio. Euro

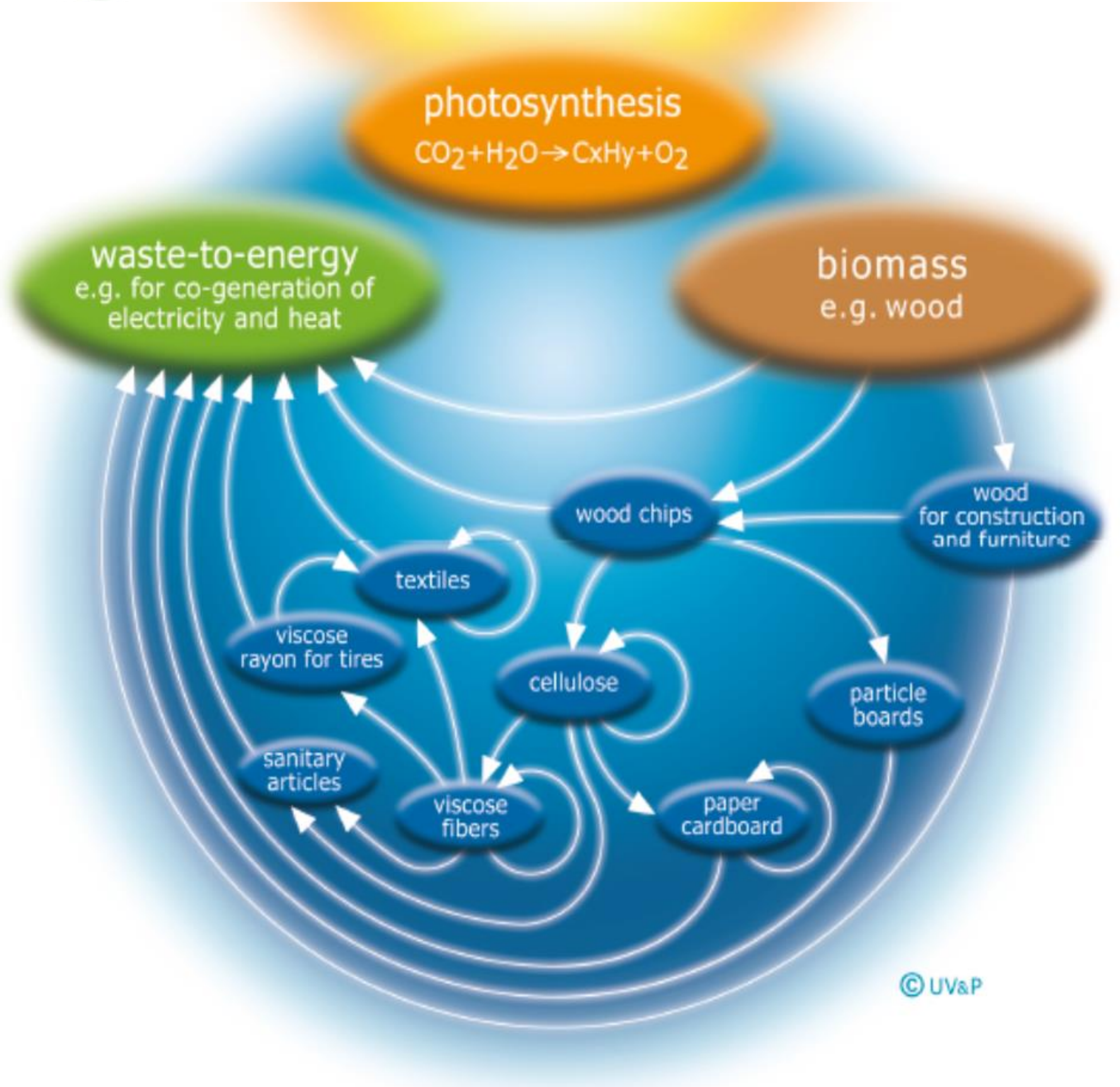
Recommendation:
The determining factor for <u>future success</u> is the competent development and systematic evaluation of relevant technical alternatives and feasibility studies by independent expert teams in cooperation with local partners (costs < 0,01-0,1%!)

Technical cooperation with local institutions and firms:



1. **Concept**
   - Analyses of Status-Quo and Prognosis
   - Master-Plan for Project Implementation
   - General Concept for Project Design
2. **Planning, Procurement**
   - Project Design
   - Feasibility Study
   - Environmental Impact Assessment
   - Basic Engineering
   - Tender Documents
   - Evaluation of Bids
3. **Construction**
   - Detail Engineering
   - Project Control
   - Training of Operating Personnel
   - Supervision of Start-up
4. **Operation**
   - Maintenance Supervision
   - Environmental Audit

Sustainable Development based on Renewable Resources, Recycling and Recovery



The ultimate policy for quality of life must be based on sustainable economics.

We must protect the environment and preserve the uniqueness of our planet.

We work together towards this goal.

Controlled incineration of (residual) wastes is – according to state-of-the-art and experience in Austria – an absolutely necessary part of sustainable development.

Our projects for waste management demonstrate the highest standards in environmental protection and economic sustainability.

UVP, since 1991.

Think Globally • Work Locally

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We always cooperate with local partners!