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Experiencias y estrategias globales

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Outlook of the energetic utilization of waste

-Factors of success in Germany-

Dr. Helmut L. Schnurer
Deputy Director General (retired), Federal Ministry for the Environment

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SECRETARÍA DE ENERGÍA

SEMARNAT
SECRETARÍA DE MEDIO AMBIENTE Y RECURSOS NATURALES

Embajada de la República Federal de Alemania
Ciudad de México

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AGENDA

1. Development of waste techniques from the early days until today
2. Development of legal regulations
3. Some important features of the German way for waste management
4. New technologies
5. Contributions to climate protection and resource recovery

Total amount of waste (2012) 332,000,000 tonnes per year

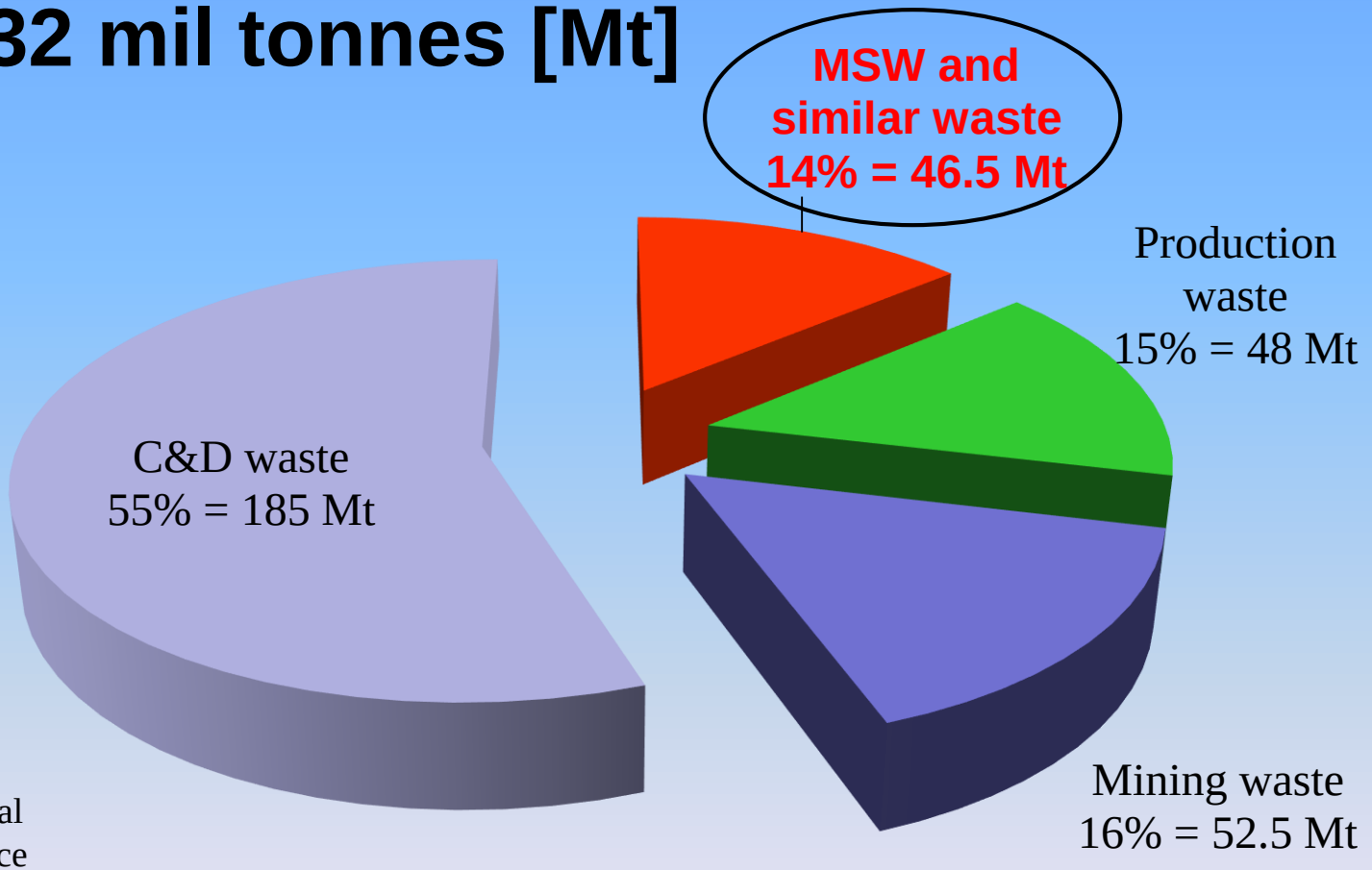
Today: 78% recycling or energy recovery

This was in our early days

MSW: 456 kg per head and year

Almost 100% recycling and energy recovery

Total waste production in Germany 332 mil tonnes [Mt]



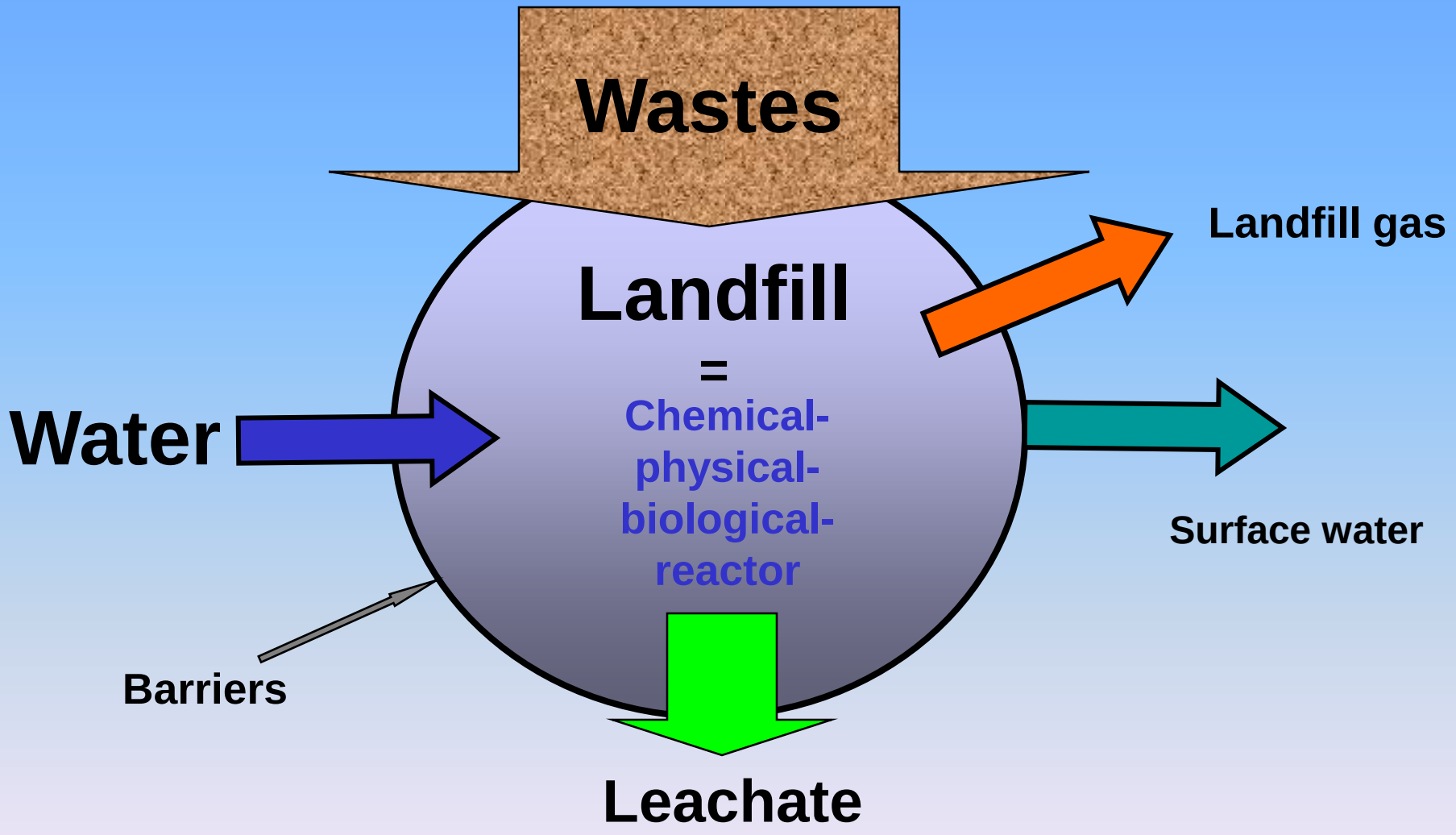
[Source: Federal Statistical Office 2012]

Situation up to 1990

- Increasing amounts of waste
- Waste more complex
- No space for new landfills!!!
- Increasing costs
- Export to distant regions created political problems
- Environmental problems

Dumping of waste became a severe problem

Landfilling creates Problems



Why it is not possible to make landfilling of MSW safe?

- **MSW generates leachate and gas (a.o. methane)**
- **In order to protect the environment we would need a sophisticated barrier system with a long term reliability - long term reliability does not exist**
- **The leachate control is not perfect and will fail**
- **The collection and control of landfill gas is not efficient (collection rate only up to 50%)**

➔Landfills on the long term are harmful to groundwater, supply of drinking water, health of citizen, climate – and may create contaminated sites, they waste resources

Landfilling of MSW is not sustainable

First steps in the right direction

- **Shut down of all uncontrolled dumps after 1970**
- **They have been replaced by larger, engineered and central landfills:**
  - **bottom and surface liners**
  - **gas collection and incineration of landfill gas**
  - **leachate collection and treatment / energy recovery**
  - **higher costs for landfilling promoted recycling**
- **Increase recycling instead of disposal of waste**
  - **Bio waste for composting**
  - **Waste paper (newspaper etc.)**
  - **Glass bottles**
  - **Metal scrap**
  - **Packaging waste (after 1989)**

Example for recycling and recovery

(NRW - North Rhine Westphalia, year 2006)

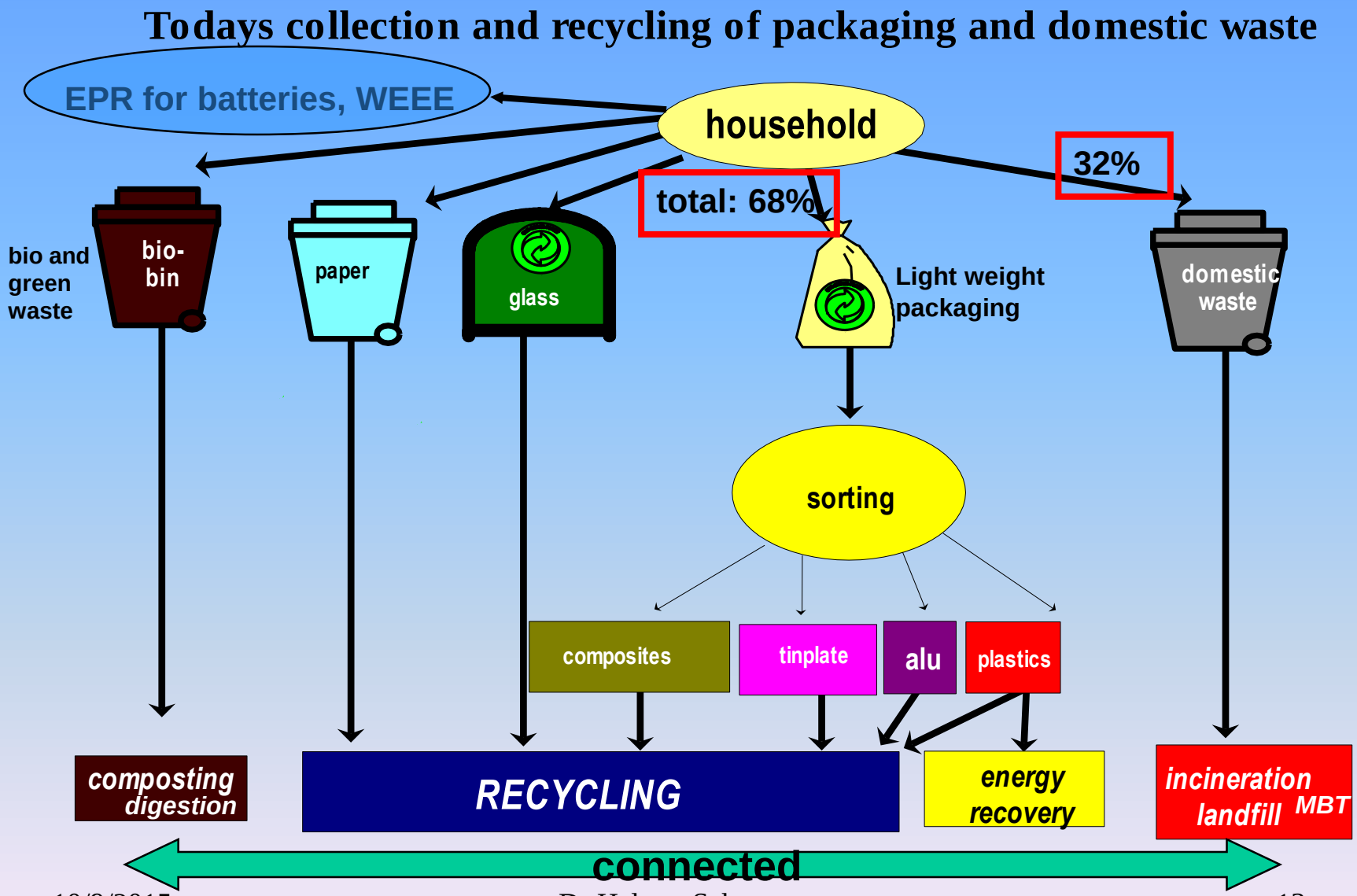
Type of waste	Collection kg/p.year	Recycling %	Energy recovery %	Other %
Bio-waste	64	89 / comp.	11 /digestion	
Green waste	40	87 / comp.	1 /digestion	12 / sorting
Paper	72	90	10	
Glass	22	95		5
Packaging	34	80	20	sorting
Metals	2	100		
Wood	7	48	52	
Bulky waste	37	49	51	
Residual waste	190	13 / sorting	81	6 / MBT


Recycling can be very interesting!!!

Bio waste recovery

- **Currently 100 kg/y of bio waste is separately collected per citizen on the average (9 Mt/y)**
- **Around 48% is bio waste from households and 52% is green waste from gardening, agriculture and forestry**
  - **Most of these wastes go for composting (stringent criteria exist about input into composting plant and its operation)**
  - **Energy demand for composting is higher than credit from substitution of fertilizer**
  - **Anaerobic digestion (of bio waste) is increasingly used to generate bio gas for electricity, heat or gas supply**
  - **Higher costs for anaerobic digestion are reduced by funding bio gas via the German Renewable Energy Law**
  - **Contaminated bio waste and crude material (including waste wood) go for energy recovery**
  - **Since 2015: mandatory separate collection of bio/green waste**

Germany's Approach to Resource Recovery



But, not all waste can be avoided, or recycled; at least not presently!

Restrictions in terms of technology, economy or market exist!

Attempts to design engineered landfills with long term safety failed!

What should be done with the remaining residual Municipal Solid Waste?

Our Solution: Pre-treatment

- **If landfills cannot d*ispose* of arising MSW safely – such waste has to be pretreated in order to produce waste which could be managed safely!**
- **Pre-treatment of MSW must guarantee**
  - **very low contents of organic substances (<3% TOC)**
    - **to avoid aerobic and/or anaerobic decay which will produce landfill gas in landfill**
  - **separation of soluble hazardous substances**
    - **to avoid hazardous leachate in landfill**
  - **Separation of secondary waste for recycling/recovery**
- **Such requirements can be fulfilled by thermal treatment of MSW**

No go for landfilling in 1993

Restrictions for landfilling: All MSW has to be pre-treated since 1993 (deadline was June 2005)

Regulations do not define the way – but the results:

➔**Specifications for pre-treated waste**

➔**Stringent requirements to reduce and avoid emissions into air and into water**

New criteria for landfilling (1993)

1. **Technical Standards for the construction and operation of new landfills (barriers, gas and leachate collection and treatment)**
2. **<u>Specification limits for waste to landfill</u>:**
   - **content of organic substances :**
     - **5% for glowing loss, or alternatively**
     - **3% for total organic carbon (TOC)**
   - **Leachate concentrations for a large number of soluble hazardous substances**
     - **mainly heavy metals, phenol, arsenic, fluoride, cyanides a. o.**

Specifications can (easily) be achieved by thermal treatment of MSWI (W2E)

- **As a consequence it was necessary to replace landfilling of MSW by waste incineration within 12 years (deadline 2005)**
- **In 2001 a legally binding Ordinance opened an alternative to W2E – MBT (Mechanical Biological Treatment)**

New German emission standards for waste incineration

(became later the EU Waste Incineration Directive) [2000/76/EC]

- **Stringent emission limits have been decided in 1990 (amended May 2013)**
- **Limit values are more stringent compared to industrial thermal plants**
- **New boundary value: 0.1 ng/m^3 TEQ for dioxins and furans in the off gas**
- **Limit values also for heavy metals, SO_2, NO_x, dust and others**
- **As a consequence: sophisticated flue gas cleaning systems (including active carbon filter ➔"police filter")**
- **Operators must now monitor and report emissions and are controlled by superior authority**
- **Actual emissions in MSWI today are significantly lower than the existing legal limit values**
- **Citizen have to be informed about real emissions**

Limit Values of 17th Ordinance (1)

(recently amended version from May 2013)

Parameter	Unity	Average per day	Half hour limit	Mean value per year
dust	mg/m3	5 (10)*	20	-
TOC	mg/m3	10	20	-
HCl	mg/m3	10	60	-
HF	mg/m3	1	4	-
SO2	mg/m3	50	200	-
NOx	mg/m3	150 (200)*	400	100
Hg	mg/m3	0.03	0.05	0.01
CO	mg/m3	50	100	-
Ammonia	mg/m3	10	15	-

Minimum temperature of 850 C for at least 2 sec, O2 content 11%
( )* Values for plants with firing thermal capacity <50 MW

Limit Values of 17th Ordinance (2)

(recently amended version from May 2013)

Mean values over sampling period per group	Unity	value
Cd, Tl	mg/m3	0.05
Sb, As, Pb, Cr, Co, Cu, Mn, Ni,V, Sn	mg/m3	0.5
As, Benzo(a)pyren, Cd, Co, Cr	mg/m3	0.05
Dioxine/Furanes	ng/m3	0.1
Mean value per year of NOx	mg/m3	100

Minimum volume concentration of O2 has to be 11%

Slightly less ambigous limit values apply for incinerators with less than 50 MW,

Emissions from waste incineration

(per 100 000 t of MSW)

Before1990

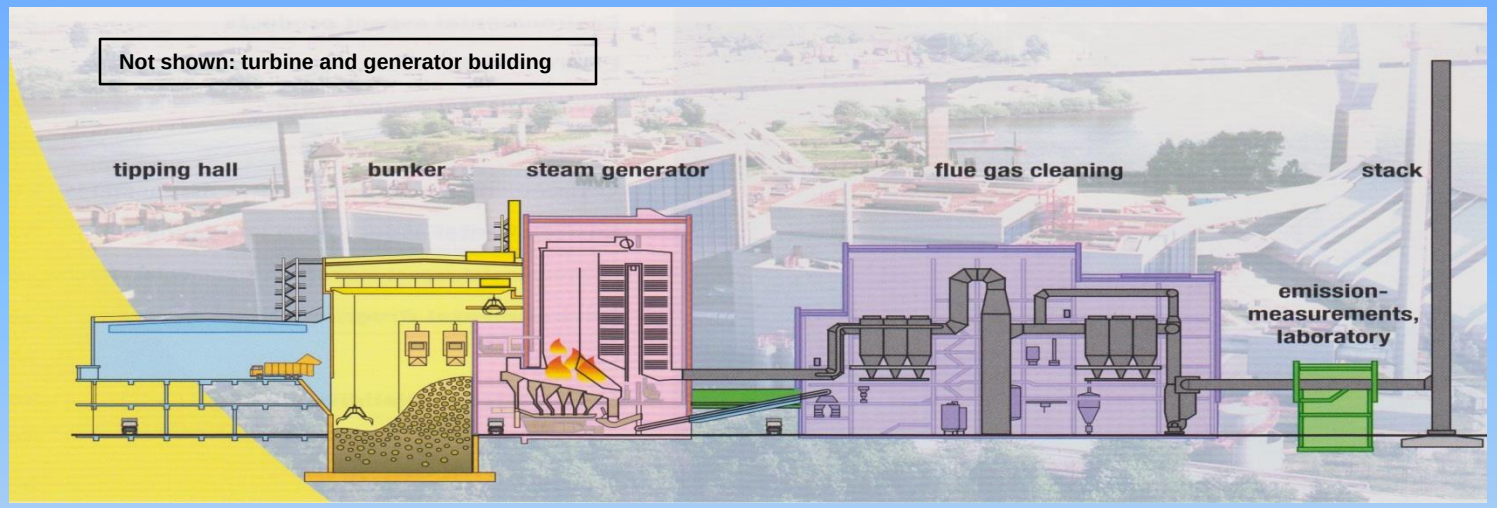
210,000 t NOX
410,000 t SO2
180 kg Cd
130 kg Hg
6 g Dioxin

Today

36,000 t NOX
0.9 t SO2
1.2 kg Cd
1.2 kg Hg
0.003 g Dioxin

Today: Best Available Technology

-defined by EU legislation -



- **Very (!) low emissions,**
- **high efficiency in recovering of heat <u>and</u> electricity,**
- **use of different by-products by producing acid, gypsum, other**
- **use of bottom ash as a construction material**
- **no landfilling, only small amount of filter ash has to be deposited (underground storage in Germany)**

example: MVR-Hamburg

Efficiency of a modern MSWI

Example: MVR Rugenberger Damm, Hamburg

1. **Capacity of 1,000 tonnes of MSW per day**
2. **Combined energy recovery and recycling results:**
   - **Electrical power: 40,000 MWh/y**
   - **Steam: 440,000 MWh/y (industrial user)**
   - **Hot water: 50,000 MWh/y (district heating)**
   - **Ferrous and non-ferrous metals: 8,000 t/y**
   - **Commercial-grade aggregate: 70,000 t/y (construction material from bottom ash)**
   - **Commercial-grade hydrochloric acid: 3,000 t/y**
   - **Commercial-grade gypsum: 1,000 t/y**

Advantages of W2E (1)

- **Waste incineration can be used for very different waste streams (also for bulky waste, sewage sludge, hospital waste a.o.)**
- **Grate firing can be seen as an „omnivore“**
- **Waste incineration has developed over the past 100 years, is a mature technology with high availability**
- **Other thermal treatment processes are only used sometimes for special wastes (e.g. homogenious waste like sludges in fluidized bed incinerators, tyres in cement kilns)**

Advantages of W2E (2)

- **Emission standards are much more stringent compared to other industrial facilities**
- **Actual emissions from W2E-facilities are significantly lower than the very low legal limit values (for dioxins/furanes lower by a factor 1000!)**
- **W2E can achieve almost 100% recovery rate (electric and thermal power, construction materials, metals, acid)**
- **Only 1-3% (in weight) are waste for disposal (fly ash, filter residues)**
- **As a consequence: The negative image of waste incineration has changed into rather broad public acceptance in Germany**

Siting criteria for W2E

- **No siting limitations due to very low emissions into air and no emissions into water**
- **If district heating (or cooling) can be used, siting can be close to residential areas**
- **W2E achieves a higher efficiency when thermal and electrical power can be produced/used simultaneously**
- **Advantageous would be an industrial customer to take over steam at all times (many examples in D)**
- **Many W2E facilities have been erected close to power plants, which take use of the generated steam and transfer it to higher steam parameters ➔no turbine/generator necessary, lower costs, higher energy efficiency**
- **Advantageous would be transport of MSW by rail/ship (in addition to truck)**

MSWI Nuernberg

- Modern architecture
- Close to zero emissions
- Close to the city
- Connected to district heating
- Also railway for waste transport

Waste to Energy Concepts

Type of waste / Type of incinerator	**MSW** (+ some other waste)	**Industrial Waste** (solid, pasty, liquid)	**Sewage sludge** (dewatered)
Grate Firing (different types)	**X**	(x)	(x)
Fluidized Bed (stationary, rotating, circulating)	(x)	(x)	**X**
Rotating Kiln (haz. waste incinerator)		**X**	
Co-Incineration (cement kiln, fossil power plant)	x (pretreated)	(x) (pretreated)	x (pretreated)

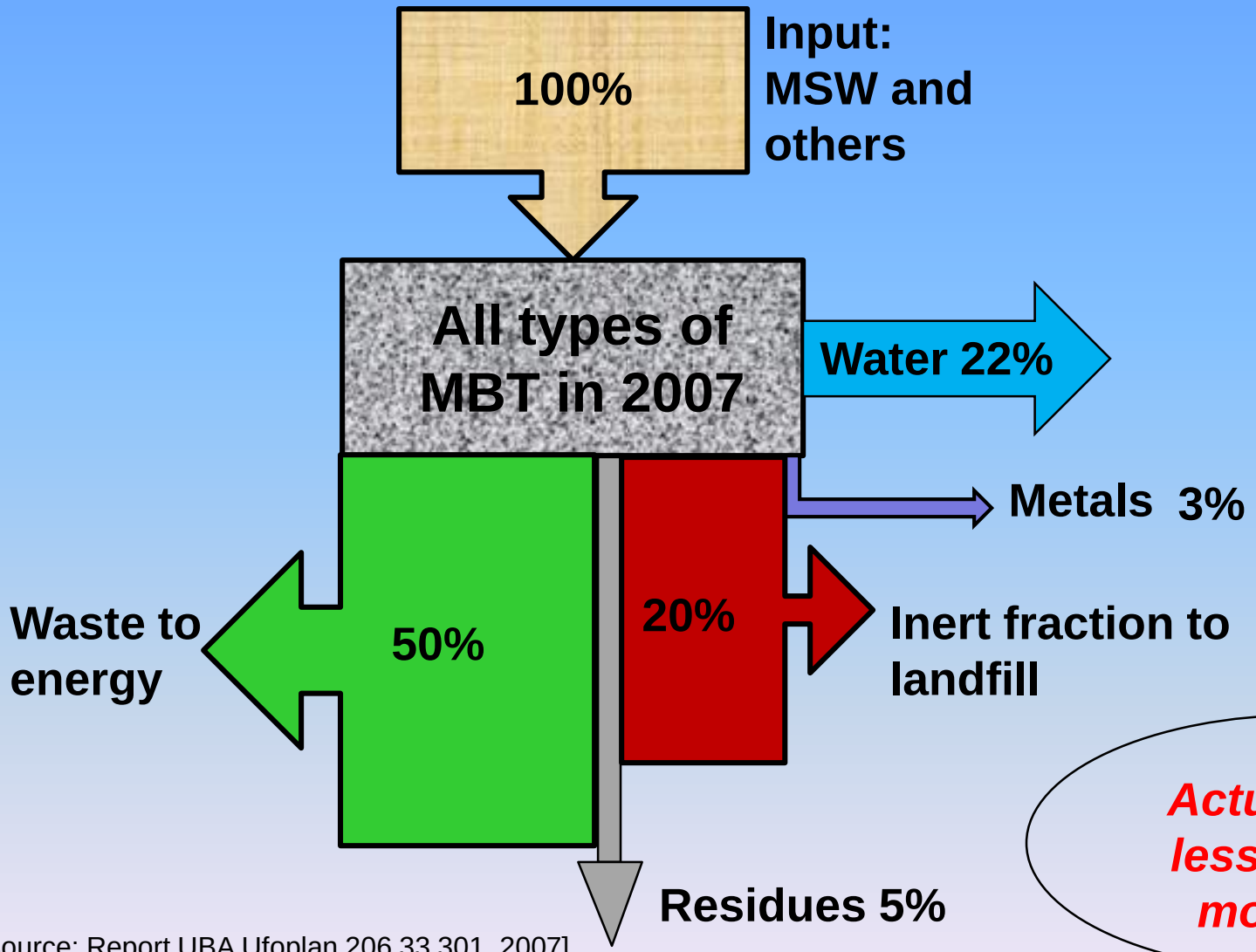
Our solution in Germany for residual MSW

- **Save waste management without landfilling can be achieved by:**
  - **Thermal treatment of waste (conditions apply for temperature, exposure time, emission standards)**
  - **In principle, grate firing, fluidizes bed, rotating kiln, pyrolysis, gasification or other techniques are possible**
  - **In Germany today only proven technology is used: grate firing for MSW, rotating kiln for homogeneous waste and hazardous waste, co-incineration for refuse derived fuel (RDF)**
  - **One alternative to thermal treatment of MSW: Mechanical-Biological-Treatment (MBT)**

Mechanical – Biological Treatment (MBT)

- **Different techniques are used:**
  - **Mechanical shredding and sorting (recycling and W2E)**
  - **Mechanical shredding and aerobic drying (sorting, recycling and W2E)**
  - **Mechanical shredding and anaerobic treatment (generation of bio-gas and sludge)**
  - **Combined processes**
- **Requirements:**
  - **Inert fraction may be landfilled, if among others: TOC <18% and heating value <6000 kJ/kg**
  - **Fraction with high heating value must go for energy recovery**
  - **Emission limits must been met (bio-filters are not sufficient)**

Flow diagram for MBT



Actual trend:
less landfill -
more W2E

[Source: Report UBA Ufoplan 206 33 301, 2007]

Advantages of MBT

- **MBT can be realized locally for smaller amounts of waste**
- **MBT can reduce water content – increase calorific value of wet waste for incineration**
- **RDF can be used as an energy source in existing power stations, special plants or cement kilns**
- **MBT is superior to landfilling - if MSWI is not appropriate or possible**

Increasing use of RDF for power production in Germany

- **Total amount of secondary fuel (RDF) has risen to 5 Mt/y (including from waste wood)**
- **RDF is being used in existing power plants, cement kilns and in 30 specially designed industrial incinerators which deliver steam and/or electricity to**
  - **district heating or -cooling**
  - **paper mills**
  - **chemical industry**
  - **food producers**
  - **other next door industry**

Disadvantages of MBT

- **MBT is only an upstream facility and needs an industrial facility to incinerate the secondary fuel - and a landfill for the inert waste (➔ complex system of facilities and transports are necessary)**
- **Environmental effects for landfilling „inert“ fractions are worse compared to W2E (TOC up to 18% - compared to 3%)**
- **Mechanical and biological treatment consume energy - instead of energy recovery**
- **Operatig experience showed quite often technical and economical problems**

MBT experienced even accidents due to design failures

Explosion in MBA Göttingen, 2006

➔ Ranking for MSW Management

1. Material Recycling

of paper, metal, glass, plastic, bulky waste, waste wood, construction/demolition waste, electronic appliances, batteries, end of life vehicles, pharmaceuticals, textiles, shoes and other wastes…

2. Biological treatment

(Composting or digestion)

3. Energy Recovery

(including RDF from MBT)

4. (no) Landfilling

Integrated WM-Systems

MSW is only part of the whole waste being generated

- An important other waste stream is sewage sludge
  - Utilization as a fertilizer in agriculture will be phased out in Germany (hazards of containing dangerous substances like heavy metals and chemicals)
  - As an alternative: mono-incineration, incineration in MSWI, in power stations or cement kilns (also after digestion to produce bio gas) will be necessary
- The biggest amount of waste – C&D-waste – goes to a large degree to recycling (70-80%); non recyclable fractions (wood, plastic, glass, stones) end up in waste incineration or landfills for inert waste
- Also certain hazardous wastes may be used in MSWI (e.g. SLF)
- All recyclable waste fractions produce after sorting also residues which cannot be recycled but must be incinerated or landfilled (if inert)

Results in Germany for W2E

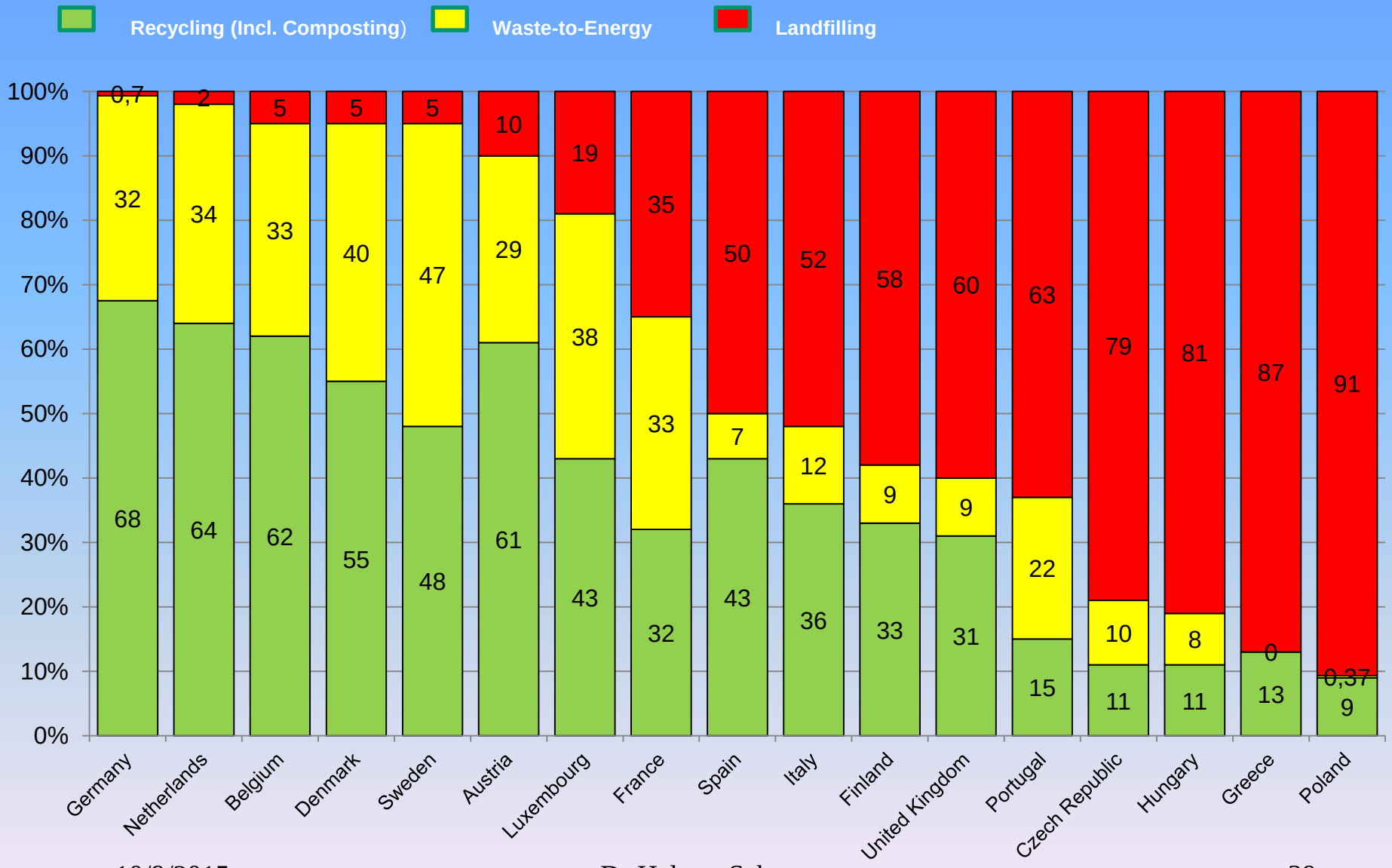
Public and private waste managers

- rely mainly on proven technology: Municipal Solid Waste Incineration (MSWI, mainly grate, a few fluidized bed)
  - 70 MSWI facilities are operating presently
  - Total capacity of 17.9 million tonnes per year ➔ (60%)
- others use Mechanical-Biological-Treatment (MBT)
  - 40 facilities with 7.2 million tonnes per year ➔ (24%)

    (some are transferred to bio waste treatment due to economical problems)
- RDF from MBT substitutes fossil fuels in coal fired power plants, cement kilns and special RDF power plants
  - presently 5 million tonnes per year ➔ (16%)
- But also other waste (waste wood, waste oil, mixed plastic, tyres, residues from recycling, shredder light fraction a. o.) to a large deal go for energy recovery

Treatment of MSW in some EU Member States

Source: EUROSTAT 2006



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Waste management needs obligatory legal regulations

- **Waste always tries to go for the cheapest disposal which is dumping or even illegal littering on land or into rivers/sea**
- **The producer or owner of waste tries to get rid of the waste without paying – or at least as little as possible**
- **Only valuable residues (like metals) easily find their way to recycling – there exists an economic incentive**
- **Only in poor countries waste pickers collect voluntarily valuable materials from waste**
- **With few exemptions, there is no market for mixed waste**
- **Therefore, binding rules are necessary which wastes should go which way!**
- **Rules and regulations have to be enforced**
- **Violations must be prosecuted**

Important steps in waste legislation (1)

- Our first waste law in 1972 phased out uncontrolled landfills which contaminated our environment
- Instead of small local authorities (50,000) larger counties or cities (440) became responsible for the management of waste
- They can exclude industrial waste from their responsibility (the producer will then be responsible)
- They can bring in private companies to act on their behalf
- They are supervised by the district/province authority
- Collection, transport and any management of waste need a license, issued from the superior authority
- Violations will be prosecuted by administrative courts

Important steps in waste legislation (3)

- **2006 was the year of implementing a very new paradigm – waste management shall no longer only be environmentally friendly – but should contribute to save resources**
- **Recycling now aims to substitute natural resources - raw materials and fossil fuel - and these have priority**
- **In the meantime most requirements for waste management have been regulated by European Directives – postulating a five level waste hierarchy:**

[Also of great importance: EU Regulations on Extended Producer Responsibility - for Packaging, WEEE, Batteries, ELV, Waste oil]

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Enforcement

- **Regulations on waste management exist on European, Federal, State, Provincial and even Municipal level (legislative level)**
- **Their adequate and timely implementation has to be enforced and controlled**
- **For that purpose we rely on split responsibility between the different levels of administration**
- **Responsible for waste management are larger counties/cities (not small communities)**
- **Responsible authorities and private of actors in waste management will be supervised by superior authorities**
- **The third power, our courts, prosecute violators**

The polluter pays principle

- **Waste management affords investments and costs for collection, transport, recycling, recovery etc.**
- **For MSW the responsible authorities calculate total costs and charge citizen an annual fee, depending on capita per household (alternatives exist)**
- **Total amount for 4-headed family may be on the average at 200 €/y (1 € per week per person!)**
- **If certain activities will be outsourced to private waste managing companies, the authority is obliged to call for tenders**
- **Waste from commercial producers will be charged depending on competition and market conditions**

Education and training

- **Modern technology of waste management needs qualified staff for operation and maintenance**
- **Responsible persons have to know, understand and being able to implement the rather complex regulatory and technical requirements**
- **Waste producers and waste managers have to nominate educated people who are assigned for being “waste expert”**
- **“Responsible waste experts” have to proof their respective qualification before the authorities**
- **As legal and technical requirements will be amended from time to time, responsible waste experts have to qualify themselves by attending repeated training courses**
- **Many universities have established chairs for waste management and educate students for waste management**

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Alternative Waste Techniques ?

During the last 20-30 years many so called „alternative technologies“ have been proposed as a „better alternative to proven technologies (like MSWI)“ in Germany and elsewhere:

- **Pyrolysis**
- **Gasification**
- **Plasma**
- **Depolimerisation**
- **Deep well injection**

None of these proved to be reliable or economical – most failed and produced enormous financial losses

Lessons to be learned

- **Established technologies for defined and clean substancies don‘t work automaticly for heterogeneous wastes ➔ MSW = chameleon**
- **Alternative technologies have to cope with:**
  - **Existing stringent emission standards**
  - **Warrant reliable continous operation**
  - **Verify a complete analysis of inputs/outputs**
  - **Proof of reliable costs (investment, operation, maintenance)**
- **Decisions to rely on alternative technologies need backup by other possibilities to manage the wastes – in case of the new technology system will fail (like it happened in Germany!)**

Consequences of missing reliability and availability and economy

Definitely the worst case for our environment (and economy)!

examples: Napoli, Italy

and not operating "new" technology in Germany

Pyrolisis: last plant (from 8) will be shut down at the end of 2015
Thermoselect: loss of 400 M€ at Karlsruhe
Gasification: Schwarze Pumpe has been sold for 1€

source: WDR, German Television, DUH 2007

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A new Experience: Waste Management contributes to Climate Protection

(Research report from BMU/UBA/Oeko-Institut/ifeu, January 2010)

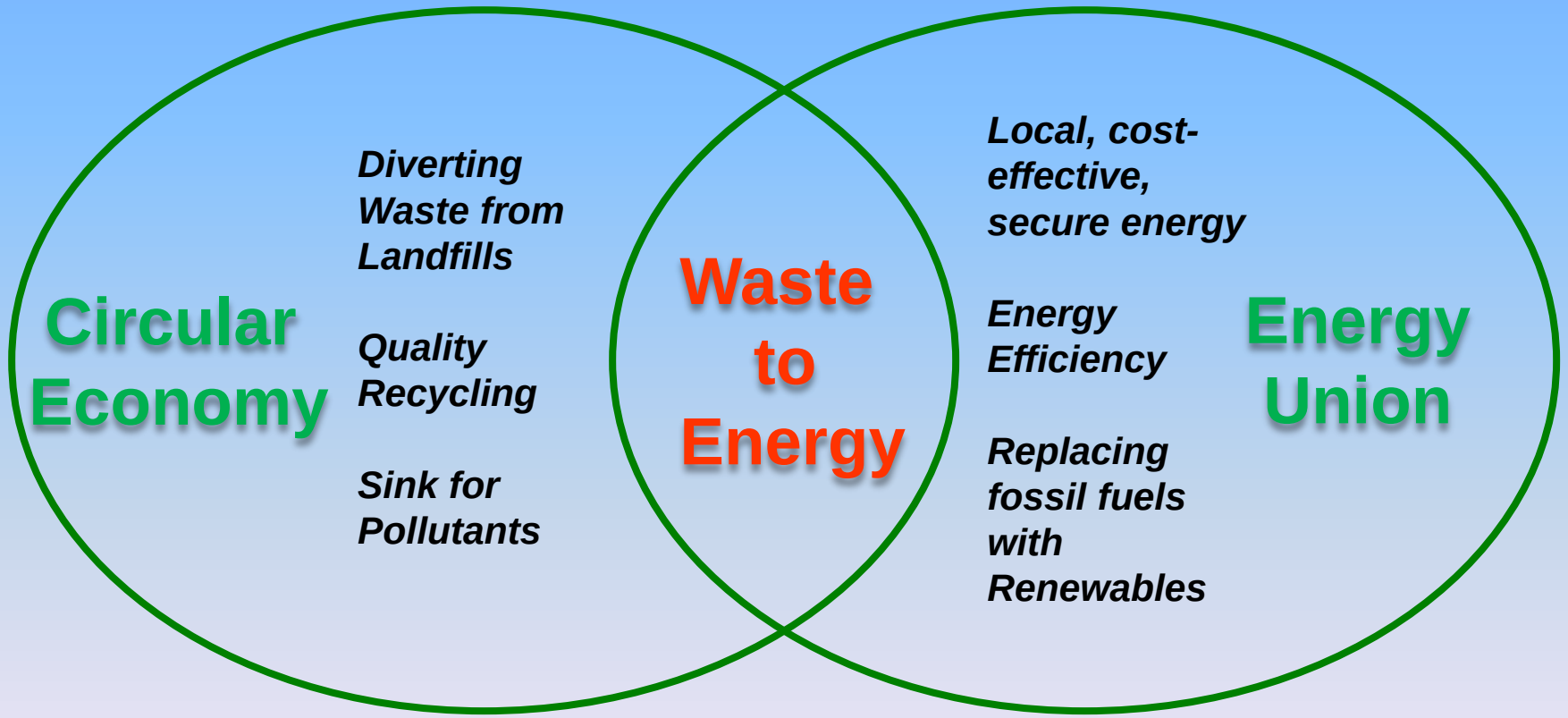
- **In 1990 methane-emissions from dumps caused 38 Mt of CO_2e/y in Germany**
- **Out phasing landfilling of MSW in Germany until 2005 has reduced such climate damaging gas emissions significantly**
- **Mayor other contributions for reduction of GHG emissions are:**

– MSWI and Co-incineration:	-2.3 Mt CO_2e/y
– Recycling of separately collected waste:	
– Paper, cardboard:	-6.0 Mt CO_2e/y
– Glass	-0.9 Mt CO_2e/y
– Light weight packaging	-2.3 Mt CO_2e/y
– Bio waste, garden waste	-0.1 Mt CO_2e/y
– Waste wood	-6.5 Mt CO_2e/y
Total reduction until 2006:	**-17.8 Mt CO_2e/y**

- **Out phasing landfills + increased recycling and recovery activities have contributed to a total reduction of 56 Mt CO_2e/y**

Waste-to-Energy as a part of EU-Circular Economy and Energy Union

[Publication by EU Commission, February 2015]



Waste Management has become a significant factor in Germany‘s economy, and the life of our people:

- Creating a high technology industry
- With an annual turn over of 83 billion Euros (2012)
- Has created more than 362 000 high grade jobs (2012)
- Promotes innovations in many associated areas
- Offers a solution for the environmentally safe handling of our large amounts of waste
- Reduces consumption of fossil energy and raw materials
- Helps to reduce climate damaging green house gases

➔ **WM is approaching sustainability!**

My conclusion

Waste to energy does not solve all waste problems

- but -

without waste to energy there will be no sustainable waste management!

THANK YOU FOR LISTENING

More information on
www.bmub.de
and
http://europa.eu.int