THERMAL TREATMENT AS A ONE SOLUTION FOR SUSTAINABLE WASTE MANAGEMENT

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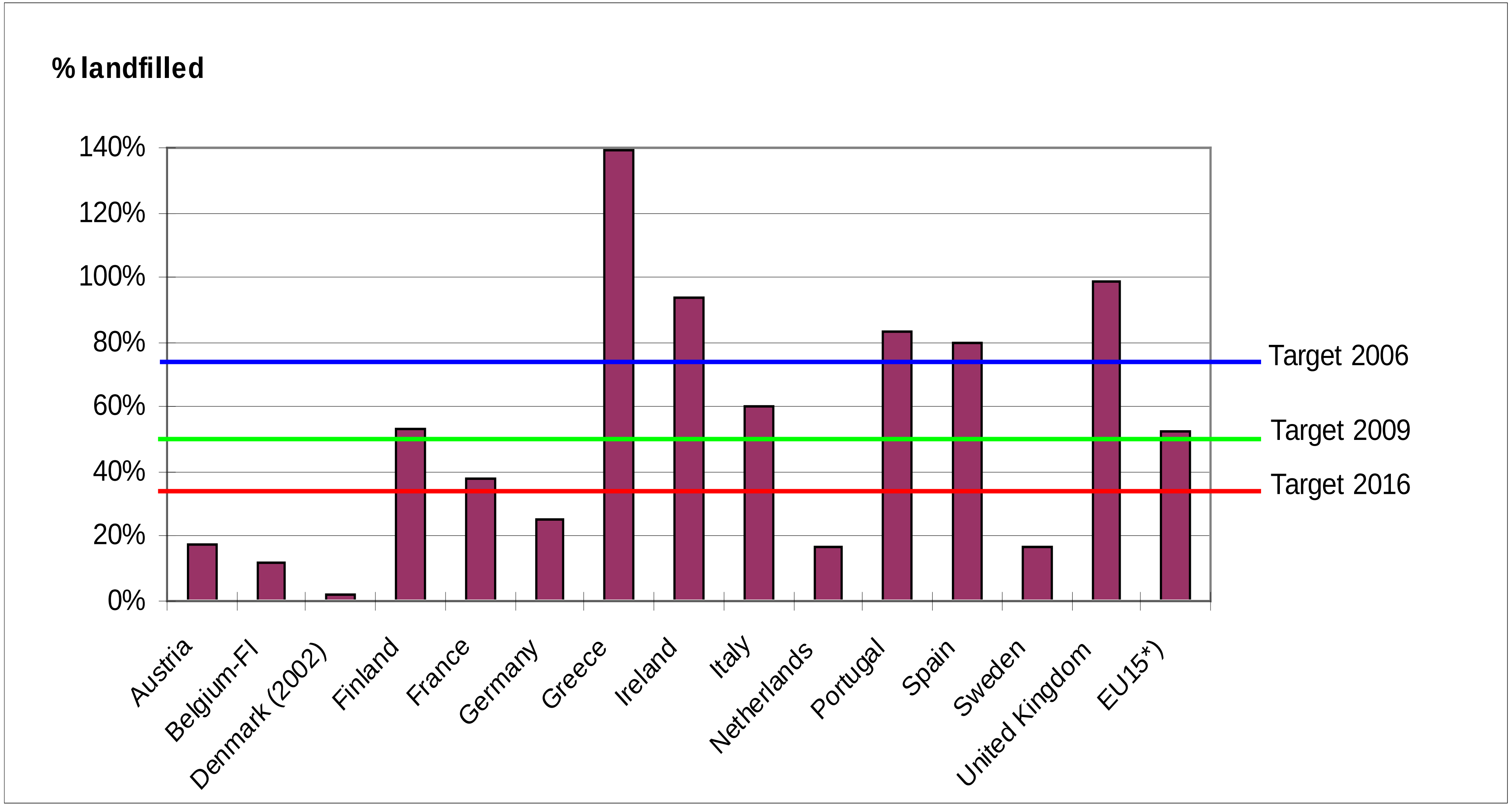
WTE – Landfilling – Mechanical Biological Treatment (MBT)

	WTE	Landfilling	MBT	**Best Environ. Performer**
Energy - Conservation	Highest	Low	Lowest	**WTE**
Resource – Consumption	Lowest	Highest	High	**WTE**
Waste - Reduction	Highest	Lowest	Low (only 1/3rd)	**WTE**
Smog, GHG's, Ozone Destruction, Acid Rain	Reduces	Increases	Increases	**WTE**
Risk – Water & Air pollution	Lowest	Highest	Low	**WTE**

Strategy on biodegradable waste
Distance to targets (2003)



Recycling and WTE in 10 Metropolitan Cities of the World

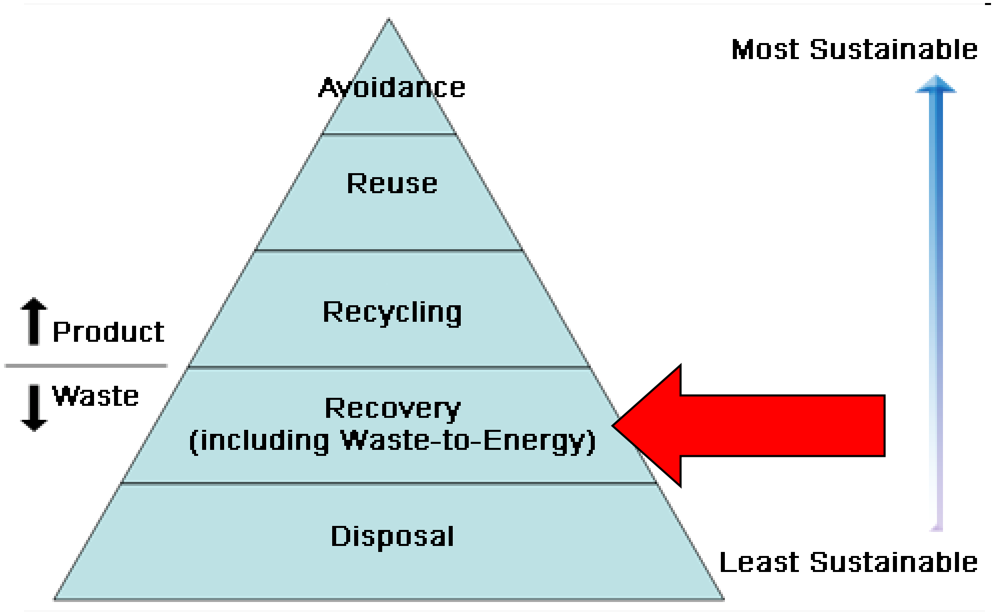
CITIES	POPULATION mill.	WASTE PRODUCTION mill. tones	RECYCLING	WTE	COMPOSTING	LANDFILLING
SINGAPORE	5,0	6,1	57%	41%	-	2%
BERLIN	3,4	0,7	50%	40%	10%	-
METRO VANCOUVER	2,3	3,4	51%	8%	7%	34%
VIENNA	1,6	1,0	23%	63%	11%	3%
MUNICH	1,4	0,6	44%	49%	6%	1%
COPENHAGEN	0,9	2,1	62%	25%	4%	9%
MALMO	0,7	2,0	20%	69%	6%	5%
LEE COUNTRY FLORIDA	0,6	1,1	46%	51%	3%	-
ZURICH	0,4	0,3	29%	62%	9%	-
MARION COUNTY OREGON	0,3	0,4	45%	34%	9%	12%

Challenges in some Member States and Candidates States

Observed issue…	**…in direct conflict with:**
Landfill disposal is by far the most common way	Waste Hierarchy Targets in Landfill Directive (diversion of biowaste)
In many cases, landfills are not compliant	Landfill Directive (minimization of environmental hazards)
No tradition or means (e.g. no separate collection) for recovery and recycling	Waste Hierarchy Targets in Packaging Waste Directive (recovery & recycling)
Poor application of Polluter Pays Principle and, in any case, significant affordability constraints	Significant investment needs to bring the systems up to the standards
Fragmentation of sector and weak institutional setting	Efficient use of (scarce) available resources

WASTE DISPOSAL IS HISTORY

Today the accepted objective of every responsible waste economy strategy must be **the use of waste as a resource.**



Five-step waste hierarchy according to EU Directive 2008/98/EC

Avoidance before reuse before recycling before other recovery (including WtE) before disposal.

Energy recovery from “wastes”(waste-to energy or WTE) is equivalent to recycling (E.U.)

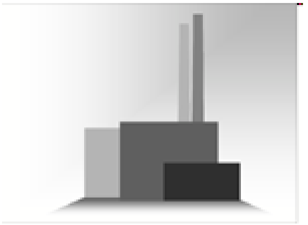
- Today, several countries such as Japan, Austria, Switzerland, Germany, the Netherlands, Korea and Singapore use WTE as the main process for treating post-recycling municipal solid wastes (MSW).

There are only two options for managing post-recycling wastes: Sanitary landfill or thermal treatment (WTE)

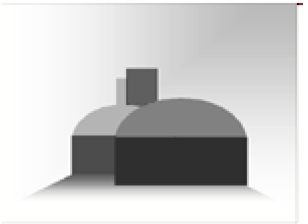
WTE advantages:

- Conservation of land near cities
- Energy recovery: 0.5 MWh/ton, over landfill gas recovery
- Reduction of Greenhouse Gas (GHG) emissions: 0.5-1 ton CO_2 per ton MSW (vs. landfilling)
- Esthetically more acceptable to communities; in fact only acceptable option in most developing countries.

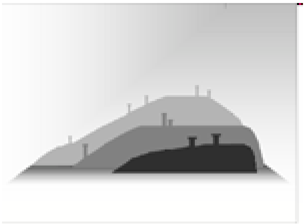
Treatments



Thermal Treatment
Recovers the energy, and partly material too, by direct combustion.



Anaerobic Treatment
Recovers the energy and material by fermentating organic wastes to generate biogas.



Landfill Gas Utilization
Ban on new landfills for untreated waste, however the methane emitted from current landfills must be used.

Basic facts about fuel and combustion

The Formation of Fuels

- Solar energy is converted to chemical energy through photo-synthesis in plants
- Energy produced by burning wood or fossil fuels
- Fossil fuels: coal, oil and natural gas
- solid (coal, MSW, …), liquid, natural and off gas

Properties of Fuels

✓ **Physical properties**

- **Heating or calorific value (GCV)**
- **Moisture content**
- **Volatile matter**
- **Ash**

✓ **Chemical properties**

- **Chemical constituents: carbon, hydrogen, oxygen, sulphur**

✓ **Proximate analysis of coal**

- **Determines only fixed carbon, volatile matter, moisture and ash**
- **Useful to find out heating value (GCV)**
- **Simple analysis equipment**

✓ **Ultimate analysis of coal**

- **Determines all coal component elements: carbon, hydrogen, oxygen, sulphur, other**
- **Useful for furnace design (e.g flame temperature, flue duct design)**
- **Laboratory analysis**

Waste characteristics

Different waste types have different heat values *ie* the amount of heat released during complete combustion - Calorific Value (CV)

- Gross Calorific Value (CV) includes heat released by steam condensation
- Net Calorific Value does not include the heat from condensation

Also important:

- Flash point
- Viscosity
- Chlorine, fluorine, sulphur & heavy metals

Examples of Calorific Value

Mixed waste from plant cleaning operations	10,000 - 30,000 kJ/kg
Wastewater	5,000 kJ/kg
(0 - 10,000kJ/kg depending on organic content)	
Industrial sludge	1,000 - 10,000 kJ/kg
Paints and varnishes	>20,000 kJ/kg
Chlorinated hydrocarbons	5,000 - 20,000 kJ/kg

MSW = < 10,000kJ/kg

Serbian lignite coal max. 9000 kJ/kg

Performance Evaluation

Principles of Combustion

- Combustion: rapid oxidation of a fuel
- Complete combustion: total oxidation of fuel (adequate supply of oxygen needed)
- Air: 20.9% oxygen, 79% nitrogen and other
- Nitrogen: (a) reduces the combustion efficiency (b) forms NOx at high temperatures
- Carbon forms (a) CO2 (b) CO resulting in less heat production

Performance Evaluation

Principles of Combustion

- **Control the 3 Ts to optimize combustion:**

1T) Temperature

2T) Turbulence

3T) Time

- **Water vapor is a by-product of burning fuel that contains hydrogen and this robs heat from the flue gases**

Good practice in waste combustion

3 Ts:

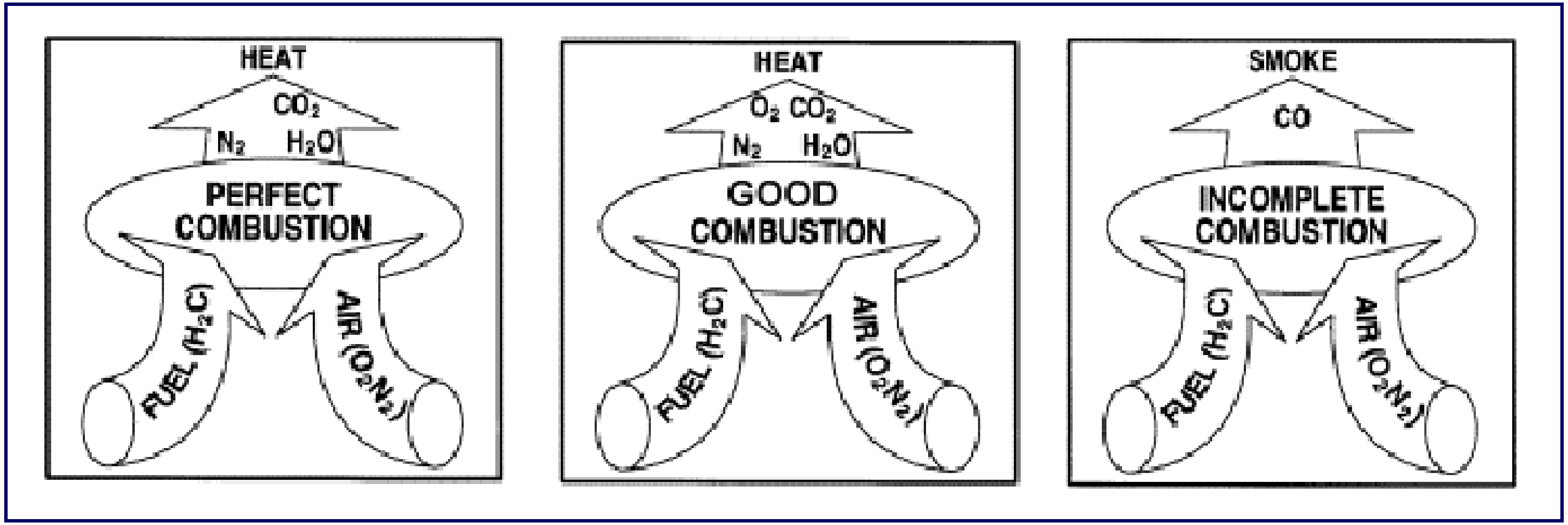
- **Time – 2 or 3 sec**
- **Temperature – 850 or 1100 ^{o}C**
- **Turbulence – good mixture of oxygen and fuel**

Flue gas cleaning systems

Performance Evaluation

Principle of Combustion

Oxygen is the key to combustion



Performance Evaluation

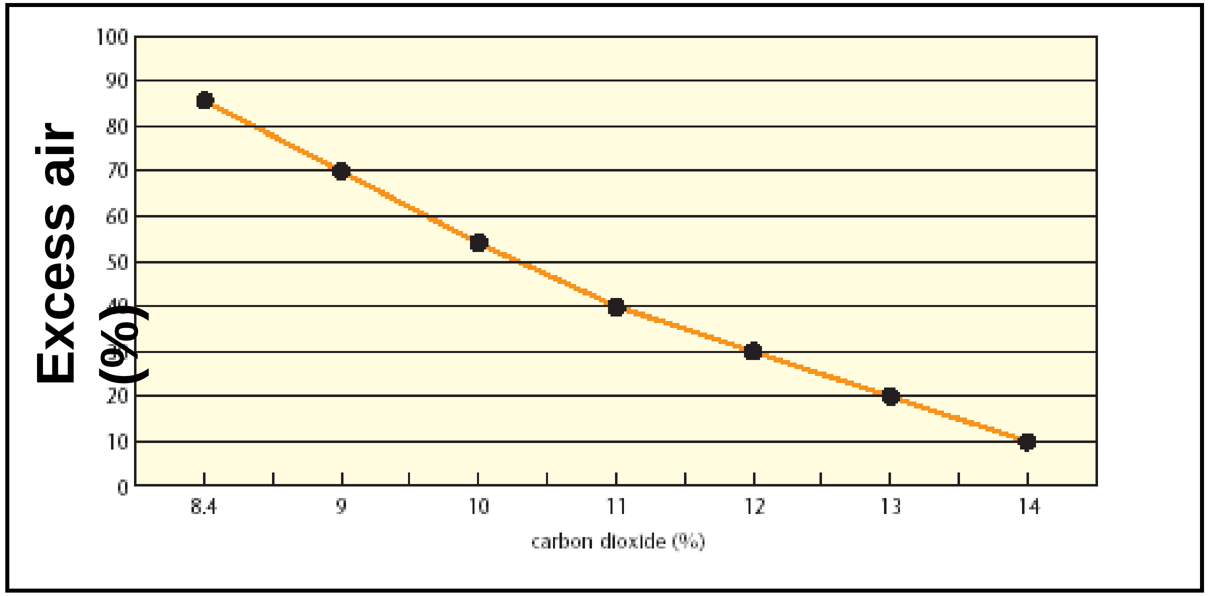
Stochiometric calculation of air required

- ✓ Stochiometric air needed for combustion of furnace oil
- ✓ Theoretical CO2 content in the flue gases
- ✓ Actual CO2 content and % excess air
- ✓ Constituents of flue gas with excess air
- ✓ Theoretical CO_2 and O_2 in dry flue gas by volume

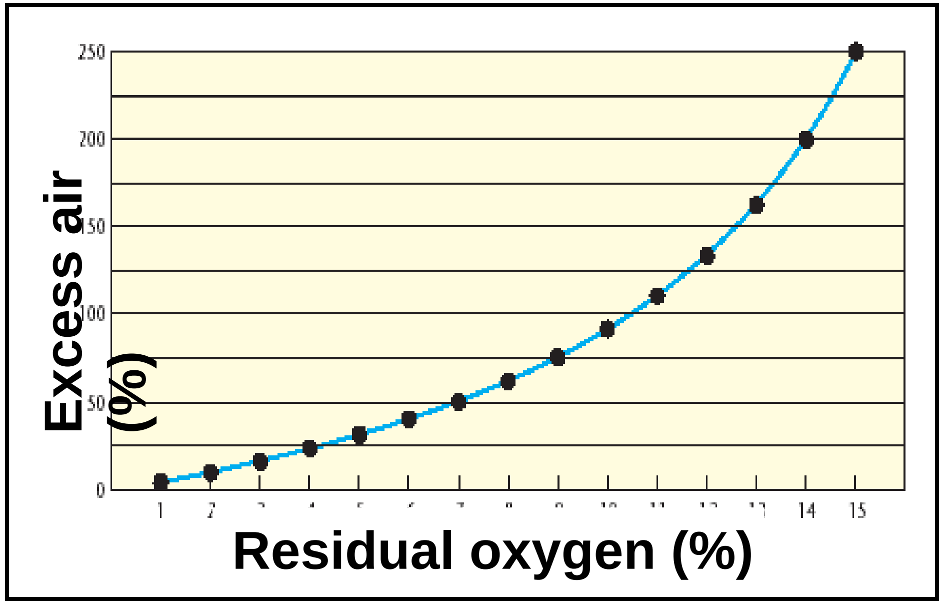
Performance Evaluation

Concept of Excess Air

- Measure CO_2 in flue gases to estimate excess air level and stack losses



- Measure O_2 in flue gases to estimate excess air level and stack losses



Combustion

Requires:

- **addition of excess air**
- **mechanical mixing of waste**
- **even distribution and aeration of waste**

Behaviour of waste during combustion varies according to its heat value and its form

Some low CV wastes burn easily = straw

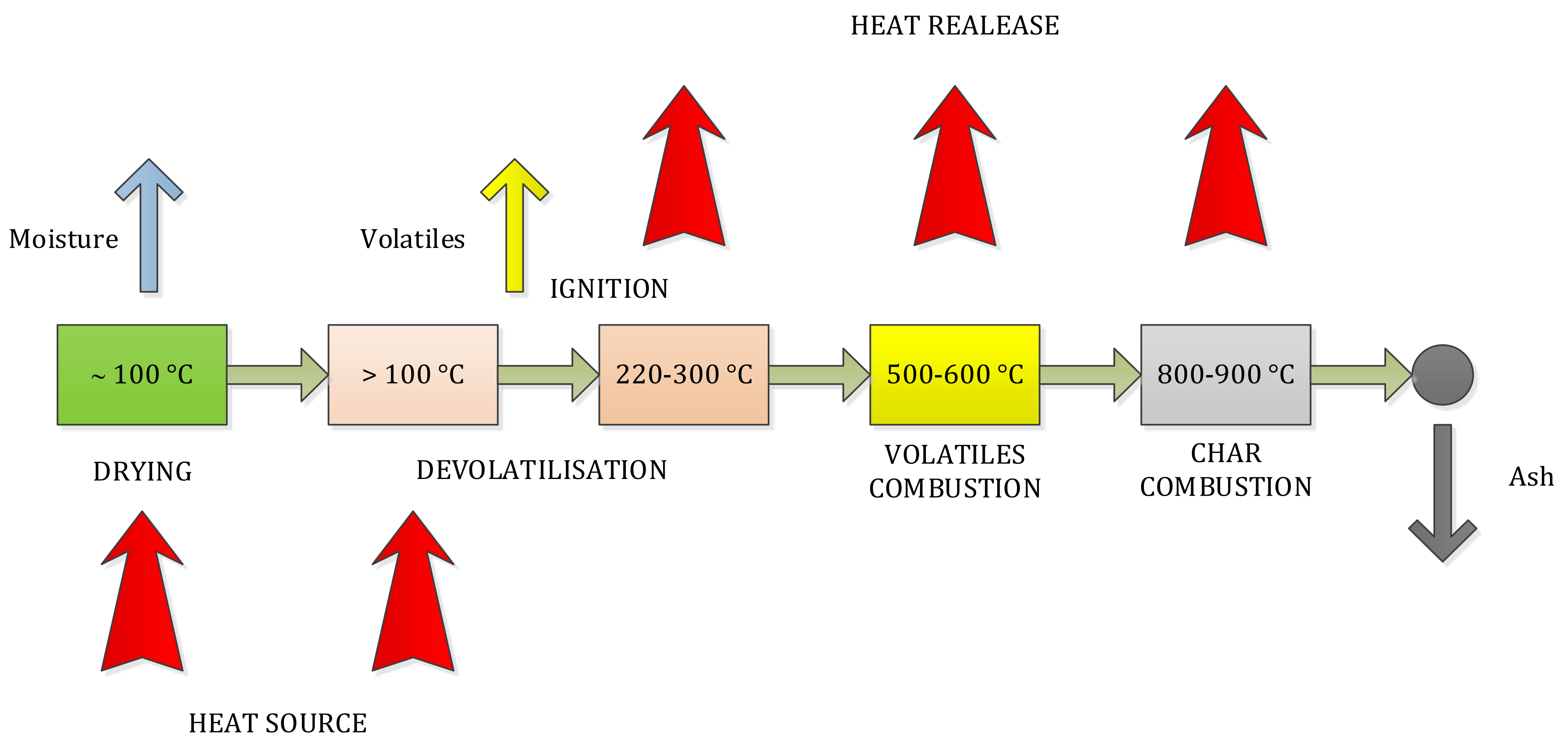
Some low CV wastes are difficult to burn = wet sludges

Some high CV wastes burn easily = tank bottoms

Some high CV wastes are difficult to burn = contaminated soils, certain plastics

Certain wastes change their physical characteristics during combustion

COMBUSTION PROCESS



Performance Evaluation

Draft System

- ✓ **To exhaust combustion products to atmosphere**

- ✓ **Natural draft:**

  - **Caused by weight difference between the hot gases inside the chimney and outside air**
  - **No fans or blowers are used**

- ✓ **Mechanical draft:**

  - **Artificially produced by fans**
  - **Three types a) balanced draft, b) induced draft and c) forced draft**

Energy Efficiency Opportunities

Four main areas

- ✓ Preheating of combustion oil
- ✓ Temperature control of combustion oil
- ✓ Preparation of solid fuels
- ✓ Combustion controls

MODERN HISTORY OF WtE IN GERMANY

1893
First German waste incineration plant in Hamburg

1972
Waste Disposal Act of 1972

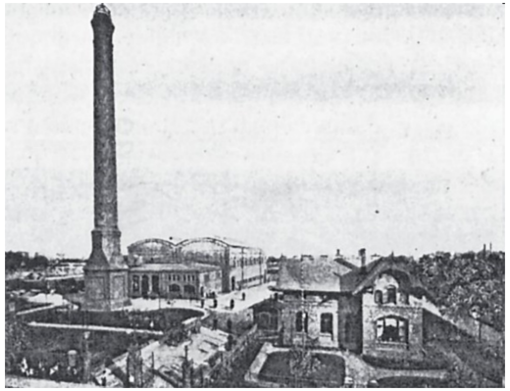
1973
World oil crisis

1980s
Dioxin scandal

1990
Ordinance on Waste Incineration and Co-Incineration (17th BImSchV)

1996
51 WtE Plants (11 million tons/year)

June 1st 2005
Disposal of untreated municipal waste terminated



Germany´s first Waste Incineration Plant in Hamburg[1]

State-of-the-art German WtE Plant in Nuremberg[2]

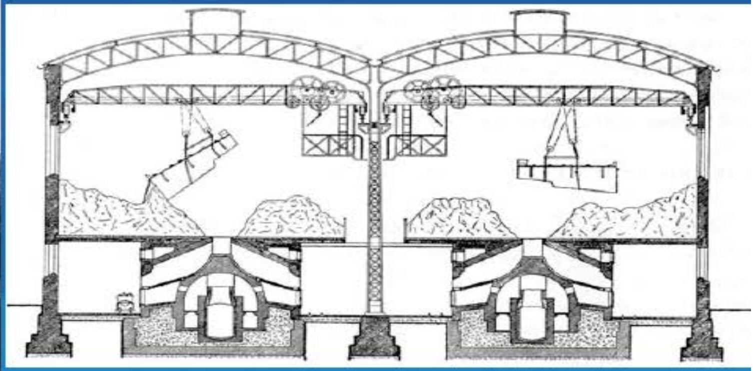
Photo Sources:
1) www.abfallberatung-unterfranken.de
2) www.lfu.bayern.de

Incineration at the end of the 19th century

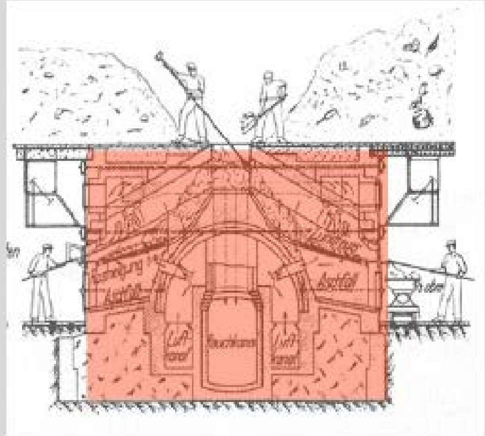
Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft

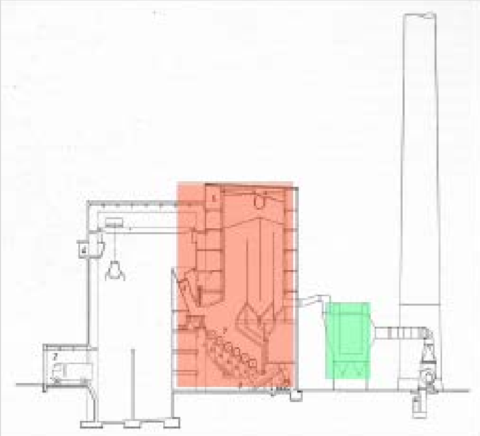
Bioenergy NoE

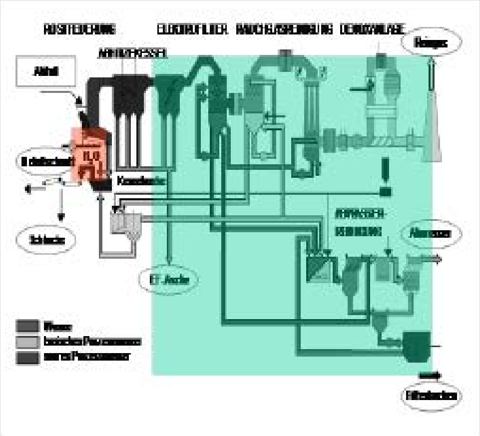
1896 1. plant on continent in Hamburg-Bullerdeich (Germany)
1900 further plants on other cities

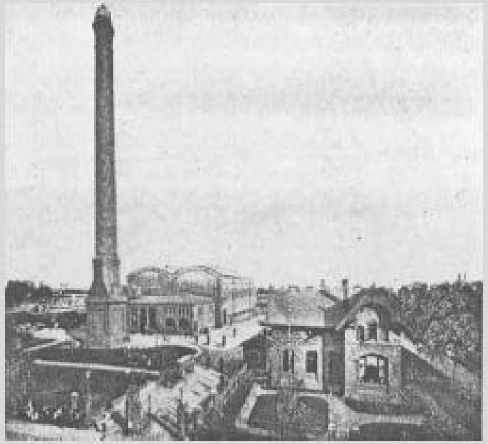


incinerator Hamburg Bullerdeich



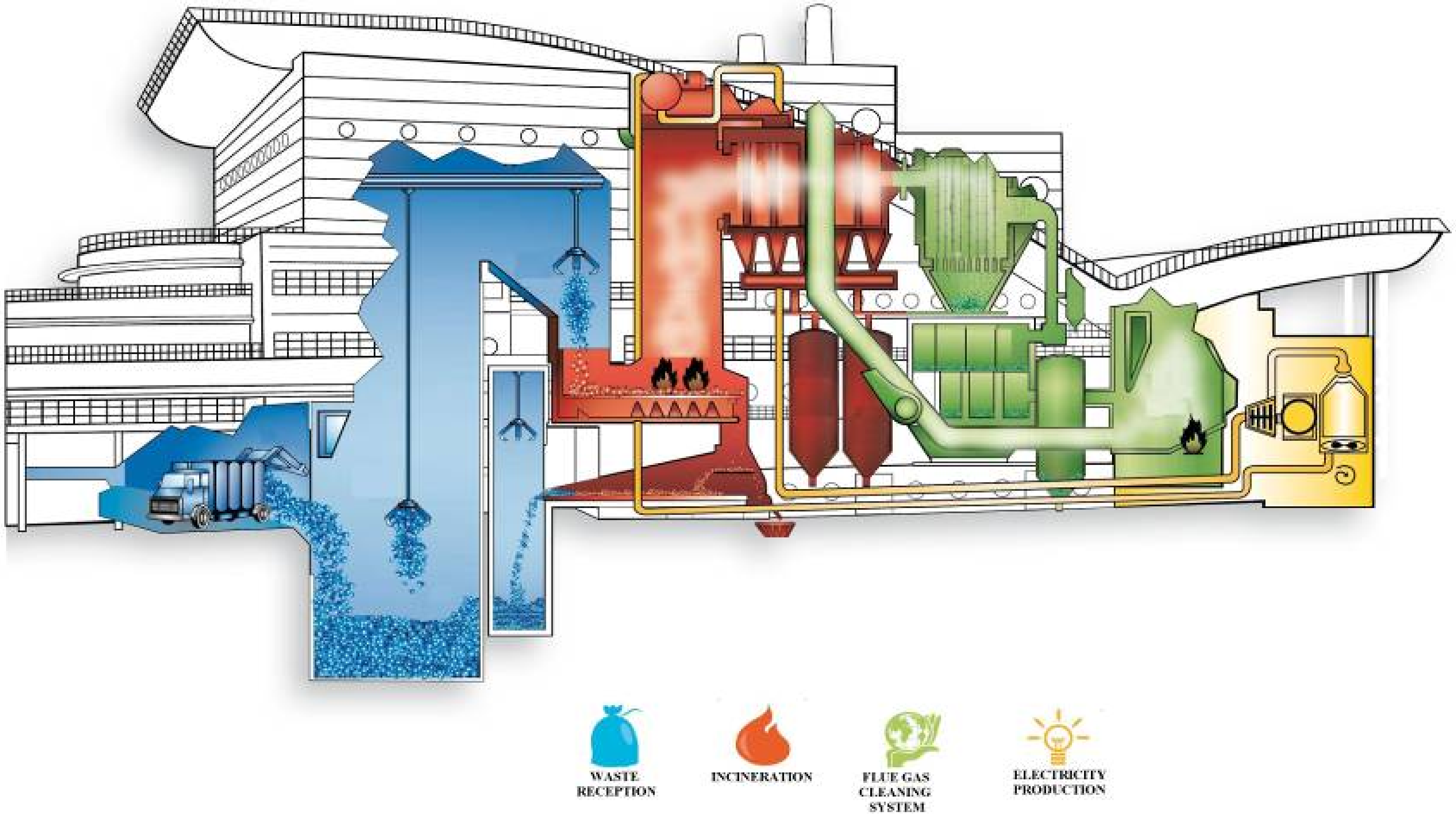


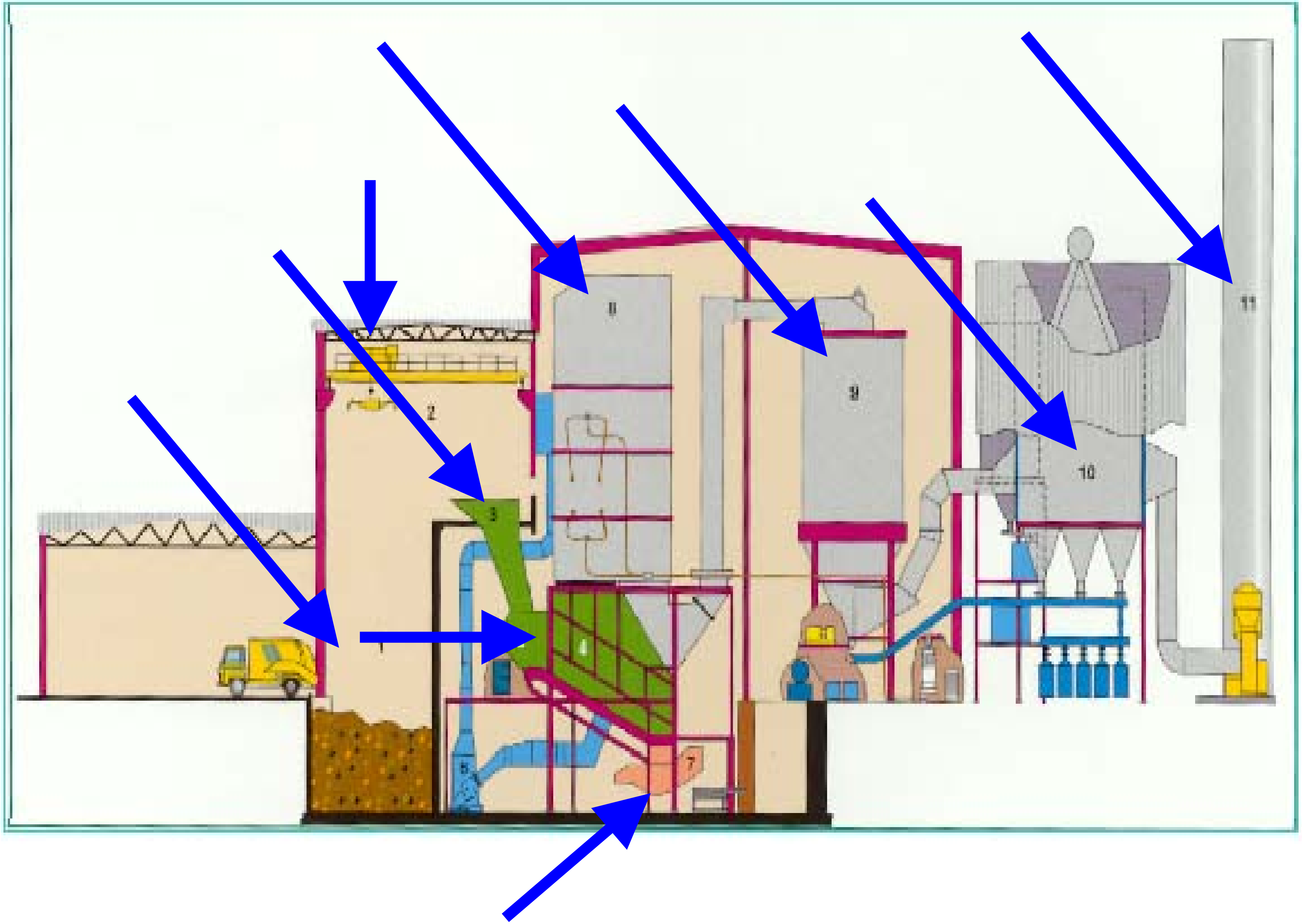




1896 **1970** **1990**

Waste-to-Energy in Europe
Typical WTE Plant

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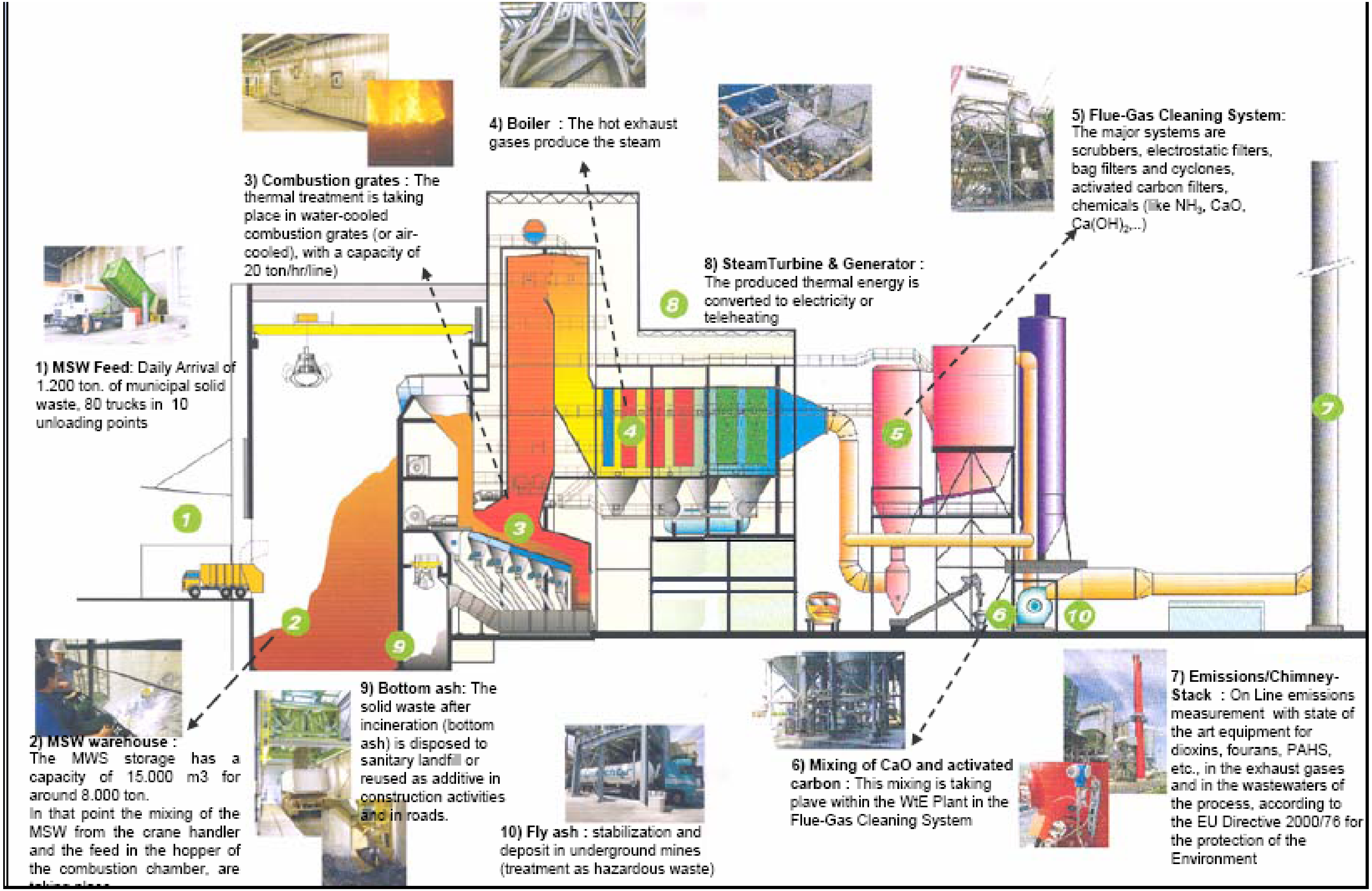
1) MSW Feed: Daily Arrival of 1.200 ton. of municipal solid waste, 80 trucks in 10 unloading points
2) MSW warehouse : The MWS storage has a capacity of 15.000 m3 for around 8.000 ton. In that point the mixing of the MSW from the crane handler and the feed in the hopper of the combustion chamber, are
3) Combustion grates : The thermal treatment is taking place in water-cooled combustion grates (or air-cooled), with a capacity of 20 ton/hr/line)
4) Boiler : The hot exhaust gases produce the steam
5) Flue-Gas Cleaning System: The major systems are scrubbers, electrostatic filters, bag filters and cyclones, activated carbon filters, chemicals (like NH_3, CaO, $Ca(OH)_2$,..)
6) Mixing of CaO and activated carbon : This mixing is taking plave within the WtE Plant in the Flue-Gas Cleaning System
7) Emissions/Chimney-Stack : On Line emissions measurement with state of the art equipment for dioxins, fourans, PAHS, etc., in the exhaust gases and in the wastewaters of the process, according to the EU Directive 2000/76 for the protection of the Environment
8) SteamTurbine & Generator : The produced thermal energy is converted to electricity or teleheating
9) Bottom ash: The solid waste after incineration (bottom ash) is disposed to sanitary landfill or reused as additive in construction activities and in roads.
10) Fly ash : stabilization and deposit in underground mines (treatment as hazardous waste)
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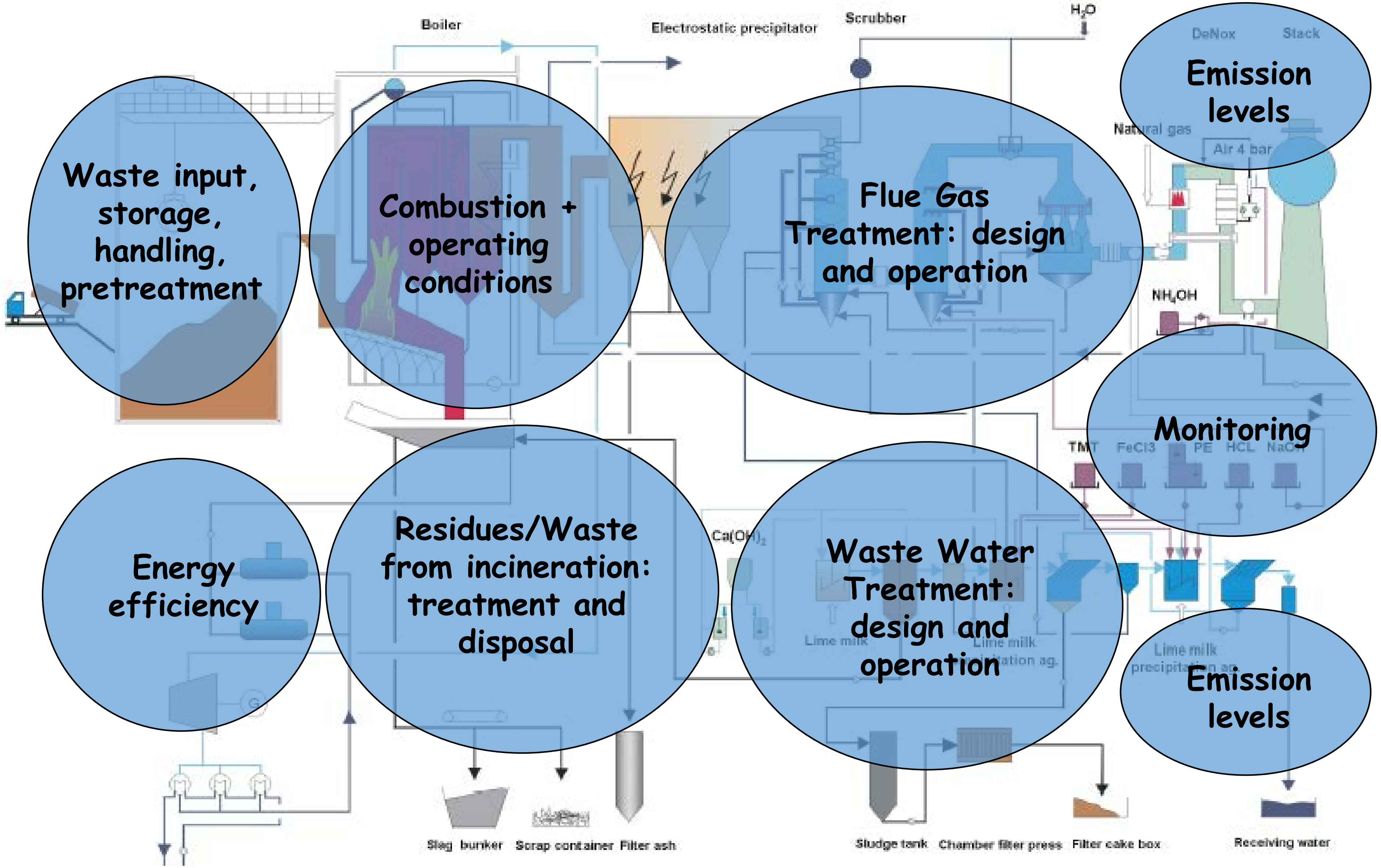
BAT issues coverage:



Application of thermal treatment

Suitable for organic wastes

Thermal treatment processes:

- **require high capital investment**
- **are highly regulated**
- **need skilled personnel**
- **require high operating and safety standards**
- **have medium to high operating costs**

Combustion techniques

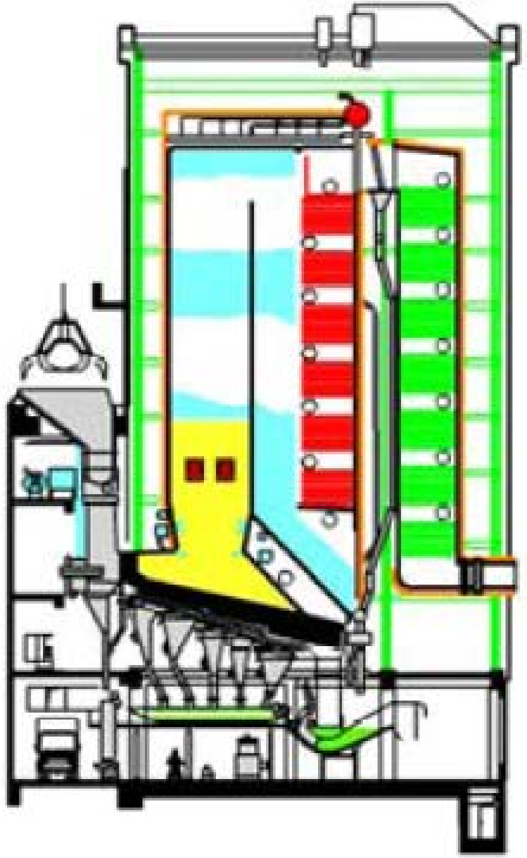
Bed plate furnaces: use gravity to mix waste - used for homogeneous and wet wastes such as sludge cake

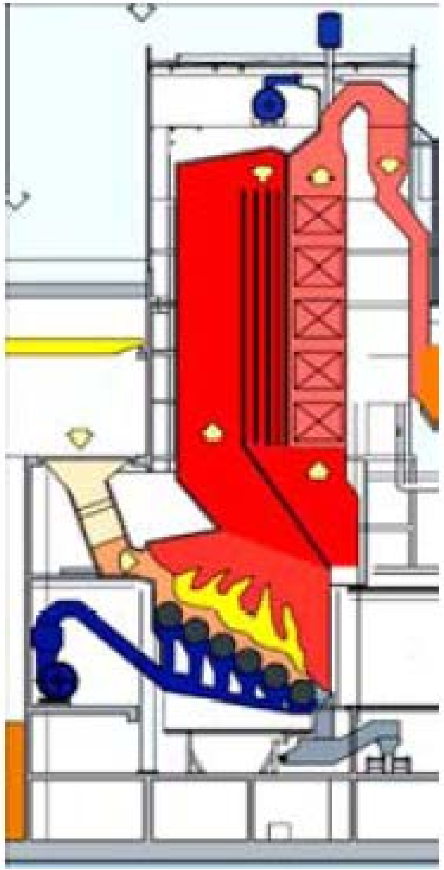
Fluidised bed furnaces: waste is introduced into a bed of sand which is kept in suspension - used for wastes of similar size and density

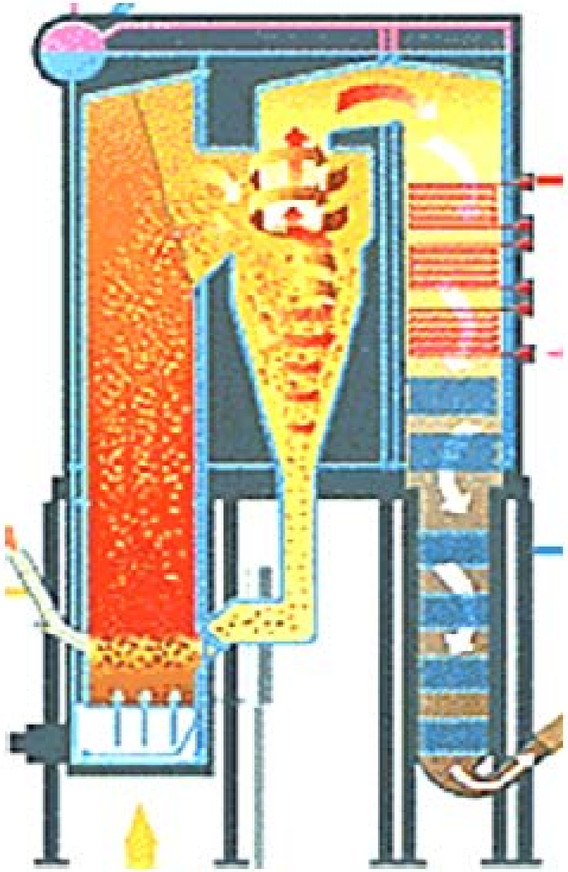
Incineration grates: wastes fed onto the grate are turned or moved to ensure aeration of the waste mass via holes in the grate - used for solid wastes eg municipal wastes, not liquids or sludges

Rotary kilns: wastes are placed in slowly rotating furnace - suitable for solids, sludges and liquids

THERMAL TREATMENT TECHNOLOGIES

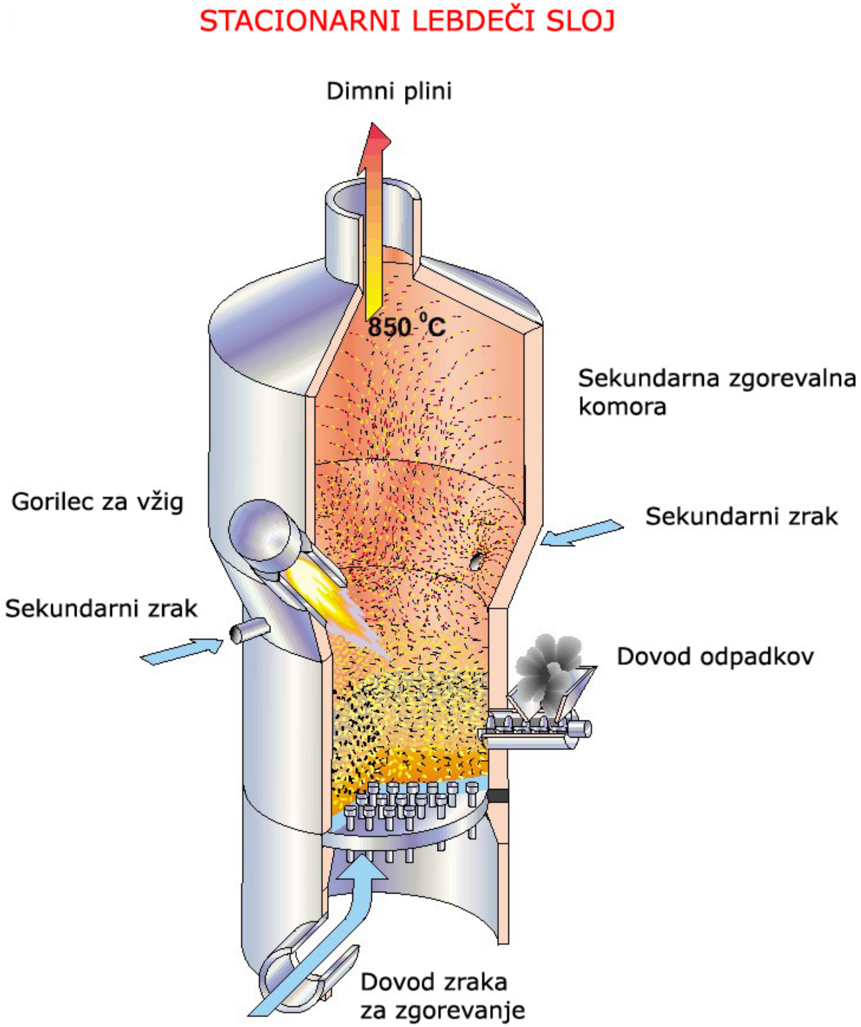

reciprocating grate

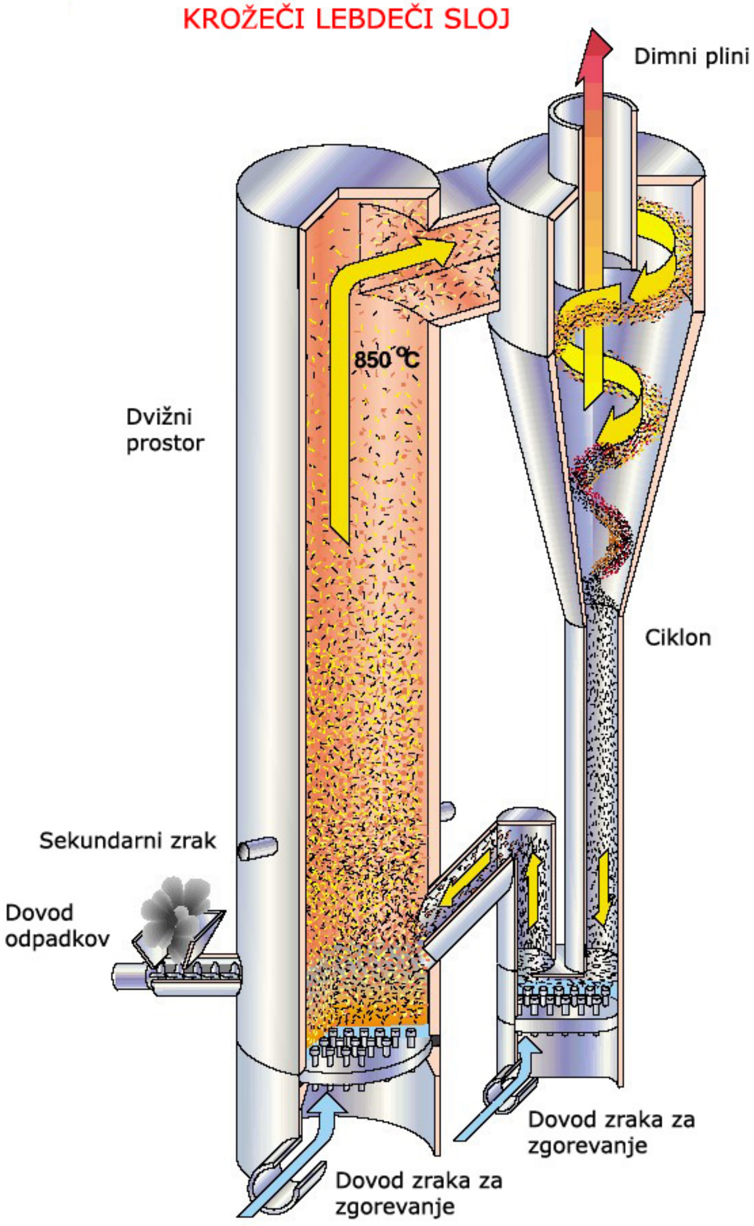

roller grate


circulating fluidised bed

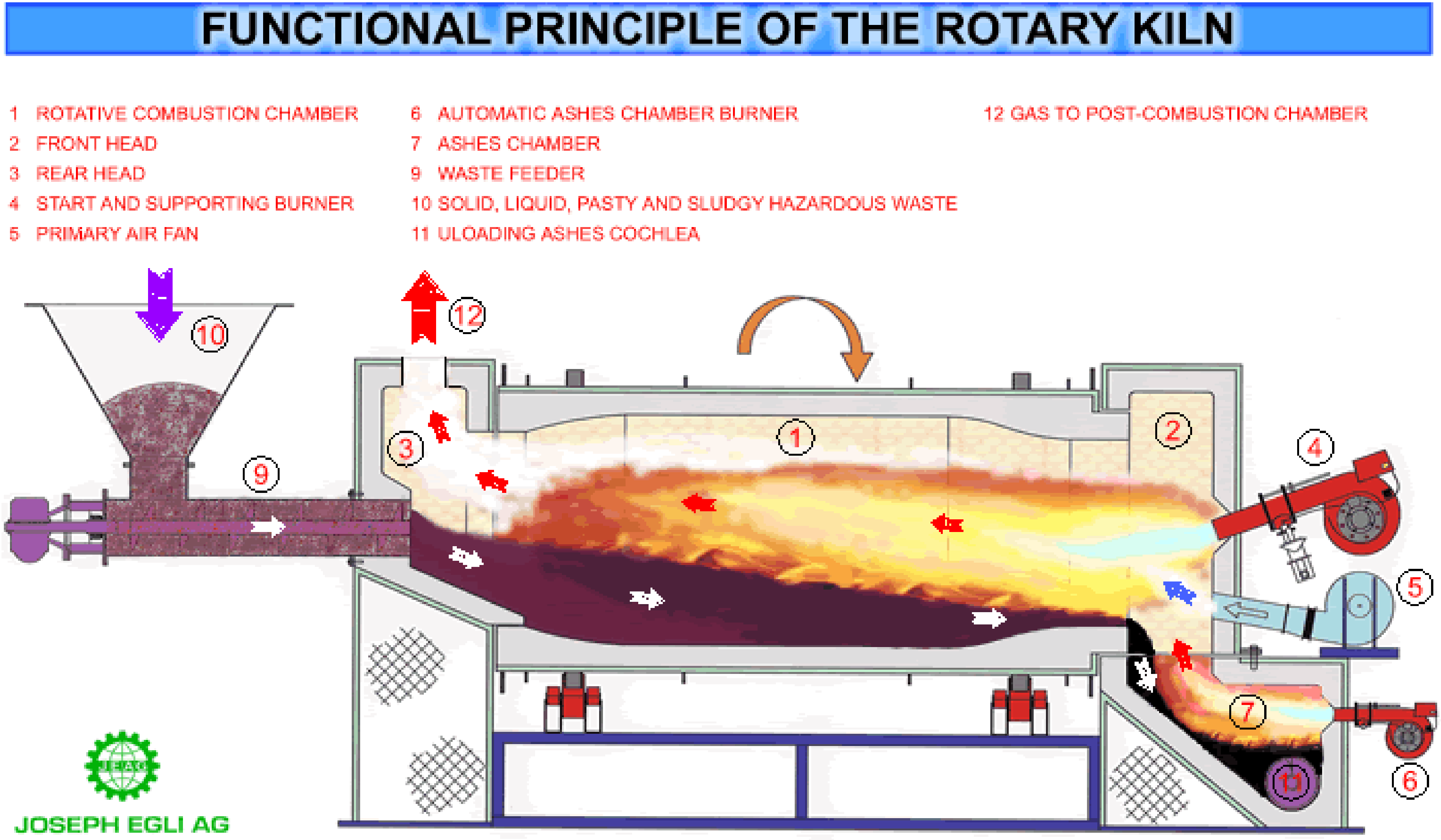
Source: Bilitewski

Von Roll system of bed combustion





Rotary kiln


FUNCTIONAL PRINCIPLE OF THE ROTARY KILN
1 ROTATIVE COMBUSTION CHAMBER
2 FRONT HEAD
3 REAR HEAD
4 START AND SUPPORTING BURNER
5 PRIMARY AIR FAN
6 AUTOMATIC ASHES CHAMBER BURNER
7 ASHES CHAMBER
9 WASTE FEEDER
10 SOLID, LIQUID, PASTY AND SLUDGY HAZARDOUS WASTE
11 ULOADING ASHES COCHLEA
12 GAS TO POST-COMBUSTION CHAMBER
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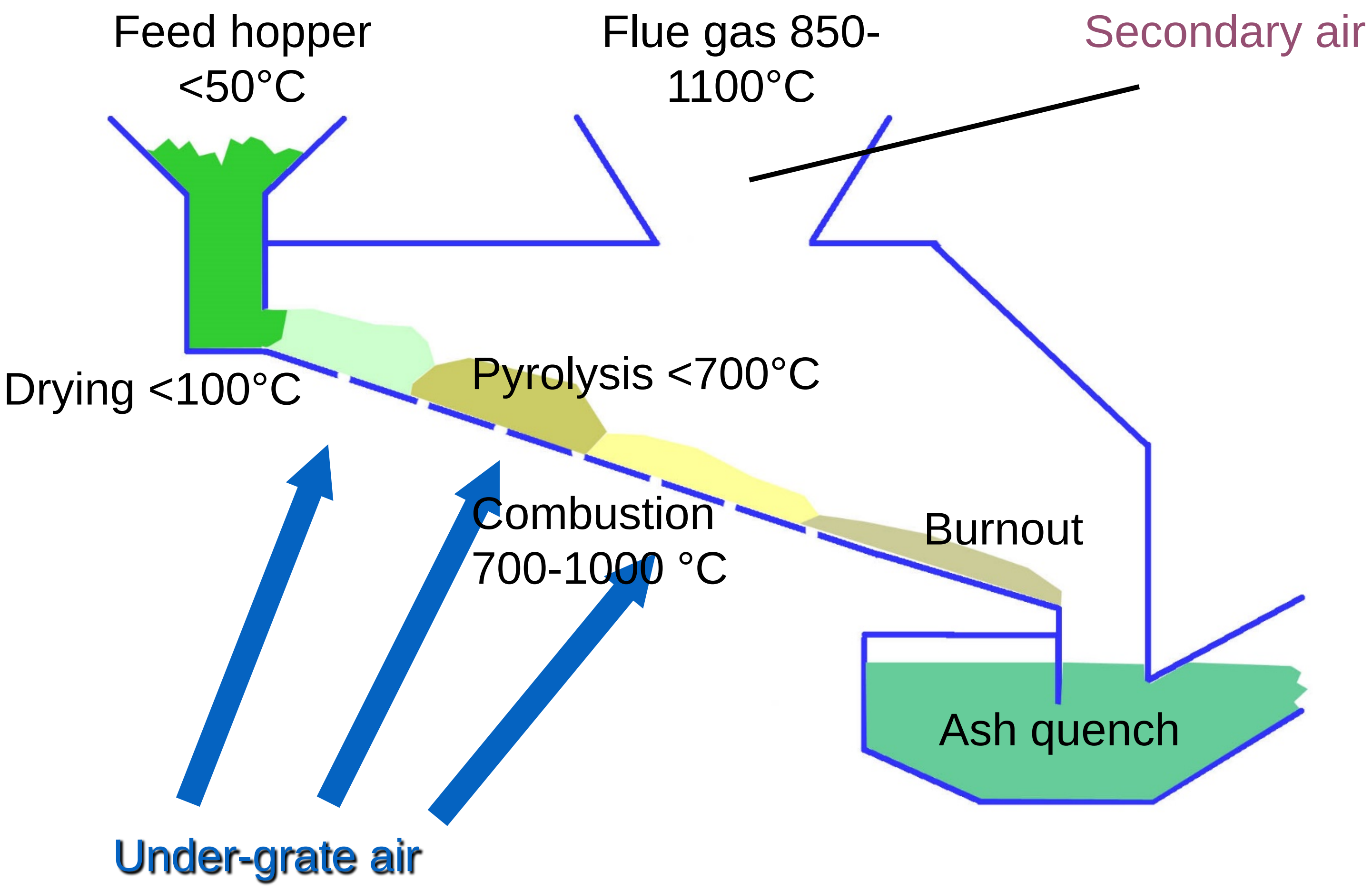
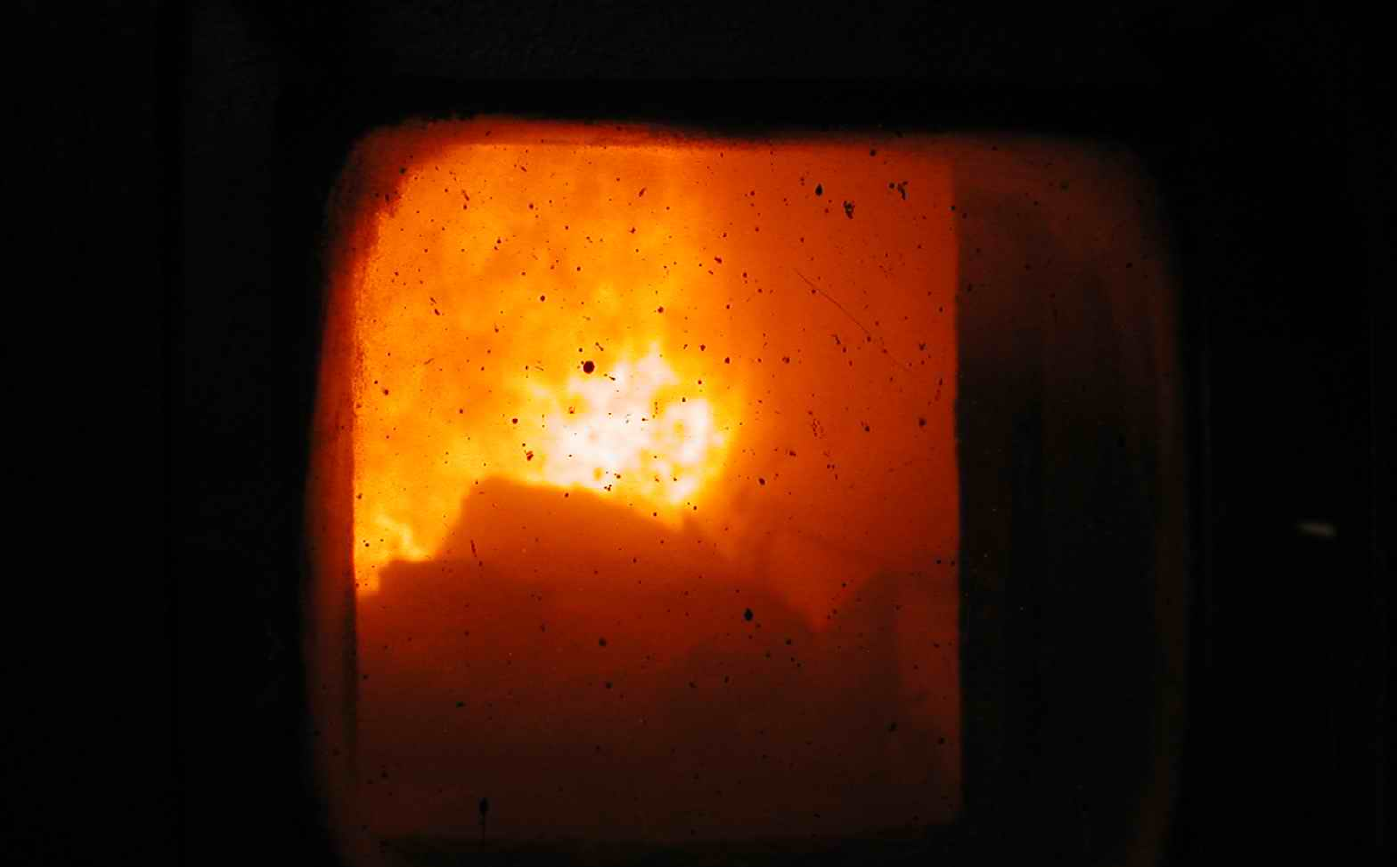
Processes in combustion chamber



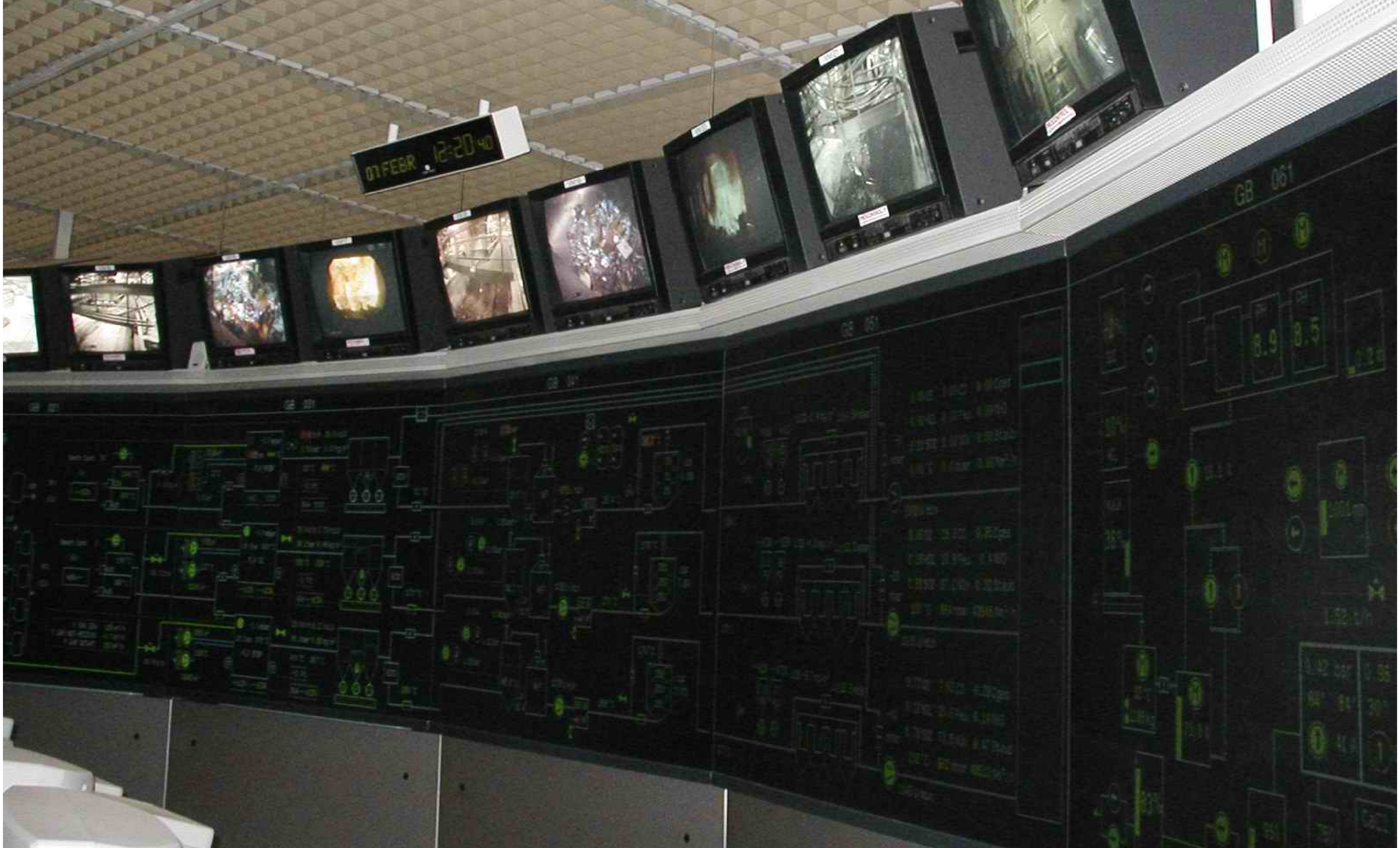



01/06/2011

Moving grate: 84%	No. of plants	Total tons per day	Average tons/day	% of Japan WTE capacity
Martin reverse acting grate (66 plants)	66	71,500	1083	62%
JFE Volund grate (54 plants)	54	10,100	187	9%
Martin horizontal grate (14 plants)	14	7,454	532	7%
Nippon Steel Direct melting (28 plants)	28	6,200	221	5%
JFE Hyper Grate (17 plants)	17	4,700	276	4%
Rotary kiln (15 plants)	15	2,500	167	2%
JFE Thermoselect (gasification; 7 plants)	7	1,980	283	2%
All other fluid bed (15 plants)	15	1,800	120	2%
Ebara fluid bed (8 plants)	8	1,700	213	1%
JFE Direct Melting (shaft furnace, 14 plants)	14	1,700	121	1%
Hitachi Zosen fluid bed (8 plants)	8	1,380	173	1%
JFE fluid bed (sludge & MSW; 9 plants)	9	1,300	144	1%
All other Direct Melting (9 plants)	9	900	100	1%
Fisia Babcock grate (2 forward, 1 roller)	3	710	237	1%
Babcock & Wilcox (43 plants)	43	690	16	1%
Total	310	114,614		100%
Total tons/year (330 days, 24 hour operation)		37,822,620		

Reasons for dominance of grate combustion

- Simplicity of operation
- Very high plant availability
- Low personnel requirement (<70 for a one-million tons/year plant) and ease of training of people in existing operating plants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Energy recovery

Waste combustion produces heat

but combustion of low CV wastes may not be self-supporting

Energy recovery is via production of steam to generate electricity

- **Only steam production: 80% efficiency is typical**
- **Steam can be used for in-house demands**
- **Steam can be delivered to adjacent users *eg* other industrial plants**
- **Electricity can be generated: 25% efficiency typical**

Opportunities to sell heat are improved where facilities are in industrial areas

Sale of surplus energy improves plant economics

Global warming – Climate Change

Energy recovered from thermal treatment of waste contributes to the reduction of greenhouse gases in two ways :

1. Prevents the production of methane CH_4 (21 times more potent greenhouse gas than **CO_2**) and other emissions from landfill sites

2. Emits less **CO_2** compared to fossil fuels which it replaces (i.e. lignite)

In thermal treatment processing plants it is possible to co-incinerate industrial waste with similar composition to municipal waste, sludge from biological treatment and biomass

WtE plants – GHG reduction plants

The Eight Emerging Large-Scale Clean Energy Sectors include

1. Onshore Wind
2. Offshore Wind
3. Solar Photovoltaic (PV)
4. Solar Thermal Electricity Generation (STEG)
5. **Municipal Solid Waste-to-Energy (MSW)**
6. Sugar-based Ethanol
7. Cellulosic and Next Generation Biofuels
8. Geothermal Power

Recycling and Waste-to-Energy in combination for sustainable waste management

They calculated that a further 89 million tonnes of CO_{2equ} could be saved per year assuming a recycling scenario of 50% + for municipal waste. This scenario is based on an increase in the average incineration rate to 25% (from 18% in 2005) and a reduction of landfilling to 22% (from 45% in 2005) in EU 27.

Prognos[3] found that there is a potential to reduce CO_{2equ} emissions between 146 and 244 million tonnes by 2020. This is possible, according to Prognos, if *inter alia*:

- "calorific and biodegradable waste is diverted from landfill
- more support is given to recycling and WtE"

In another study, FFact[4] calculated the $CO_{2\ equ}$ savings if European waste management achieved 60% recycling with the remaining 40% of municipal waste, which cannot be recycled in an environmentally sound way, being treated in efficient Waste-to-Energy Plants. Generating energy from this waste instead of sending it to landfill avoids methane (landfill) gas which equals 25 times CO_2 in mass. In combination with the energy efficiency thresholds set in Annex II, R1 (formula) of the Waste Framework Directive, this could prevent up to a further 45 million tonnes of CO_{2equ} per year.

By-products of incineration

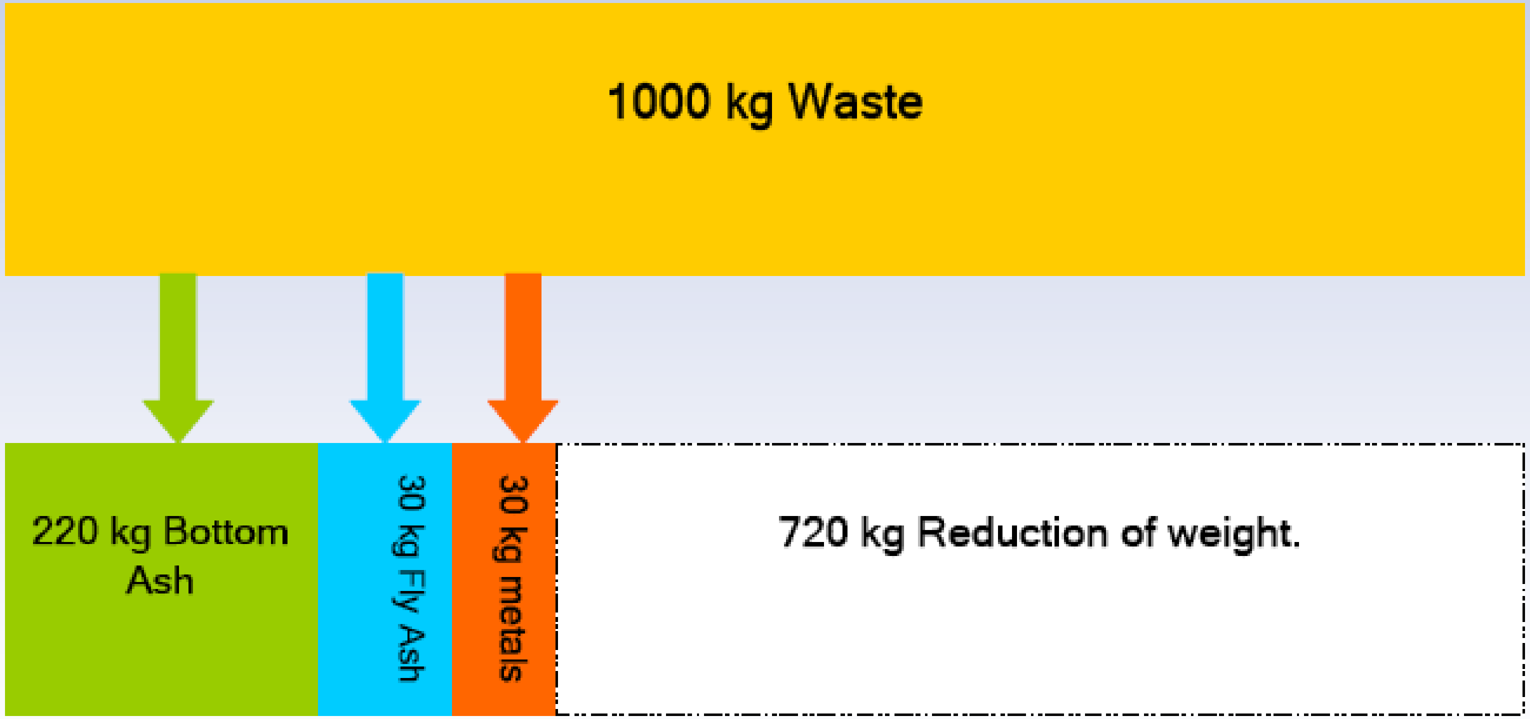
May be:

- **solid**
- **liquid**
- **gaseous**

Comprise:

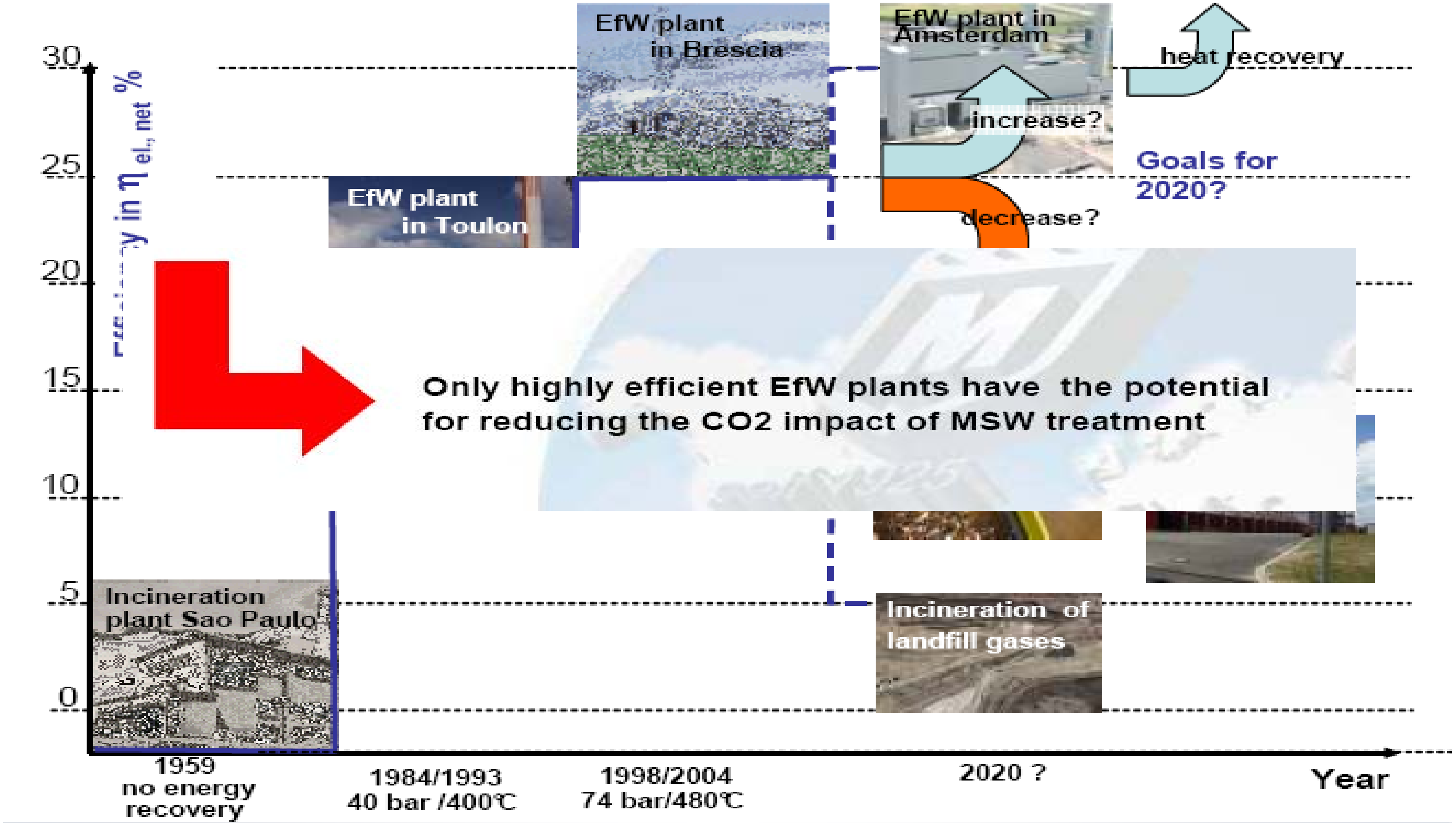
- **recovered materials such as metals, HCl**
- **flue gases**
- **slag and ash**
- **products of the flue gas treatment, also called air pollution control (APC) residues**
- **wastewater**

- Incineration plant producing 500-650 kWh/ton of post recycled municipal solid waste.



- **With the incineration of 1 ton of waste we save 1 ton of lignite.**

Efficiency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Efficiency in η el., net %
EfW plant in Brescia
EfW plant in Amsterdam
heat recovery
increase?
Goals for 2020?
decrease?
EfW plant in Toulon
Only highly efficient EfW plants have the potential for reducing the CO2 impact of MSW treatment
Incineration plant Sao Paulo
Incineration of landfill gases
1959 no energy recovery
1984/1993 40 bar /400°C
1998/2004 74 bar/480°C
2020 ?
Year

Efficiency

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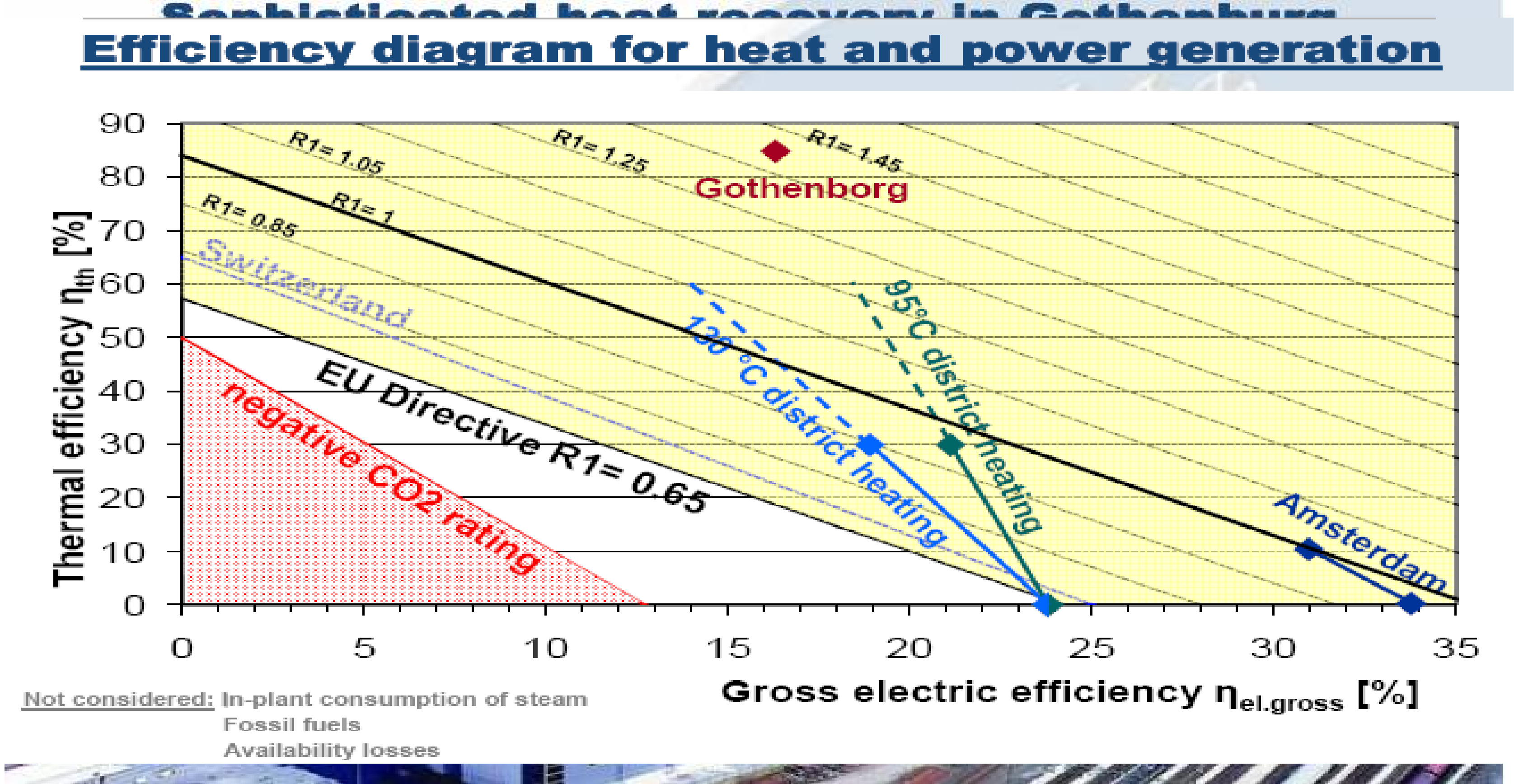

day)

Not valid for 2009

INCINERATION RESIDUES

- *Residues 5-10% of original volume*
- *15 - 20% by weight*
- *Bottom / Clinker Ash*
- *Fly Ash*
- *Energy Production*

Terms and regulations on treatment and disposal of solid residues differ between countries

Bottom ash may be landfilled or used as an aggregate substitute *eg* for road building

mcos

BOTTOM ASH

- *Waste stream that didn't burn*
- *Glassy elements, grit, metals, inert matter etc*
- *Metals recycled*
- *Overall toxicity similar to soil*
- *Stable aggregate*
- *Recycled*

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FLY ASH

- *Hazardous Material*
- *Approx. 1% of original volume*
- *Requires special disposal*
- *Flue gas cleaning residue*
- *New technologies emerging*

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Bottom ash ‘up close’

BOTTOM ASH

- **Aggregate on asphalt** (France, United Kingdom, USA)
- At landfills as a **covering material** (partial replacement of daily coverage dirt)

FLY ASH

- **Added to cement**
- **Filling in salt mines and quarries** (soil stabilization)
- Usage in **road construction** (Germany)
- **Neutralization of acid wastes** (i.e. Titanium Industry in Norway)
- **Construction material** (gravel for concrete and blocks of pulverized ash Holland)

Ash Usage – International Practice

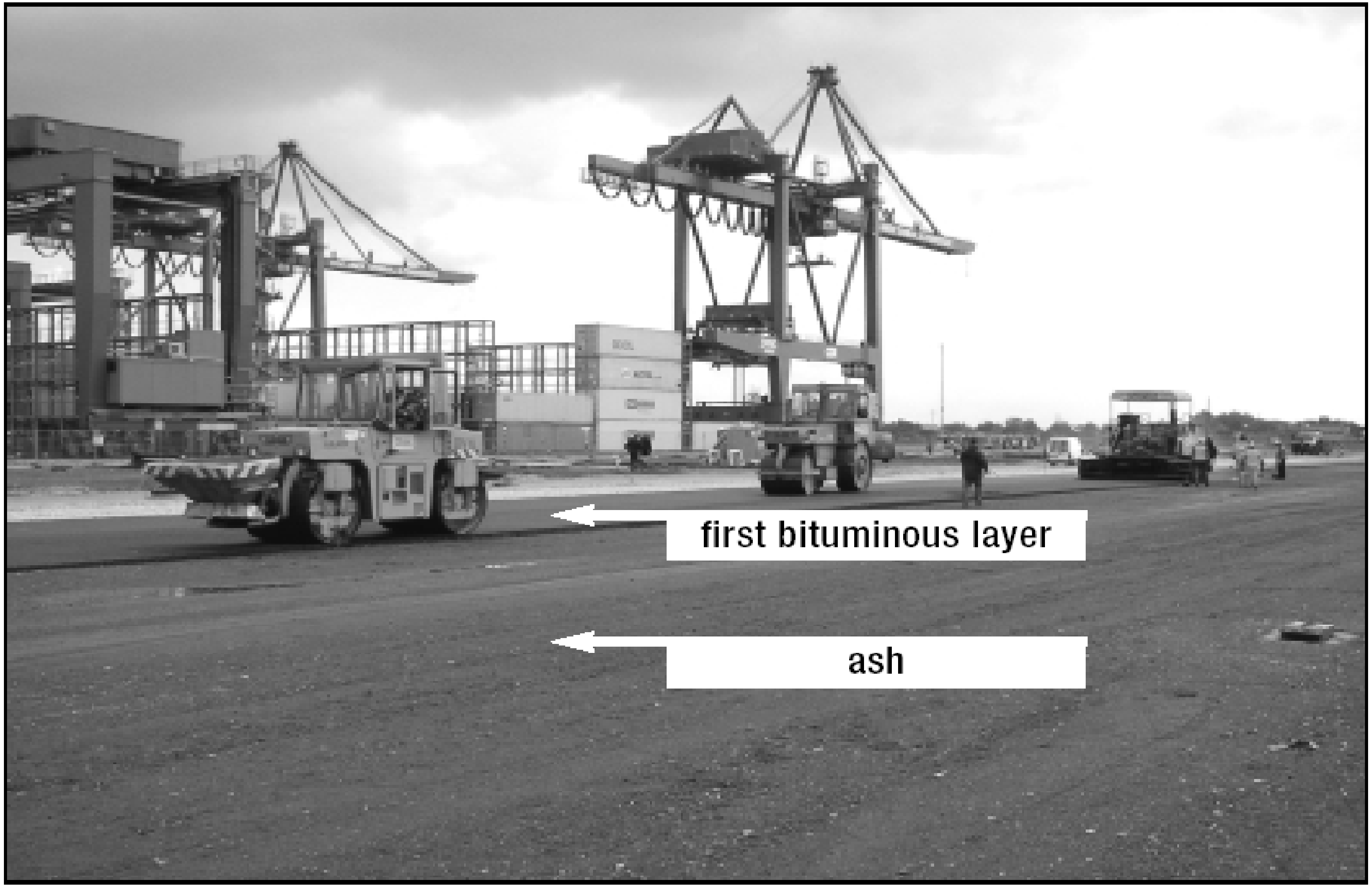
BOTTOM ASH

- Aggregate on asphalt (France, United Kingdom, USA)
- At landfills as a covering material (partial replacement of daily coverage)

FLY ASH (after stabilization/solidification)

- Filling in salt mines and quarries (soil stabilization)
- Usage in road construction (Germany)
- Neutralization of acid wastes (i.e. Titanium Industry in Norway)
- Construction material (gravel for concrete and blocks of pulverized ash ash Holland)
- or disposal in sanitary landfill

Application of ash during construction



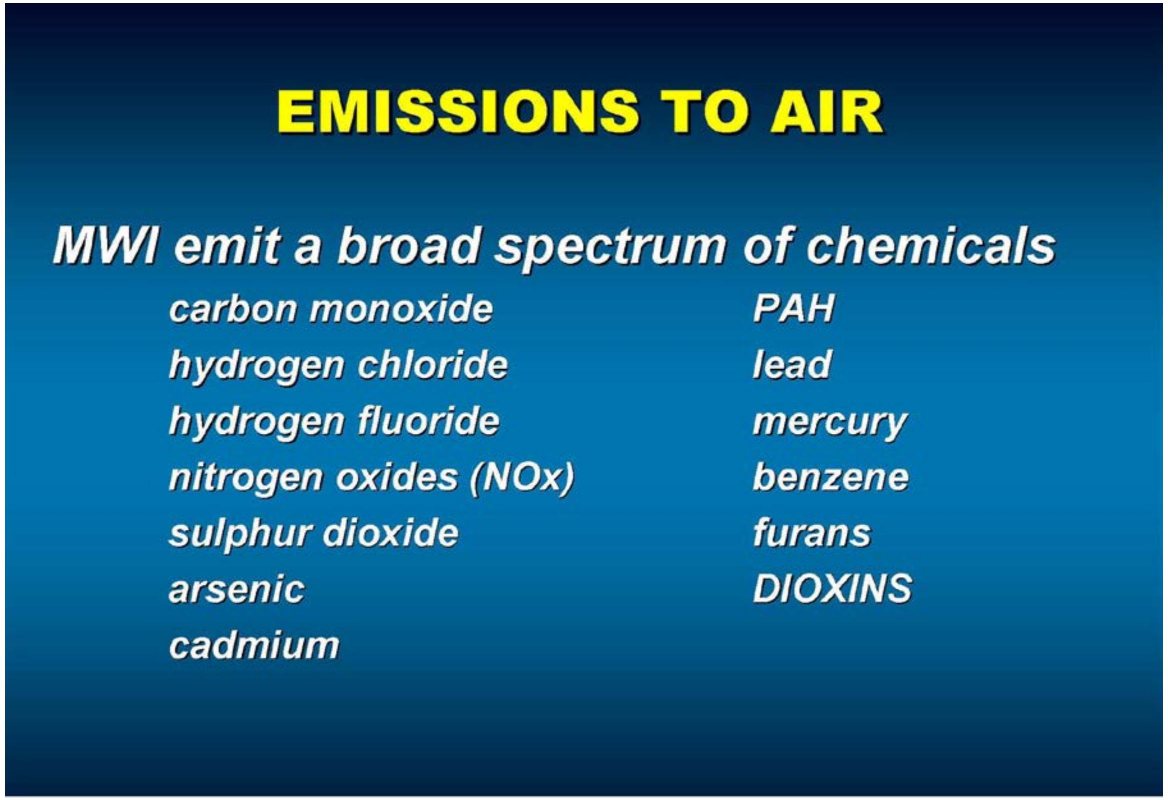
Container-Terminal Altenwerder, Hamburg (3 million TEUs annually)

Flue gases

Quantity and type of pollutants in emissions depend on:

- pollutants in waste
- technology
- efficiency of operation

Average 6 - 7 Nm^3 of flue gas per kg waste



Specific collection/treatment for:

Dust - staged filters

Chlorine - neutralised by scrubbing with lime

Sulphur - washing stage

Dioxins and other uPOPs (PAHs, PCBs, HCBs) - combustion control, activated carbon

Emission levels in Waste to Energy

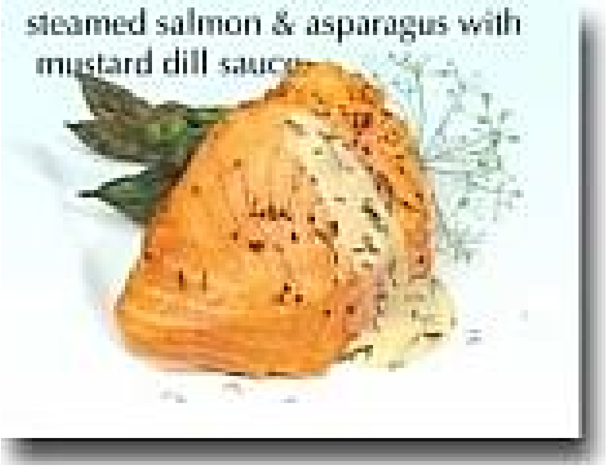
Emissions from the Brescia plant, Italy

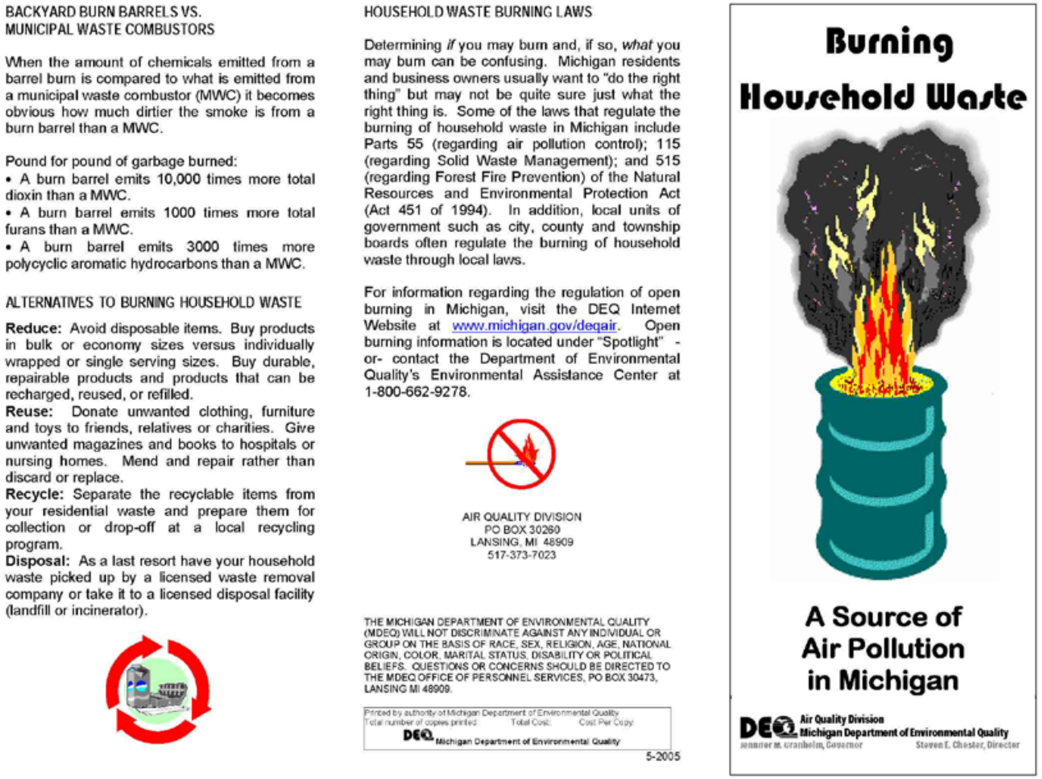
All units are in mg/Nm^3 The values correspond to dry air, normal conditions, 11% O_2	Plant authorization limits 1993	Design Plant limits 1994	European Union Limits 2000	Actual Operating Data 2005
Particulate matter	10	3	10	0,4
Sulphur Dioxide	150	40	50	6,5
Nitrous Oxides (NOx)	200	100	200	<80
Hydrochloric Acid (HCl)	30	20	10	3,5
Hydrofluoric Acid (HF)	1	1	1	0,1
Carbon Monoxide	100	40	50	15
Heavy Metals	2	0,5	0,5	0,01
Cadmium (Cd)	0,1	0,02	0,05	0,002
Merucy (Hg)	0,1	0,02	0,05	0,002
Polycyclic Aromatic Hydrocarbon (PAH)	0,05	0,01		0,00001
Dioxin (TCDD Teq)	0,1	0,1	0,1	0,002

What are the dioxins??

- Family of around 200 chlorinated organic compounds, a few of which are highly toxic
- Widespread in the environment
- Present in waste going to incineration
- Can be re-formed in cooling stages post-combustion
- 3Ts help destroy dioxins in waste, reduce reformation
- Use of activated carbon to filter from flue gases
- Emissions limits extremely low

DIOXINS AND FURANS





BACKYARD BURN BARRELS VS. MUNICIPAL WASTE COMBUSTORS

When the amount of chemicals emitted from a barrel burn is compared to what is emitted from a municipal waste combustor (MWC) it becomes obvious how much dirtier the smoke is from a burn barrel than a MWC.

Pound for pound of garbage burned:

- A burn barrel emits 10,000 times more total dioxin than a MWC.
- A burn barrel emits 1000 times more total furans than a MWC.
- A burn barrel emits 3000 times more polycyclic aromatic hydrocarbons than a MWC.

ALTERNATIVES TO BURNING HOUSEHOLD WASTE

Reduce: Avoid disposable items. Buy products in bulk or economy sizes versus individually wrapped or single serving sizes. Buy durable, repairable products and products that can be recharged, reused, or refilled.
Reuse: Donate unwanted clothing, furniture and toys to friends, relatives or charities. Give unwanted magazines and books to hospitals or nursing homes. Mend and repair rather than discard or replace.
Recycle: Separate the recyclable items from your residential waste and prepare them for collection or drop-off at a local recycling program.
Disposal: As a last resort have your household waste picked up by a licensed waste removal company or take it to a licensed disposal facility (landfill or incinerator).

HOUSEHOLD WASTE BURNING LAWS

Determining *if* you may burn and, if so, *what* you may burn can be confusing. Michigan residents and business owners usually want to "do the right thing" but may not be quite sure just what the right thing is. Some of the laws that regulate the burning of household waste in Michigan include Parts 55 (regarding air pollution control); 115 (regarding Solid Waste Management); and 515 (regarding Forest Fire Prevention) of the Natural Resources and Environmental Protection Act (Act 451 of 1994). In addition, local units of government such as city, county and township boards often regulate the burning of household waste through local laws.

For information regarding the regulation of open burning in Michigan, visit the DEQ Internet Website at www.michigan.gov/deqair. Open burning information is located under "Spotlight" - or- contact the Department of Environmental Quality's Environmental Assistance Center at 1-800-662-9278.

AIR QUALITY DIVISION
PO BOX 30260
LANSING, MI 48909
517-373-7023

THE MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY (MDEQ) WILL NOT DISCRIMINATE AGAINST ANY INDIVIDUAL OR GROUP ON THE BASIS OF RACE, SEX, RELIGION, AGE, NATIONAL ORIGIN, COLOR, MARITAL STATUS, DISABILITY OR POLITICAL BELIEFS. QUESTIONS OR CONCERNS SHOULD BE DIRECTED TO THE MDEQ OFFICE OF PERSONNEL SERVICES, PO BOX 30473, LANSING MI 48909.

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DEQ Michigan Department of Environmental Quality

5-2005

Burning Household Waste

A Source of Air Pollution in Michigan

DEQ Air Quality Division
Michigan Department of Environmental Quality
Jennifer M. Granholm, Governor Steven E. Chester, Director

Comparison of Dioxin emission
Data: Prof. Berd Bilitewski

Modern Waste incineration plant:	1	0,01 ng/m^3
Hazardous waste incineration plant:	1	0,01 ng/m^3
Household store:	100	1,00 ng/m^3
Open fire place:	1000	10,00 ng/m^3
Fire works:	10.000	100,00 ng/m^3
Burning landfill	100.000	1000,00 ng/m^3


2005-10-20

Emisije PCDD/F u Nemačkoj

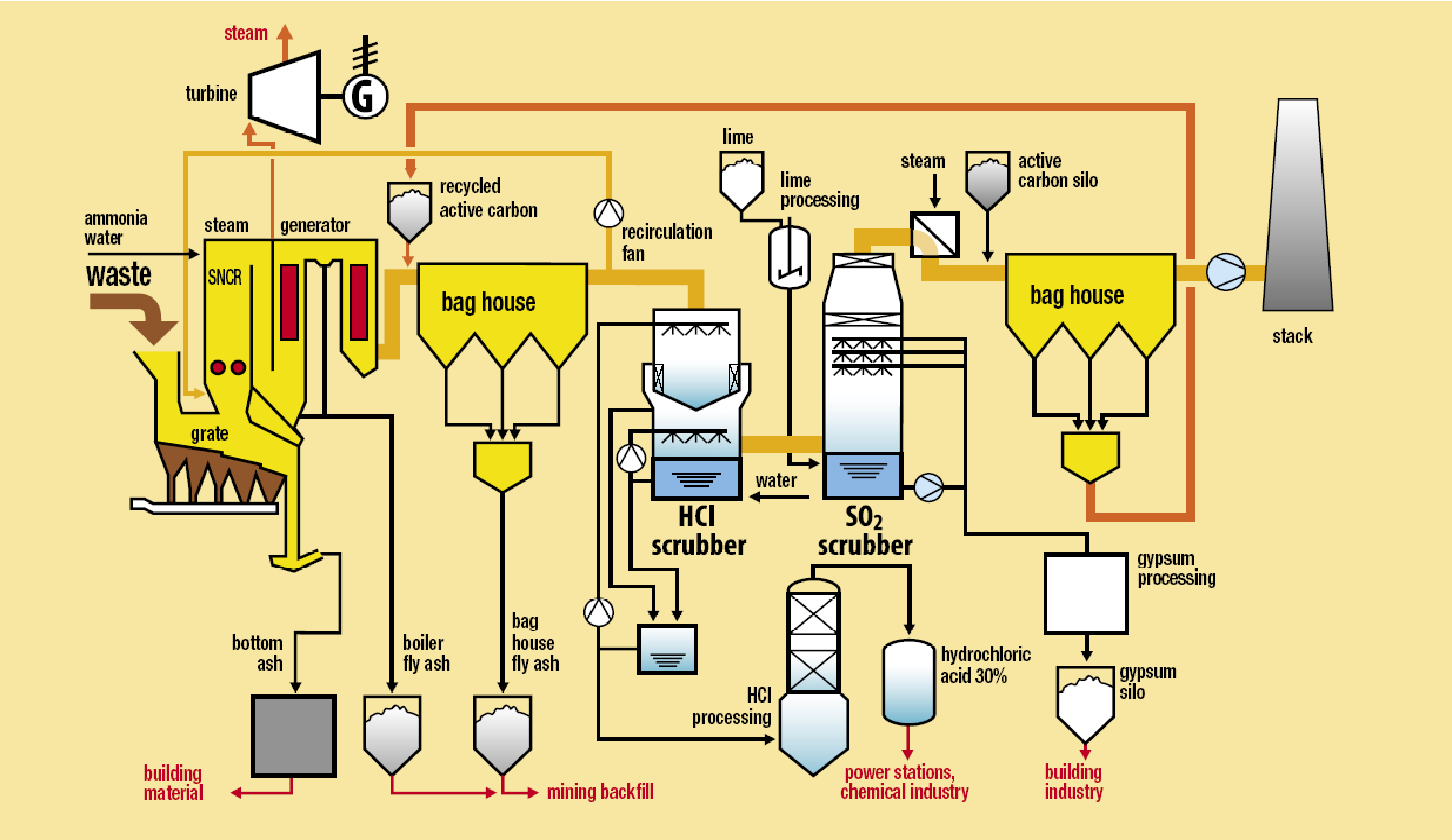
sources	emission per year in g I-TEQ		
	1990	1994	2000*
metal industry	740	220	40
sintering plants	575	168	< 20
iron- & steel production	35	10	< 5
waste incineration	400	32	< 0,5
municipal solid waste	399	30	0,4
hazardous waste		2	0,04
medical waste		0,1	0,0002
sewage sludge		< 0,1	0,03
power plants	5	3	< 3
industrial combustion facilities	20	15	< 10
domestic stoves	20	15	< 10
traffic	10	4	<1
crematoria	4	2	< 2

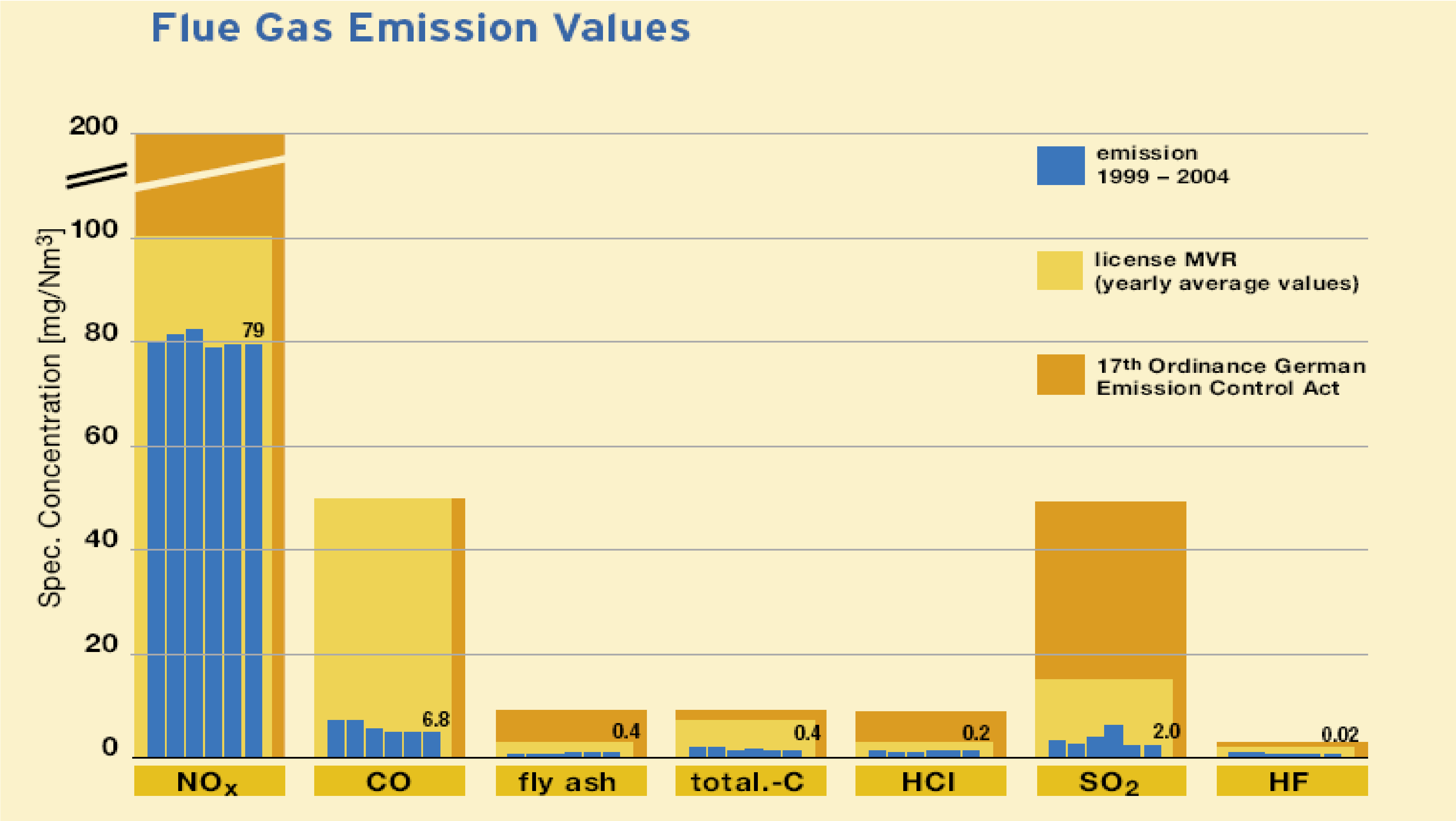
Wood and meadow fires – Serbian-Montenegro border-August 2014

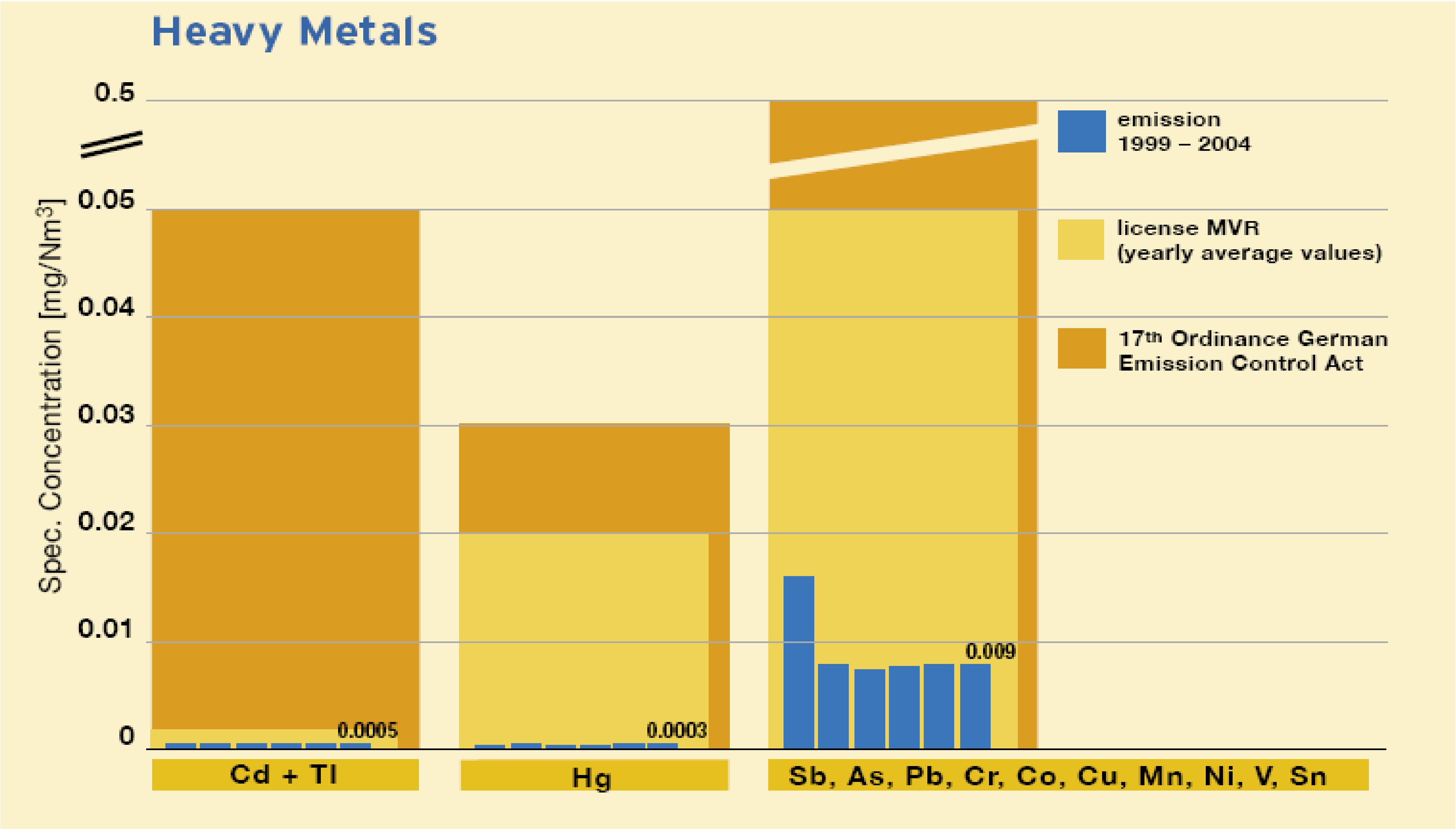
Waste landfill (dump) – near motor highway Bgd-Subotica (2014)

Agriculture field fires – near motors highway Bgd Croatian border (2014.)

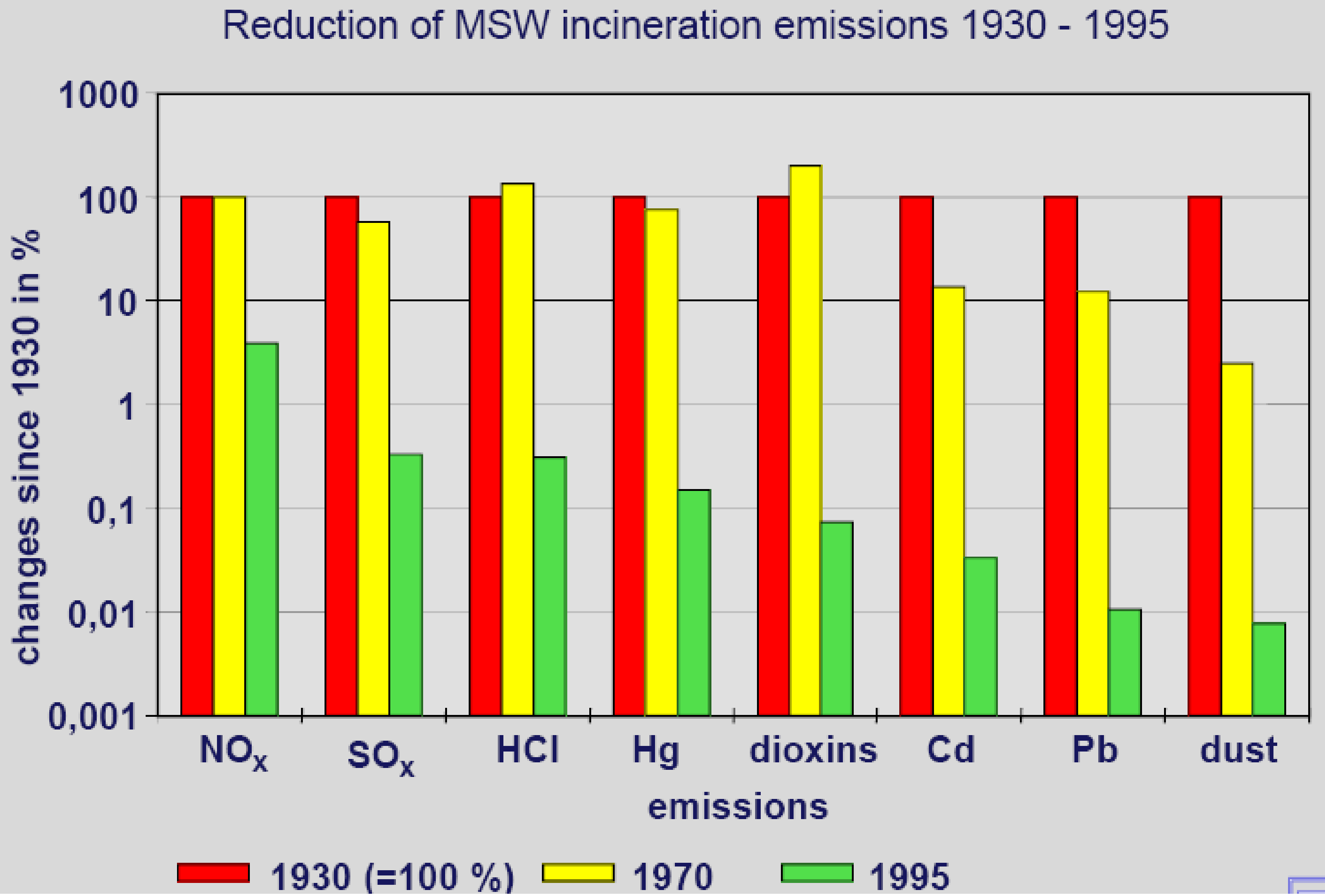
Flue-gas Cleaning @ MVR



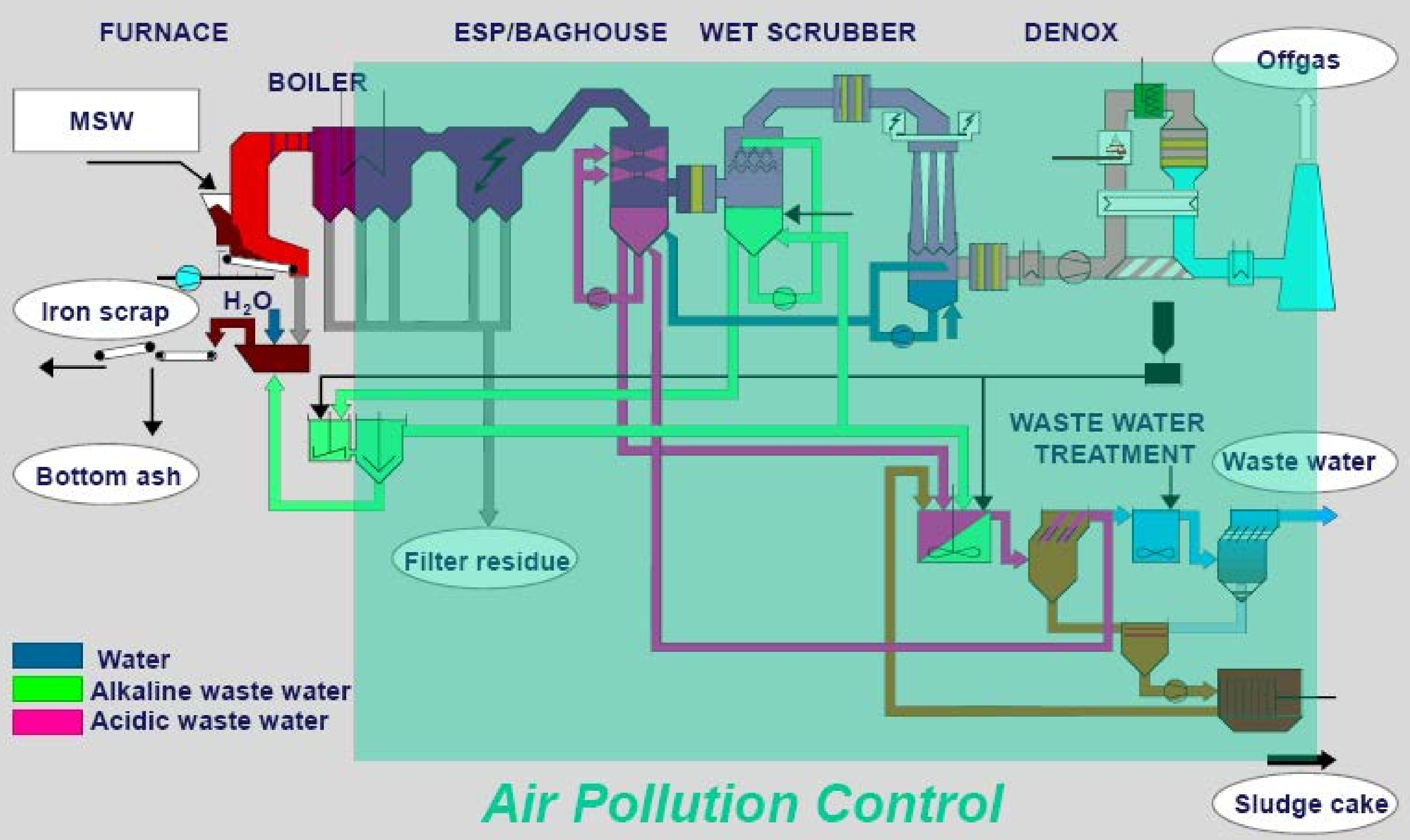

Flue Gas Emission Values
Spec. Concentration [mg/Nm3]
200
100
80
60
40
20
0
79
6.8
0.4
0.4
0.2
2.0
0.02
emission
1999 – 2004
license MVR
(yearly average values)
17th Ordinance German
Emission Control Act
NOx
CO
fly ash
total.-C
HCl
SO2
HF


Heavy Metals
0.5
0.05
0.04
0.03
0.02
0.01
0
Spec. Concentration [mg/Nm3]
0.0005
0.0003
0.009
Cd + Tl
Hg
Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V, Sn
emission
1999 – 2004
license MVR
(yearly average values)
17th Ordinance German
Emission Control Act

Air pollution control solves environmental problems



Air pollution control dominates incineration costs



Wastewater from incineration

- Controls vary from country to country
- Quantity:
  - influenced by gas scrubbing technology chosen *ie* wet, semi-dry, dry
- Treatment:
  - in aerated lagoons
  - widely used
  - low cost
  - may not meet required standard
  - physico-chemical treatment may also be needed

Measurement/Monitoring

Of what:

- **controlled parameters *eg* carbon monoxide**

How:

- **regular**
- **continuous**

Set out in:

- **national regulations**
- **permitted operating conditions**

Problems:

- **Measuring equipment may be imprecise**
- **Errors in correlation**
- **Errors in sampling**

Measurement: an example

Emissions from rotary kiln incinerator

Continuous monitoring for:

HCl, CO, dust, SO2, HF, TOC, Nox, O2

Monthly measurement for:

9 heavy metals

Twice a year (soon to be continuous):

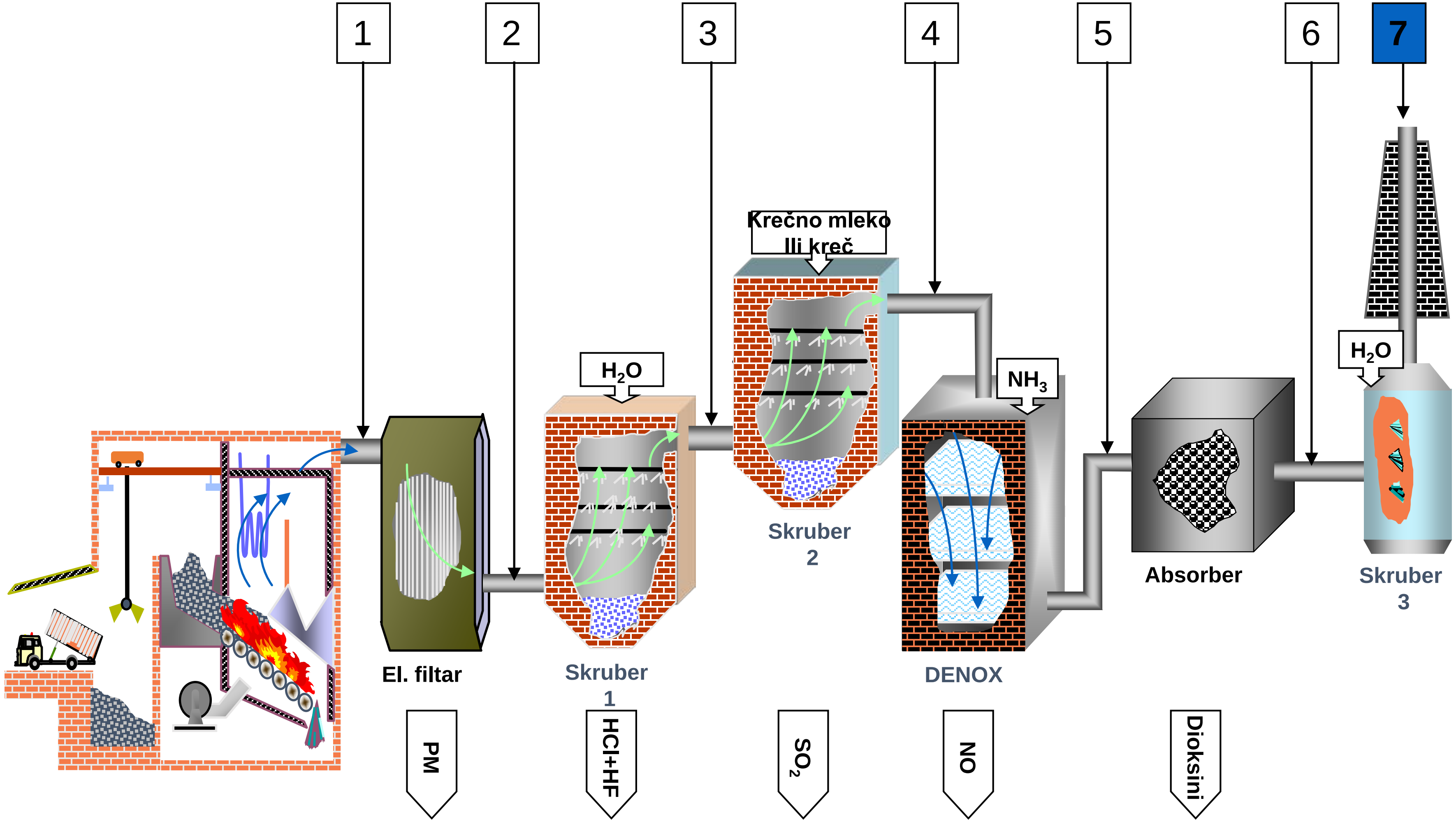
PCDD/PCDF

ALSO monitored: wastewater and solid residues

Source: Indaver, Belgium

WtE plant – monitoring of emissions

Measurement points



"BIOMONITORING"

Costs

- Related to site-specific and country-specific factors
- High level of sophistication & control = high construction costs
- Air pollution control costs = min. 30-40% of total
- Treatment costs per tonne similar to other technologies
- Cost savings because volume, weight and hazard of waste remaining for disposal greatly reduced
- Recovery and sale of energy/heat from the process improves economics

Konsultacije javnosti

Spaljivanje ostaje jedno od kontraverznih pitanja za mnoge zajednice

Naučna osnova mnogih briga je ponekad slaba, ali te brige se moraju razmotriti

Zakonski okvir konsultacija javnosti

- Nekoliko podsticajnih zakonskih akata u EU:
  - Direktiva o učešću javnosti
  - Direktiva o proceni uticaja na životnu sredinu
  - Direktiva o integrisanom sprečavanju i kontroli zagađivanja životne sredine
  - Registar emisije zagađujućih materija (EPER)
- U Srbiji je Zakon o zaštiti životne sredine glavni podsticajni pravni akt
- Usvojeni i drugi propisi u skladu sa EU

Ključna pitanja za konsultacije

- Strateško planiranje
- Razvoj prijava
- Prijava za dozvolu

Ključna pitanja za razmatranje

- Proceniti i razumeti dokaze
- Razumeti zabrinutost javnosti (videti ‘faktore straha’)
- Obezbediti informacije i argumente pre nego zaključke
- Oceniti potreban trud za konsultacije

Identifikovani ‘faktori straha‘ od strane javnosti

- *Rizici generalno izazivaju veću zabrinutost (i manje su prihvatljivi) ako se smatra:*
  - *da su više nedobrovoljni (npr. izloženost zagađenju) nego dobrovoljni (npr. opasni sportovi ili pušenje)*
  - *da su neravnopravno raspoređeni (neko ima koristi, a neko trpi posledice)*
  - *da se ne mogu izbeći preduzimanjem ličnih mera predostrožnosti*
  - *da proizilaze iz nepoznatog ili novog izvora*
  - *da su pre posledica stvorenih nego prirodnih izvora*
  - *da izazivaju skrivenu i nepovratnu štetu, npr. pojava bolesti mnogo godina nakon izloženosti*

Faktori straha (nastavak)

- *da predstavljaju neku posebnu opasnost za malu decu i trudnice ili, uopštenije, za buduće generacije*
- *da predstavlja opasnost od neke vrste smrti (ili bolesti/povrede) koja izaziva poseban strah*
- *da nanose štetu žrtvama koje se mogu identifikovati pre nego anonimnim žrtvama mada su nedovoljno shvaćeni od nauke*
- *da su predmet kontradiktornih izjava iz odgovornih izvora (ili, čak gore, iz istog izvora).*

- Što se tiče novih projekata ili izmena postojećih postrojenja, javnost se obično obaveštava o napretku procedure odobravanja dozvole ili o izgradnji pogona nekom vrstom biltena ili preko interneta.
- Na slici je prikazan primer takvog biltena (prva strana), koja informiše javnost o trenutnom statusu procedure odobravanja projekta za proširenje postrojenja za insineraciju otpada

Bürger-Info

EINE INFORMATION DER AVN FÜR DIE STANDORTBEVÖLKERUNG VON ZWENTENDORF UND SEINER NACHBARGEMEIN

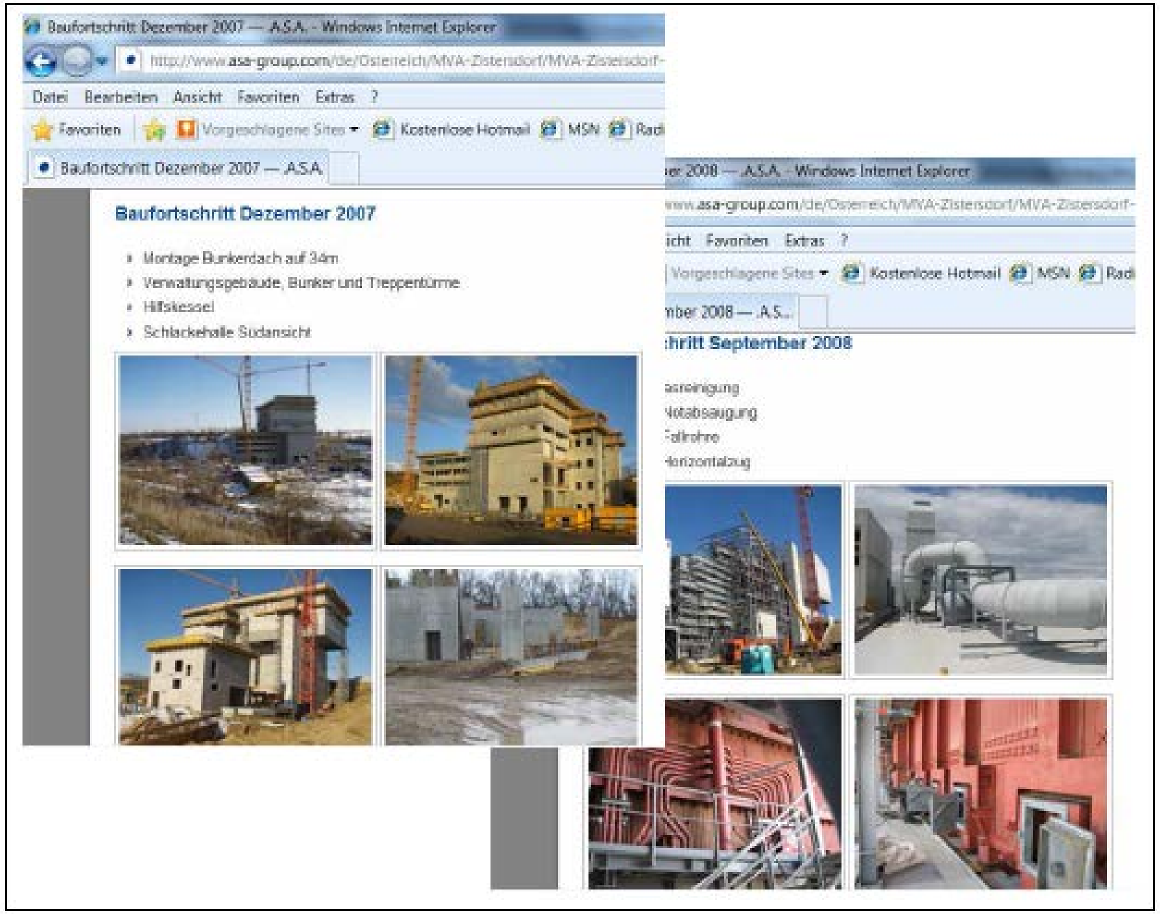
Liebe Bürgerinnen und Bürger der Marktgemeinde Zwentendorf und der umliegenden Nachbargemeinde

Wann:

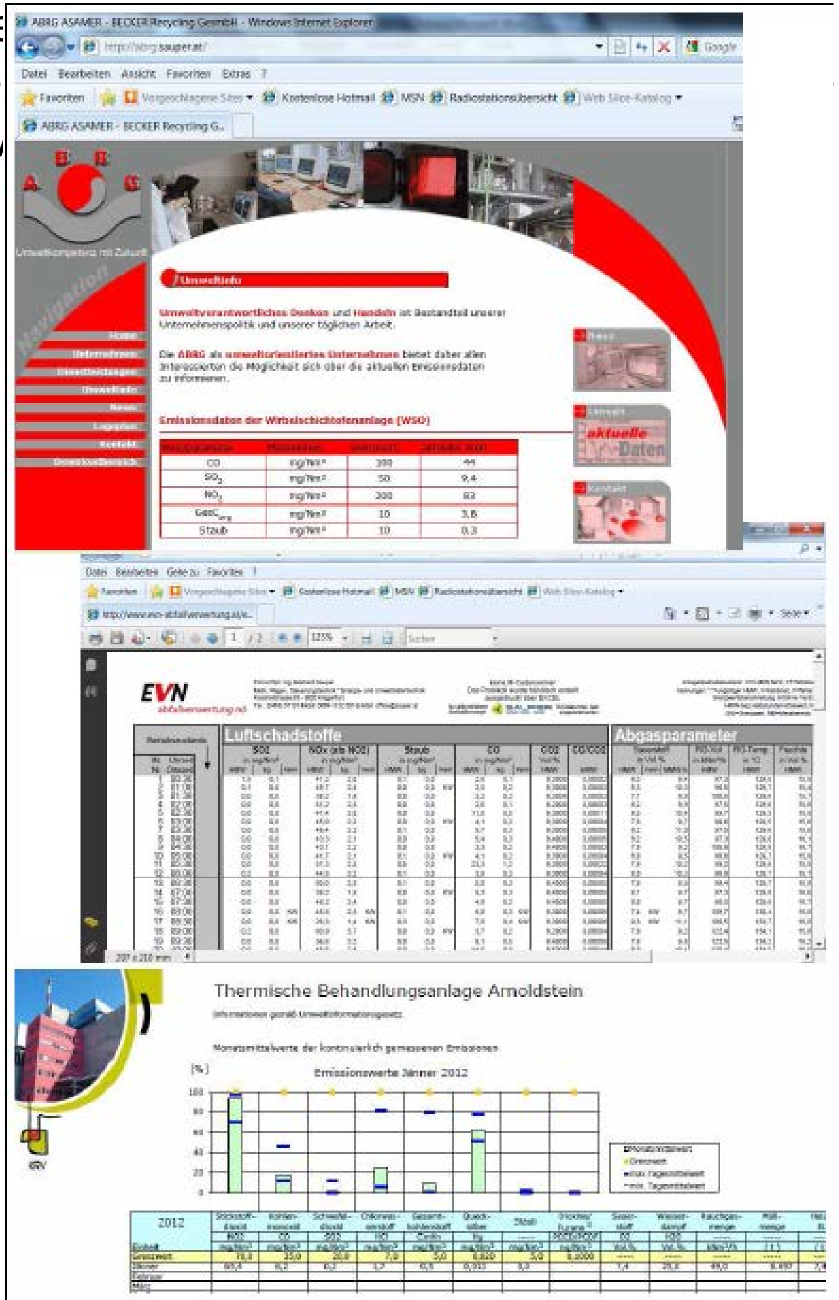
Wo:

- Sledeće dve slike sa Interneta pokazuju napredak izgradnje opštinskog postrojenja za insineraciju čvrstog otpada.
- Ovo je primer kontinuiranog informisanja javnosti u toku faze izgradnje postrojenja

Слика 2: Слике напретка изградње општинског постројења за инсинерацију чврстог отпада ASA у Zistersdorf-у (www.asa.at)



- Postrojenja za insineraciju otpada koja su operativna obično javnost informišu o trenutnoj emisiji preko svojih interne vrši poređenje emisije u vazduh sa pre da proveri usaglašenost sa graničnim v



Best Available Techniques (BAT) Reference Documents (BREF)

Reference documents under the IPPC Directive and the IED:

- http://eippcb.jrc.ec.europa.eu/reference/

Waste Incineration:

- BREF – 08.2006 – http://eippcb.jrc.ec.europa.eu/reference/BREF/wi_bref_0806.pdf
- BREF – Formal Draft - http://eippcb.jrc.ec.europa.eu/reference/BREF/WI/WI_BREF_FD_Black_Watermark.pdf

Monitoring of Emissions to Air and Water from IED Installations:

REF – 07.2018 – http://eippcb.jrc.ec.europa.eu/reference/BREF/ROM/ROM_2018_08_20.pdf

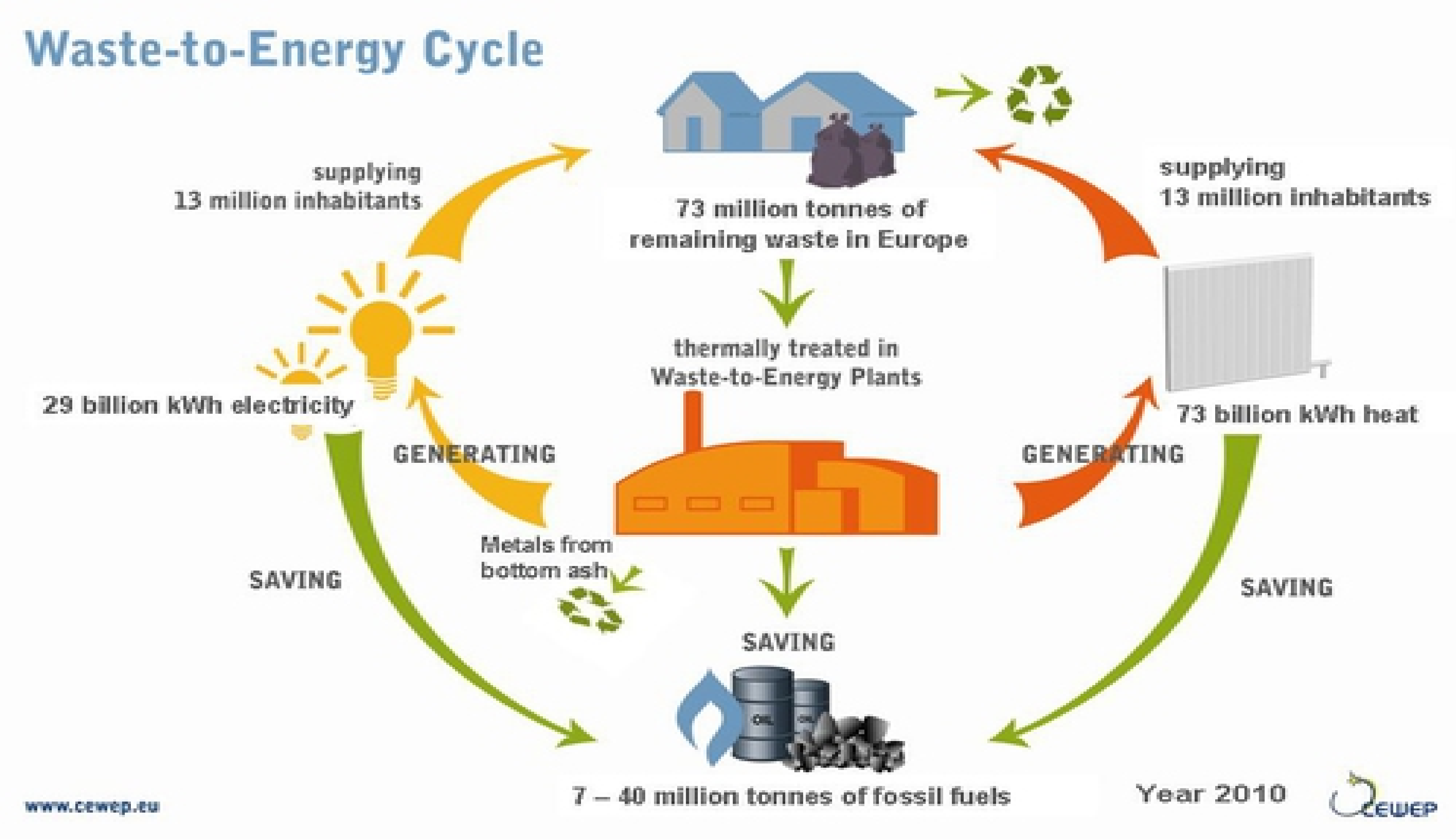
Europe

INCINERATION IN EUROPE

- *Previously uncontrolled / unmonitored*
- *1989 Directive*
- *1996 Facilities closed*
- *2000 Directive*
- *2006 - More faculties will be closed*
- *13 out of 15 members states have thermal treatment of waste*
- *Capacity continuing to grow*

mcos

Waste-to-Energy in Europe



International WTE PLANT, The case of BARCELONA

Waste-to-Energy as Renewable Energy Source

- Waste-to-Energy will contribute in achieving the goals set by the European Union regarding the **production of energy from Renewable Energy Sources**, as the biodegradable part of the MSW is considered biomass (Directive 2009/28), thus R.E.S.

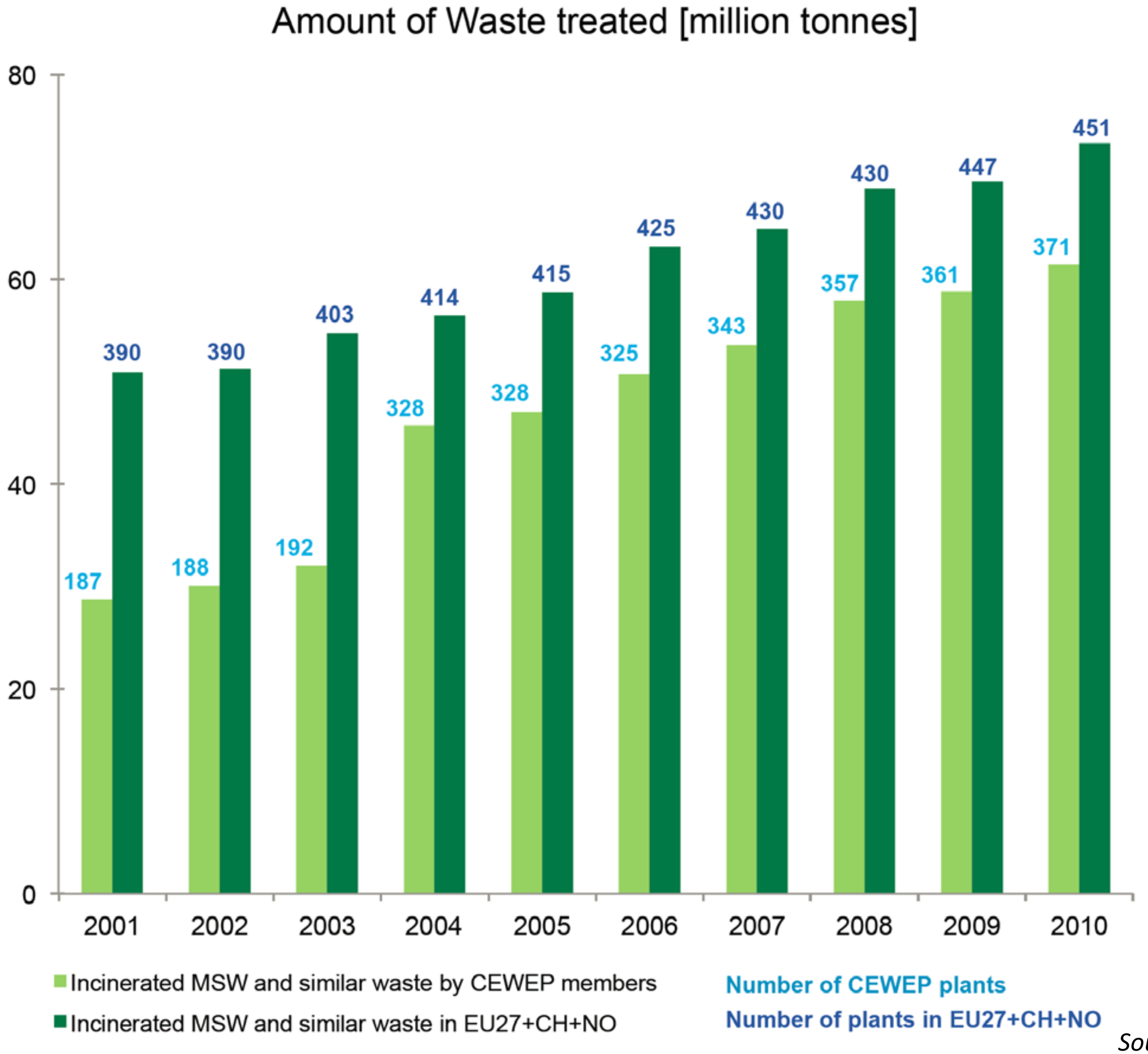
- According to international practice Waste-to-Energy plants are considered R.E.S., according to the percentage of biomass contained in the incoming waste, i.e. its biodegradable fraction. The examples of several countries are shown in the following table (Data from CEWEP)

Waste-to-Energy Plants as R.E.S.

Austria	50%	**Ireland**	72%
Belgium	47,78%	**Italy**	51%
Denmark	80%	**Netherlands**	51%
France	50%	**Switzerland**	50%
Germany	50%	**Portugal**	Calculated from empirical equation

Funded by
the European Union

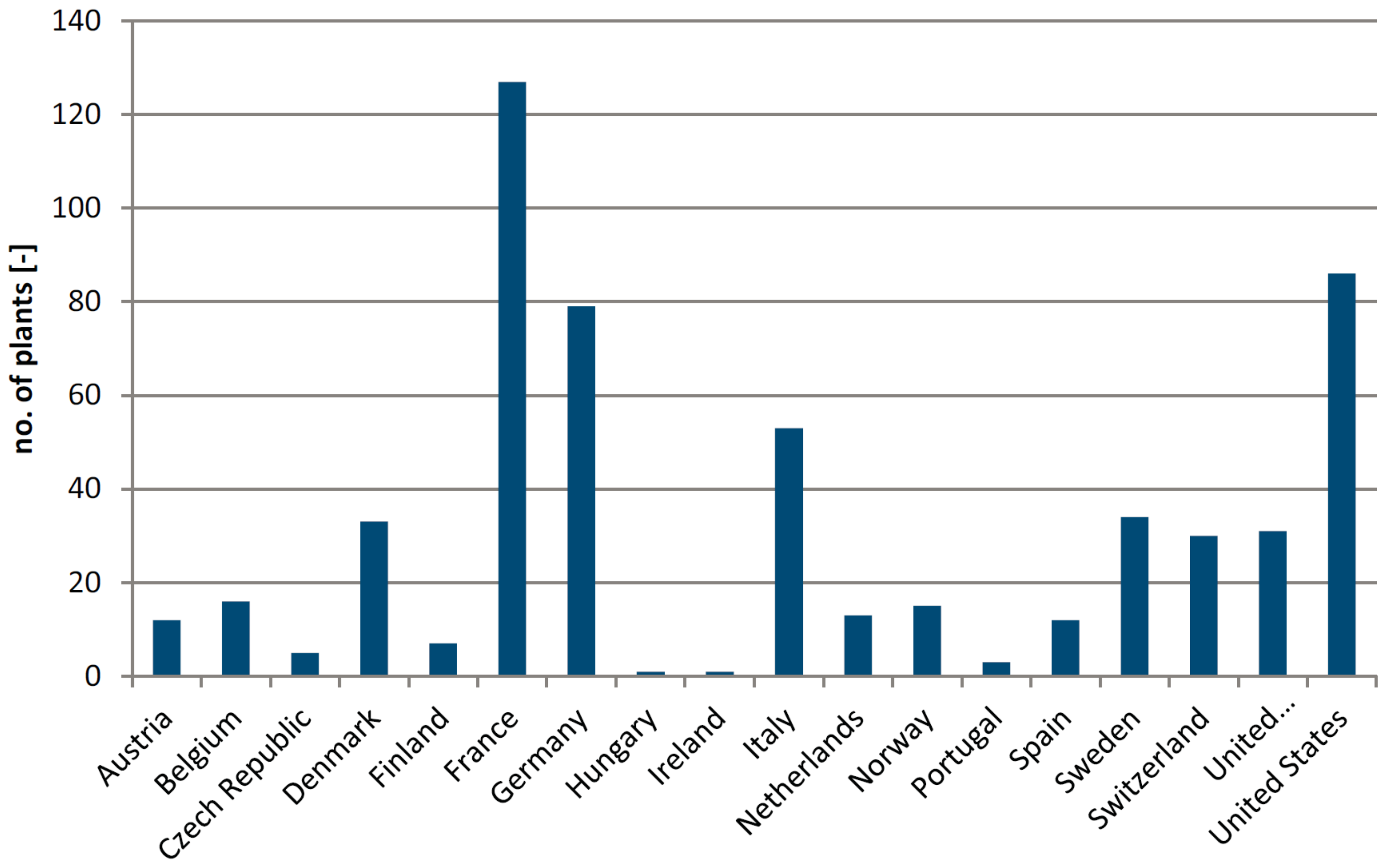
Amount of waste incinerated in EU



Source: CEWEP, 2011

Funded by the European Union

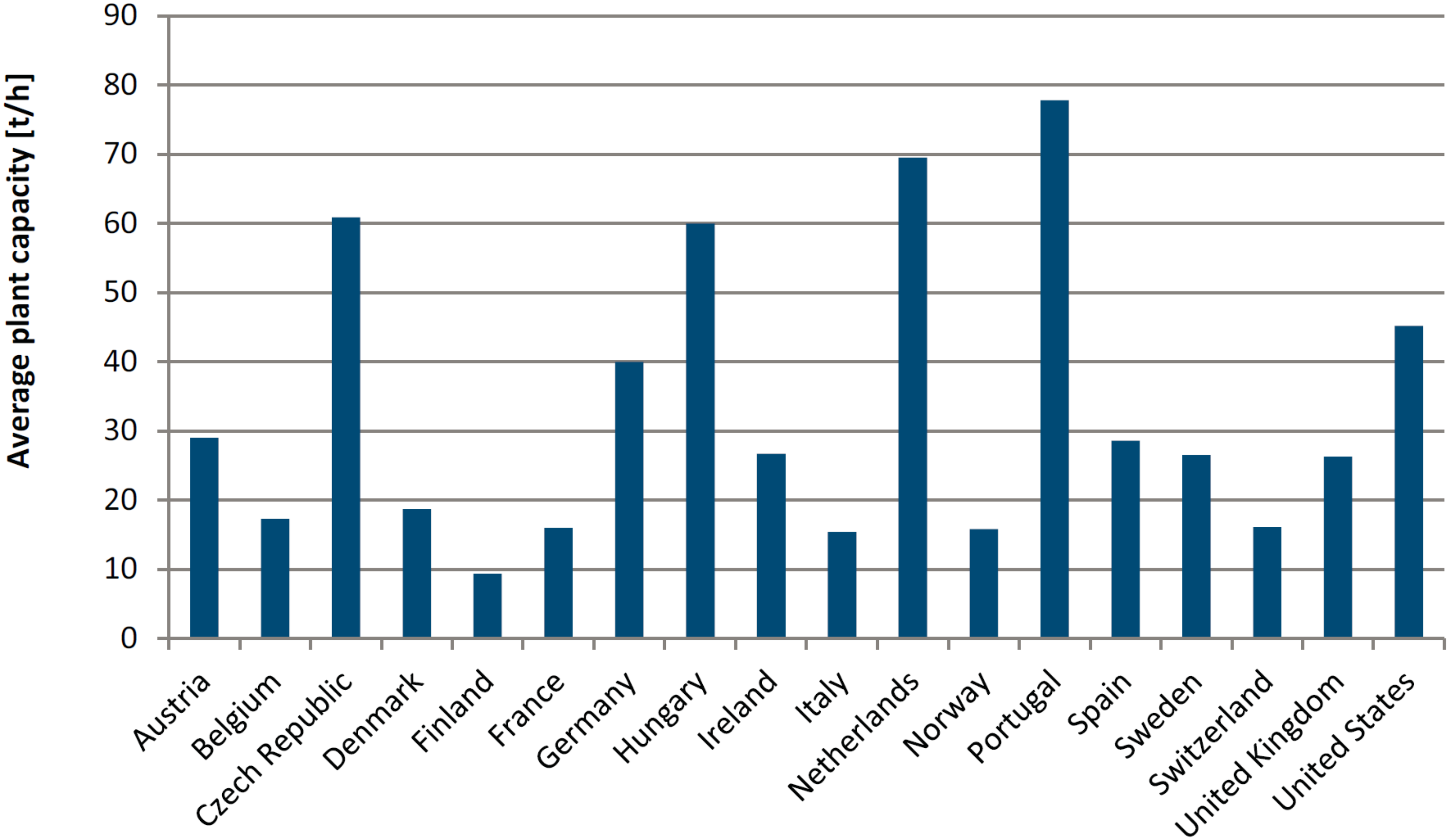
Number of plants per country



Source: ISWA 2012

Funded by
the European Union

Average plant capacity

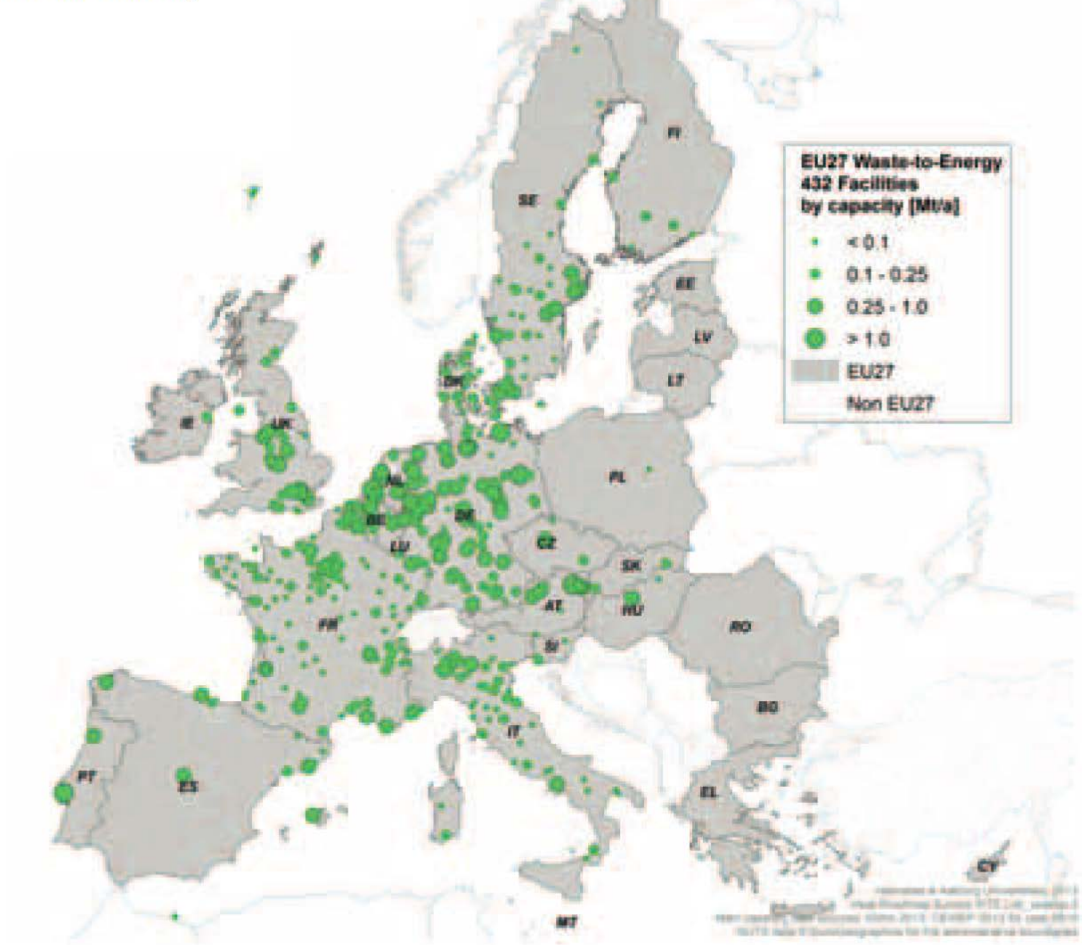


Source: ISWA 2012

Funded by
the European Union

Locations of W-t-E plants in EU

Figure 1: Location of WtE plants in Europe.
Source: Halmstad University

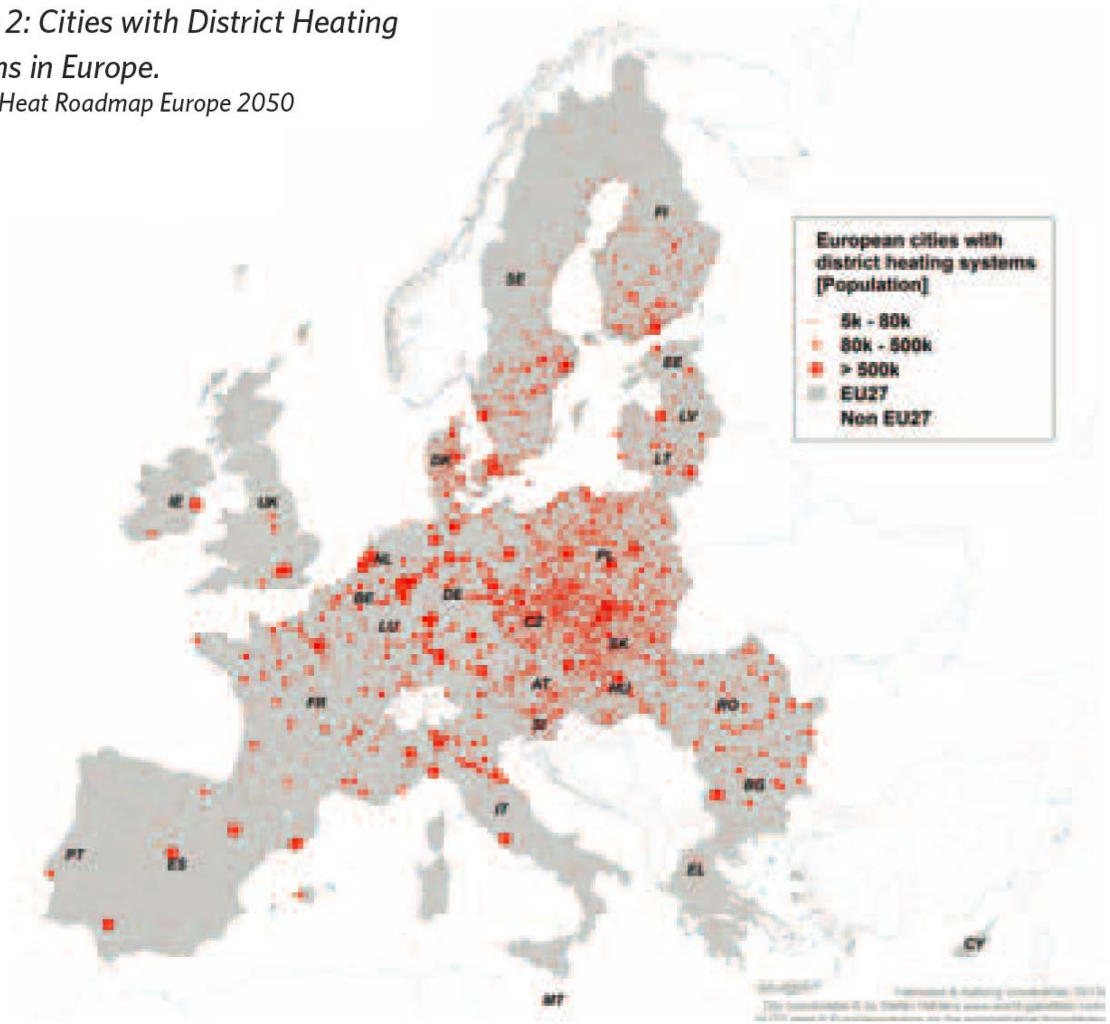


Source: Warmth from Waste: A Win-Win Synergy, Background Paper for project development, on District Energy from Waste: a common initiative

District heating systems locations across EU

Funded by the European Union

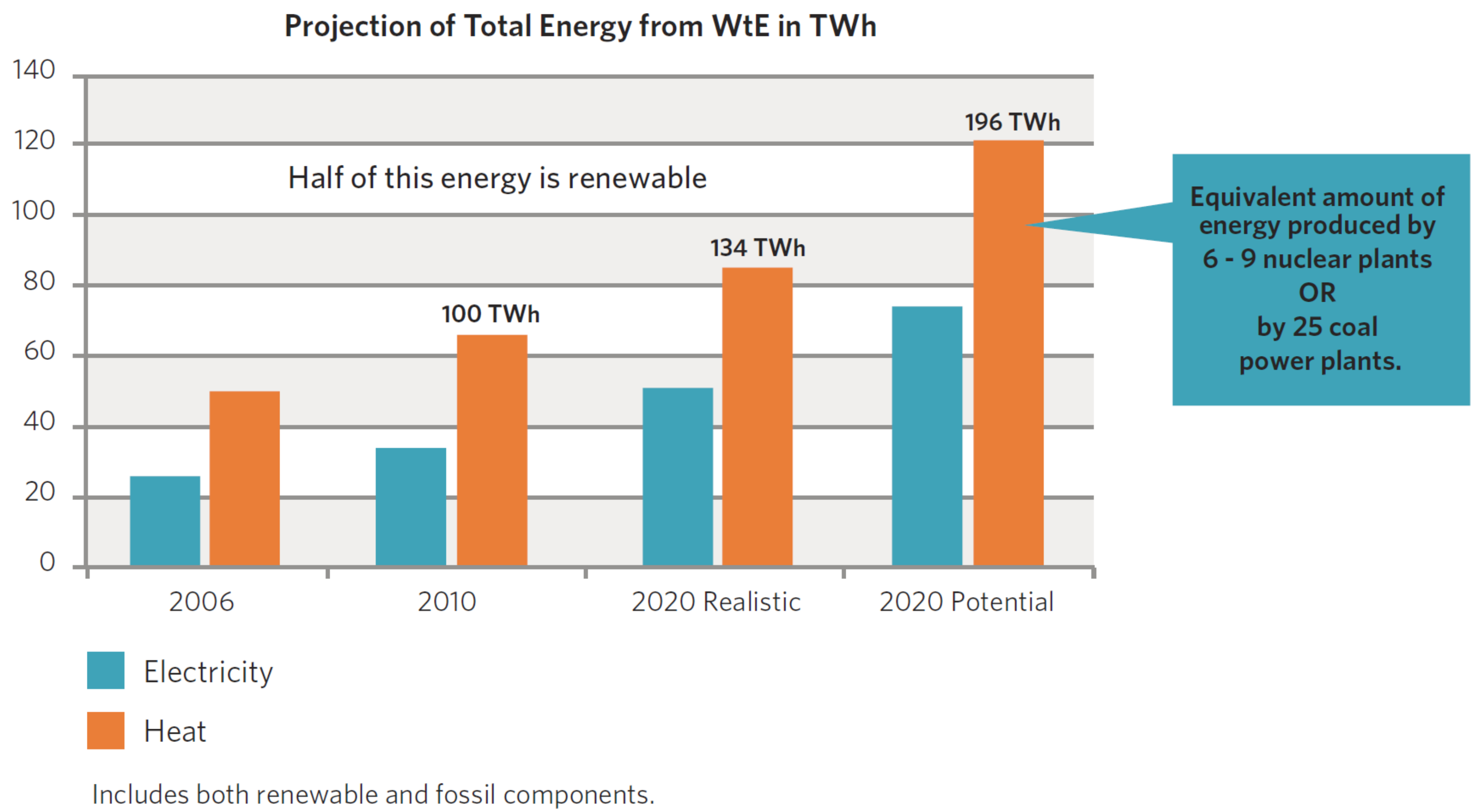
Figure 2: Cities with District Heating systems in Europe.
Source: Heat Roadmap Europe 2050



Source: Warmth from Waste: A Win-Win Synergy, Background Paper for project development, on District Energy from Waste: a common initiative

Funded by the European Union

Energy from waste in EU



Source: Warmth from Waste: A Win-Win Synergy, Background Paper for project development, on District Energy from Waste: a common initiative

USA

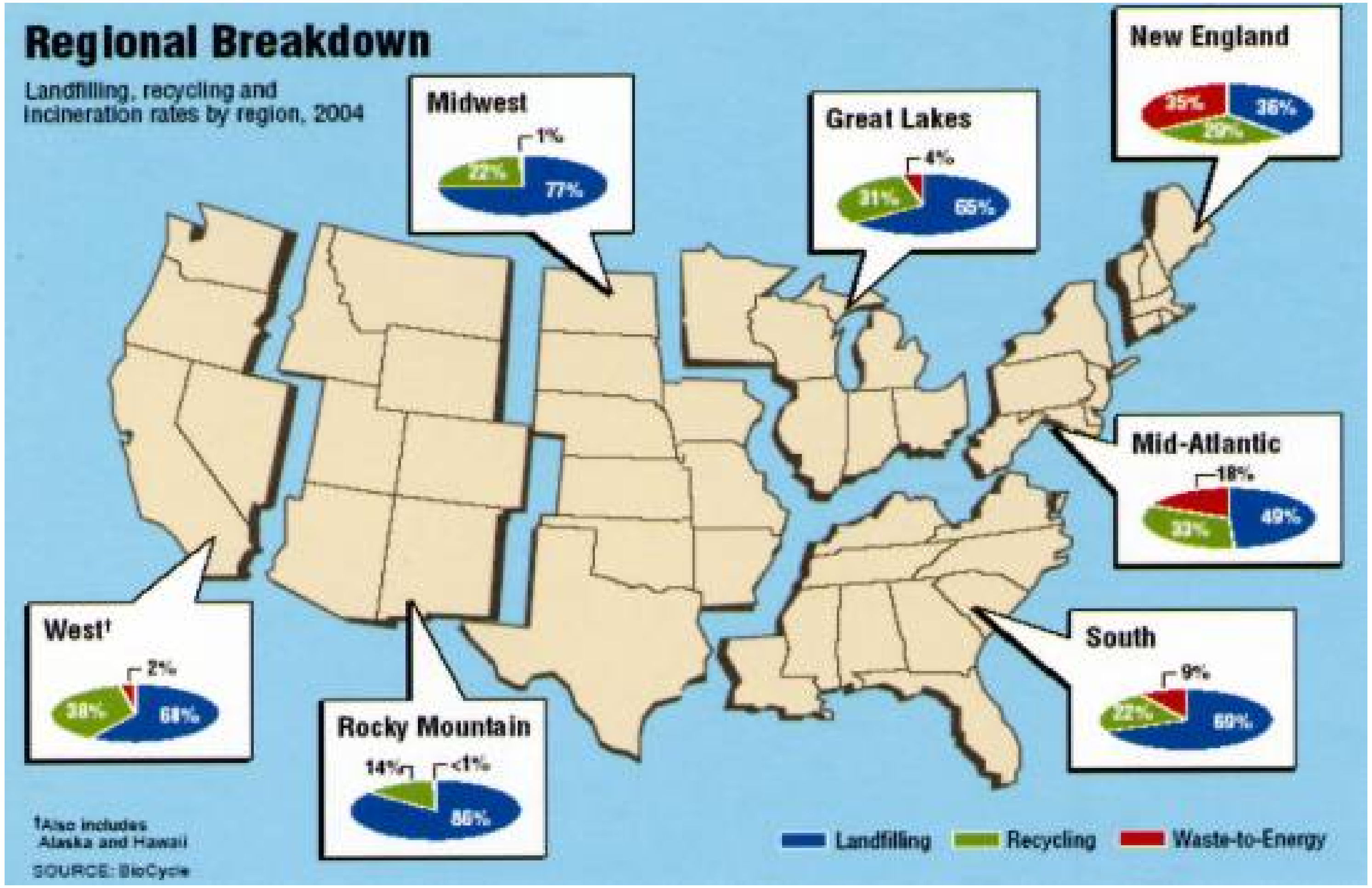
- USA

- Total waste per year
  - 5,600 Nimitz Class air craft carriers,
  - 247,000 space shuttles, ili
  - 2.3 million Boeing 747 jumbo jets

USA

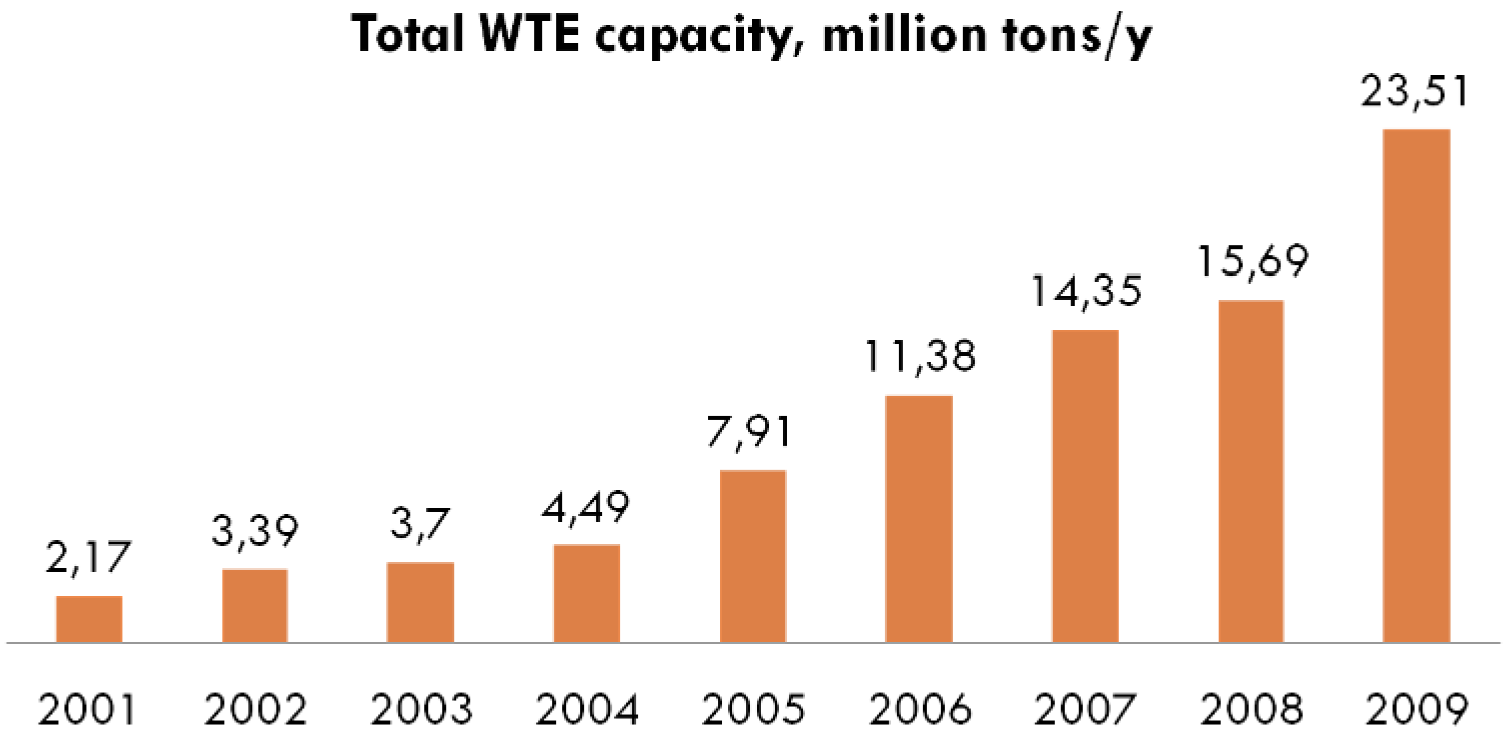
- Economic Impacts: The solid waste industry contributed over $96 billion, 948,000 jobs, and just over one percent of U.S. GDP to the nation's economy.
- Tax Impacts: The solid waste industry contributed a total of $14.1 billion in direct, indirect, and induced taxes to federal, state, and local governments.
- Employment and Compensation: The solid waste industry employed approximately 367,800 people. Total industry compensation, including benefits, was estimated at $10.0 billion

Waste management in USA



ASIA

Waste-to-Energy in China



China has become the fourth largest user of waste-to-energy (WTE), after E.U., Japan, and the U.S.

Technology of WTE in China

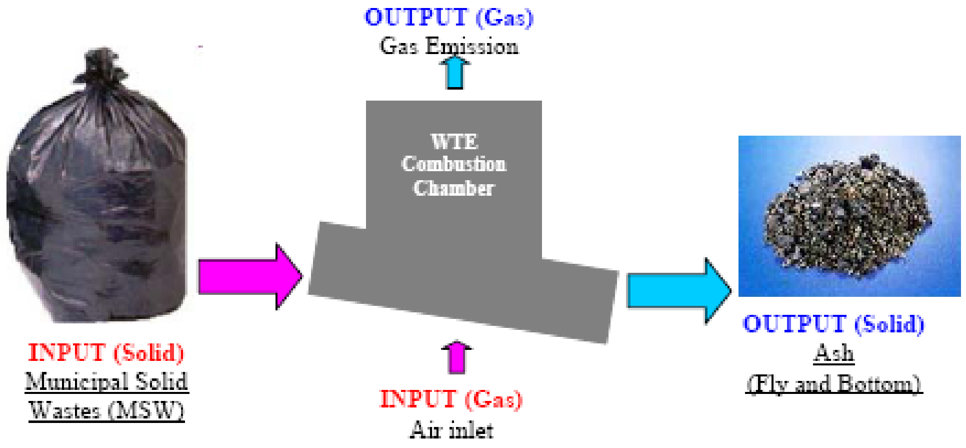


Figure 1-10: Waste-To-Energy Combustion

Combustion system	Number of plants	Total capacity, tons/day	Capacity distribution
Stoker grate, imported	56	47,585	50%
Stoker grate, domestic	20	12,885	17%
Circulating Fluidized Bed(CFB)	37	31,920	33%
Total	113	92,390	100%

MSW Composition

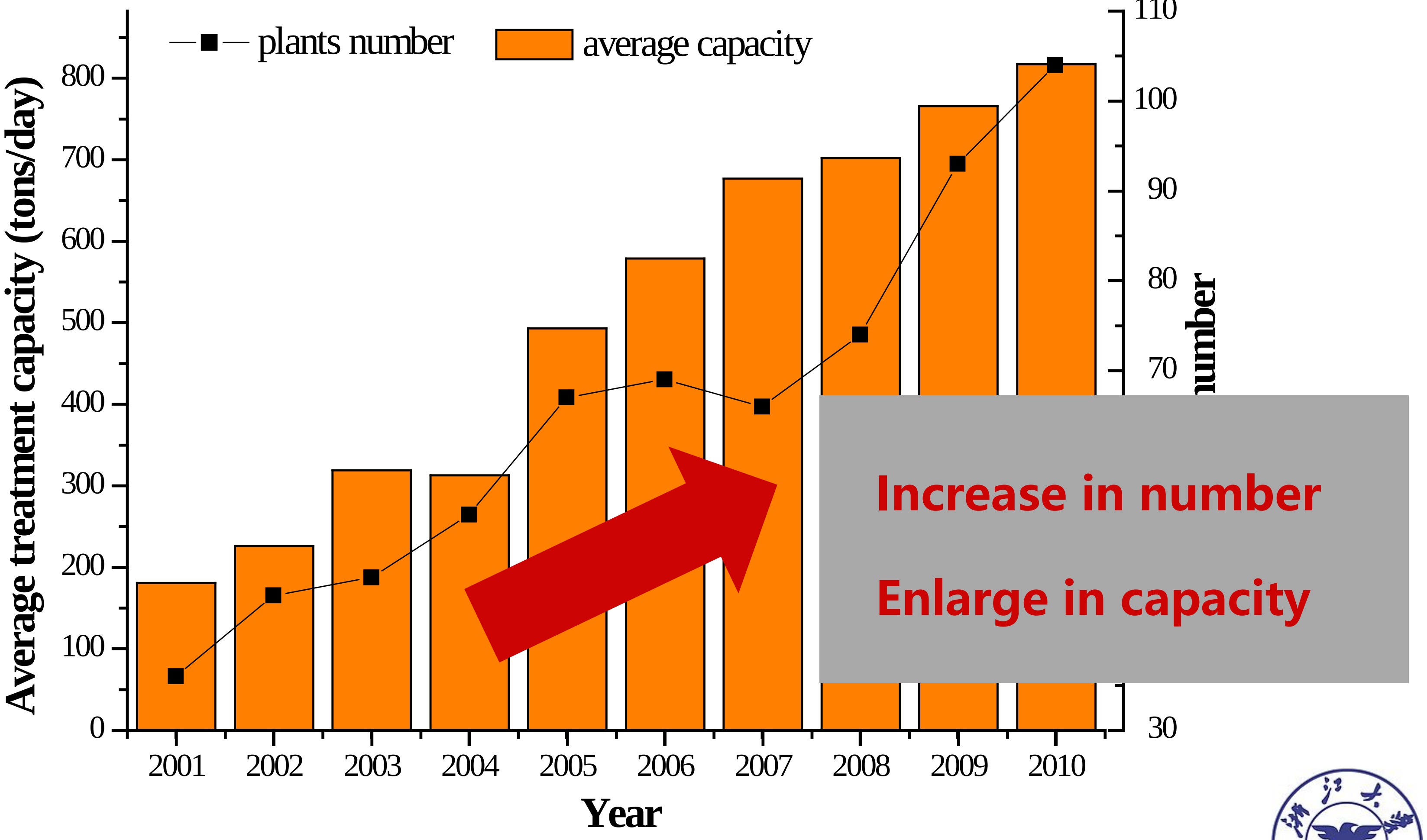
	Organic	Paper	Plastic	Glass	Metal	Textile	Wood	Ash
China (2003)	52.6	6.9	7.3	1.6	0.5	4.7	6.9	19.2
USA (2005)	25.0	34.0	12.0	5.0	8.0	-	-	-
France (2005)	32.0	20.0	9.0	10.0	3.0	-	-	-
Australia (2005)	47.0	23.0	4.0	7.0	5.0	-	-	-

Features

- High organic content
- High moisture content
- Low heating value

WTE Number & Capacity

2001-2010



WTE Tendency

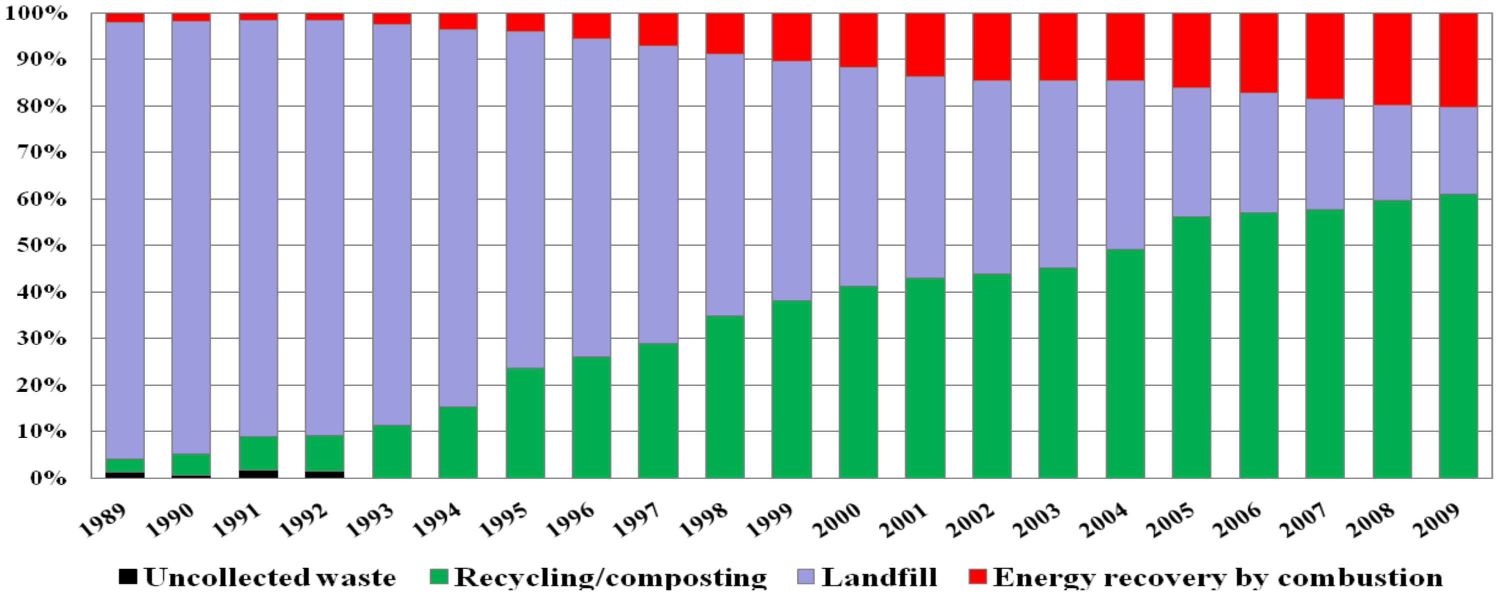
- **Renewable energy law and policy promote WTE electricity selling price (2007) :**
  WTE = fossil fuel power plant + 0.25 ¥RMB

- **Increased MSW capacity for WTE plant: 800-1000 t/d (under design and construction)**

- **Increased incineration proportion to 35% by the end of 2016, with 48% in eastern region**

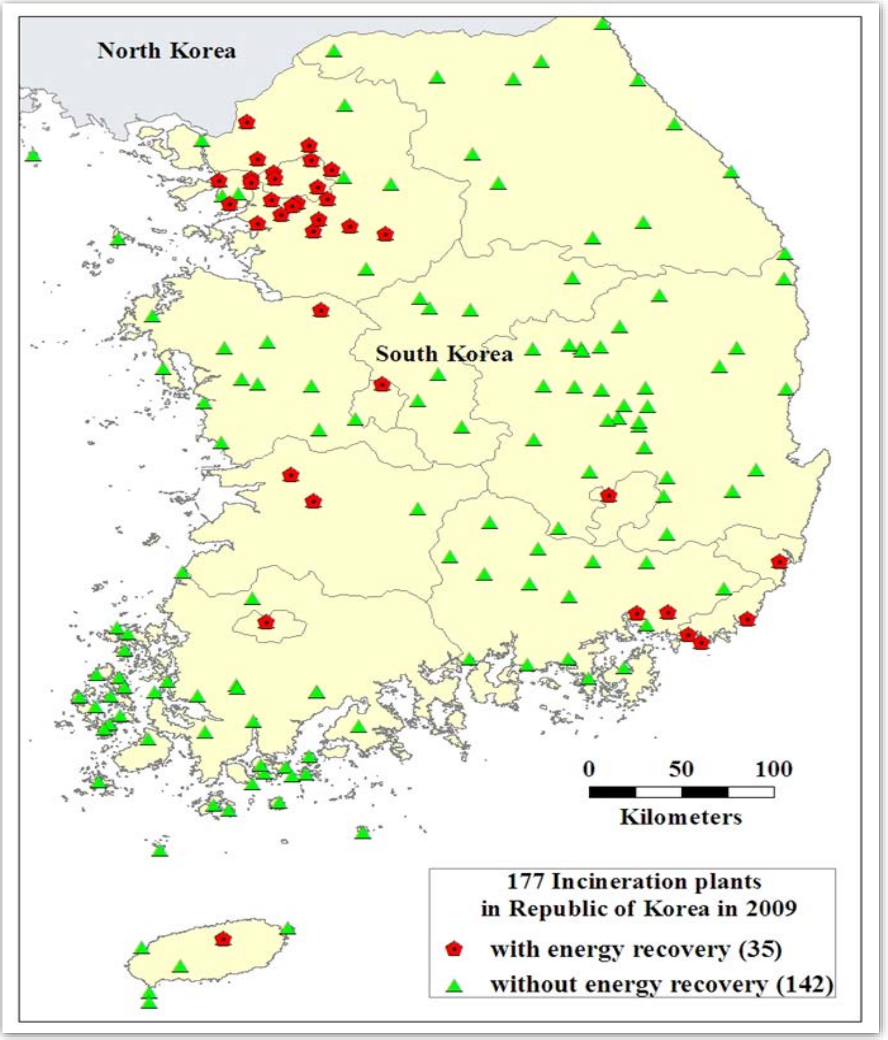
Trends in MSW treatment in the Republic of Korea (1989 – 2010)

- Energy recovery by combustion has increased from **2%** (0.5 million tons) to **20% (3.8 million tons)**.
- Recycling/composting has also increased from **3%** (0.8 million tons) to **61% (11.4 million tons)**
- Landfilling has been drastically reduced from 94% (26.8 million tons) to 19% (3.5 million tons).



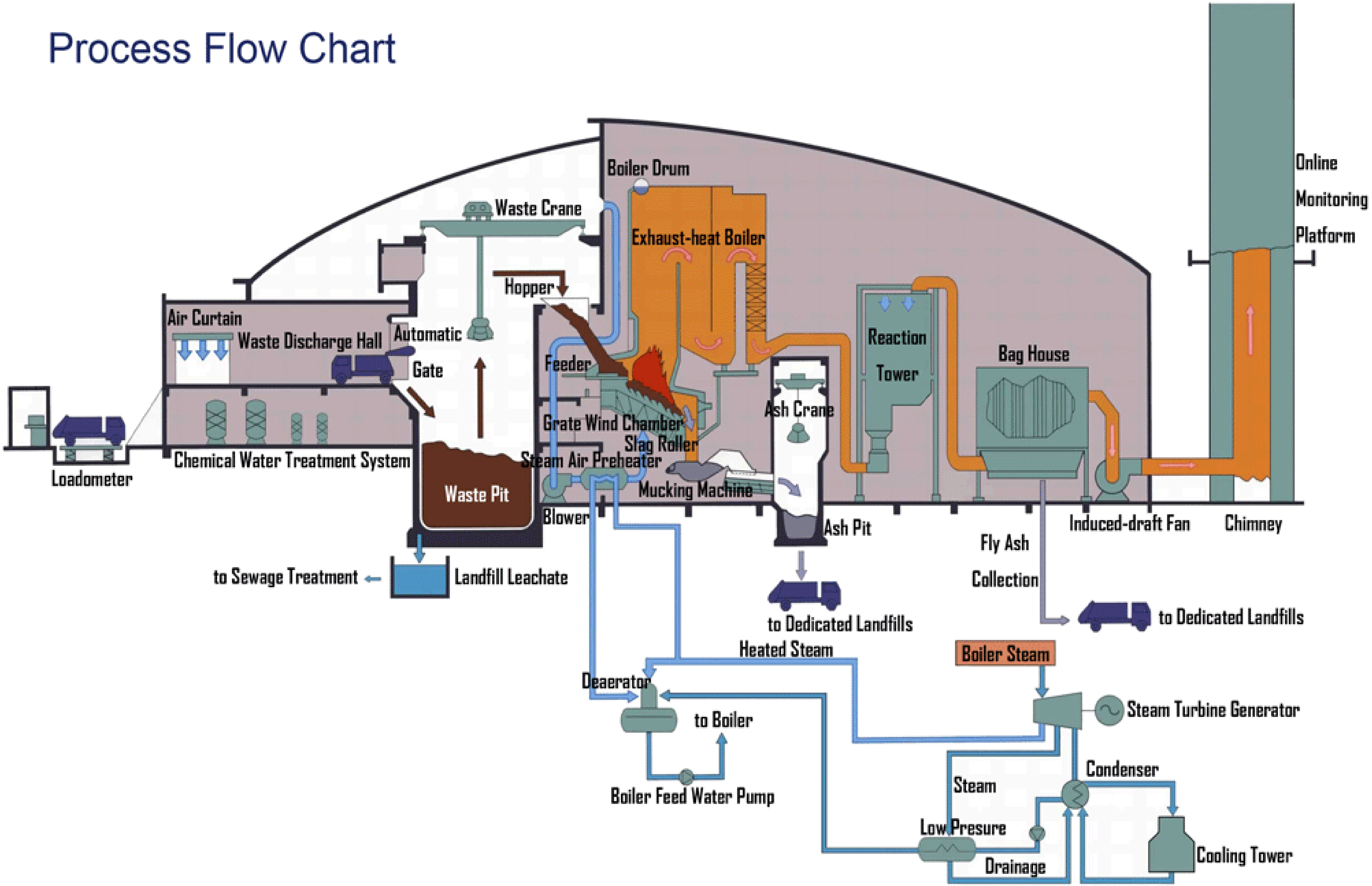
Waste Incineration Plants in the Republic of Korea

- 35 large incinerators (in red symbols), mostly using grate-type furnaces
- **Heat supply 4.4 million MWh** and **electricity generation 0.2 million MWh**



700 TPD Phuket Waste Incineration Plant

Process Flow Chart



REF：http://www.pjt.co.th/index_th.asp

700 TPD Phuket Waste Incineration Plant

- Plant Location : Phuket City Municipality
- Capacity : 2 x 350 TPD with 14 MWe (Turbine Generator Rated)
- Technology : Stoker Incinerator + Steam Turbine-Generator + SDR + Bag Filter
- Contract : BOT for 15 yr and can re-contract for another15 yr

- Project Status : Commissioning in April 2012

REF：http://www.pjt.co.th/index_th.asp

Conclusions

Conclusions

➔Many efforts should be made in order to inform the society and the policy makers that modern waste to energy technology is the demanded step after recycling and composting at the source, in order to be severed by the landfill sites and the illegal dumps

➔Green Metropolitan Capitals (Stockholm, Copenhagen, Hamburg, Paris, London , Seoul, Shanghai, Tokyo, New York) use a combination of recycling at the source and thermal treatment with energy recovery

➔Waste to energy, in harmonic cooperation with the recycling of MSW at source, is considered to be the most **efficient, dominant, integrated and proven technology** for solving the municipal solid waste management and treatment problem of metropolitan cities.

- For the short term (<5 years), building a **<u>sanitary</u>** landfill is cheaper than building a WTE (same as renting rather than buying a house).
- In the longer term (10-50 years), WTE is a better investment and, also, better for the environment, a city, and a nation.
- Regional and national governments should place sustainable waste management high up on their list of essential infrastructure, same as is done for wastewater treatment, electricity and water supply.

MUNICH WtE PLANT

Types of waste:
Household waste, bulky waste, industrial waste, sewage sludge, energy recovery waste

Capacity: 653 273 tons/year (2009)

Combustion units: 4

Heating: Reciprocating grate

Electricity sales:
131,514,000 kWh/a

District heating output:
744,772,000 kWh/a

Flue gas cleaning process:
Spray dryer – ESP – 2-stage wet scrubber – Catalyst – Fabric Filter

WtE Plant Munich North

Source: Bayerisches Landesamt für Umwelt

WASTE INCINERATION PLANT IN COLOGNE

WtERT Waste-to-Energy Research and Technology Council

Types of waste:
Household waste, bulky waste, industrial waste, sewage sludge, energy recovery

Capacity:
740 702 tons/year (2008)

Combustion units: 4

Heating: Roller grate

Electricity sales:
331,970,000 kWh/a

District heating output:
137,501,000 kWh/a

AVG Köln mbH

Flue gas cleaning process:
Spray dryer – Fabric filter – HCl-scrubber – SO_2-scrubber – DENOX dioxin catalyst – coke filter

Source: www.afgkoeln.de

Druge metode konverzije biootpada u energente

Piroliza

termička razgradnja u gas/tečno gorivo/čvrsti ostatak (čadj), srednje-visoke temperature, bez vazduha

Gasifikacija

Proces nepotpunog sagorevanja (nedovoljan višak vazduha) uz dodatak vodene pare i dr., proizvodi – gas i čvrsti ostatak

Biohemijski procesi:

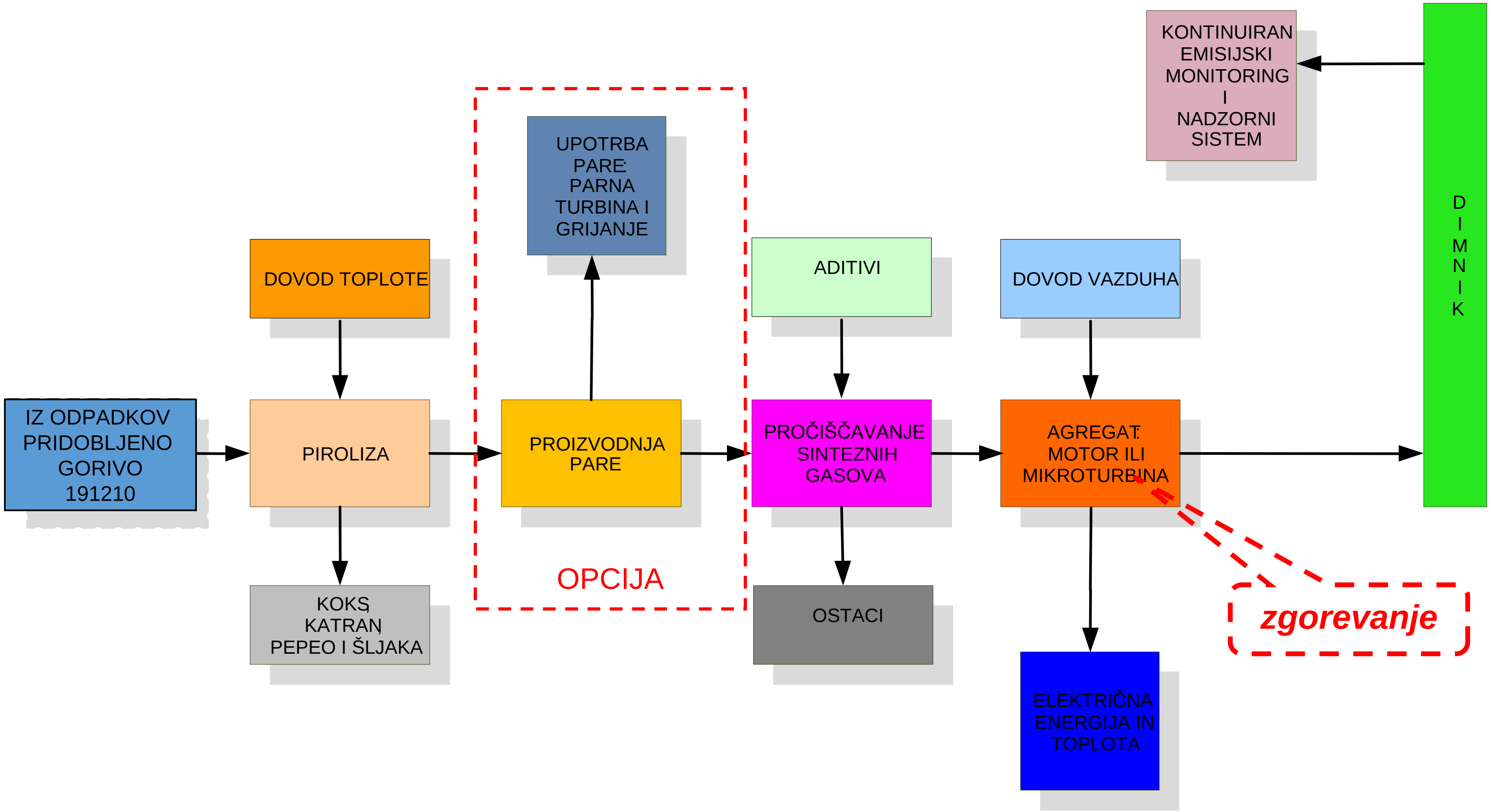
Anaerobna digestija

Kontrolisana fermentacija u cilju proizvodnje alkohola

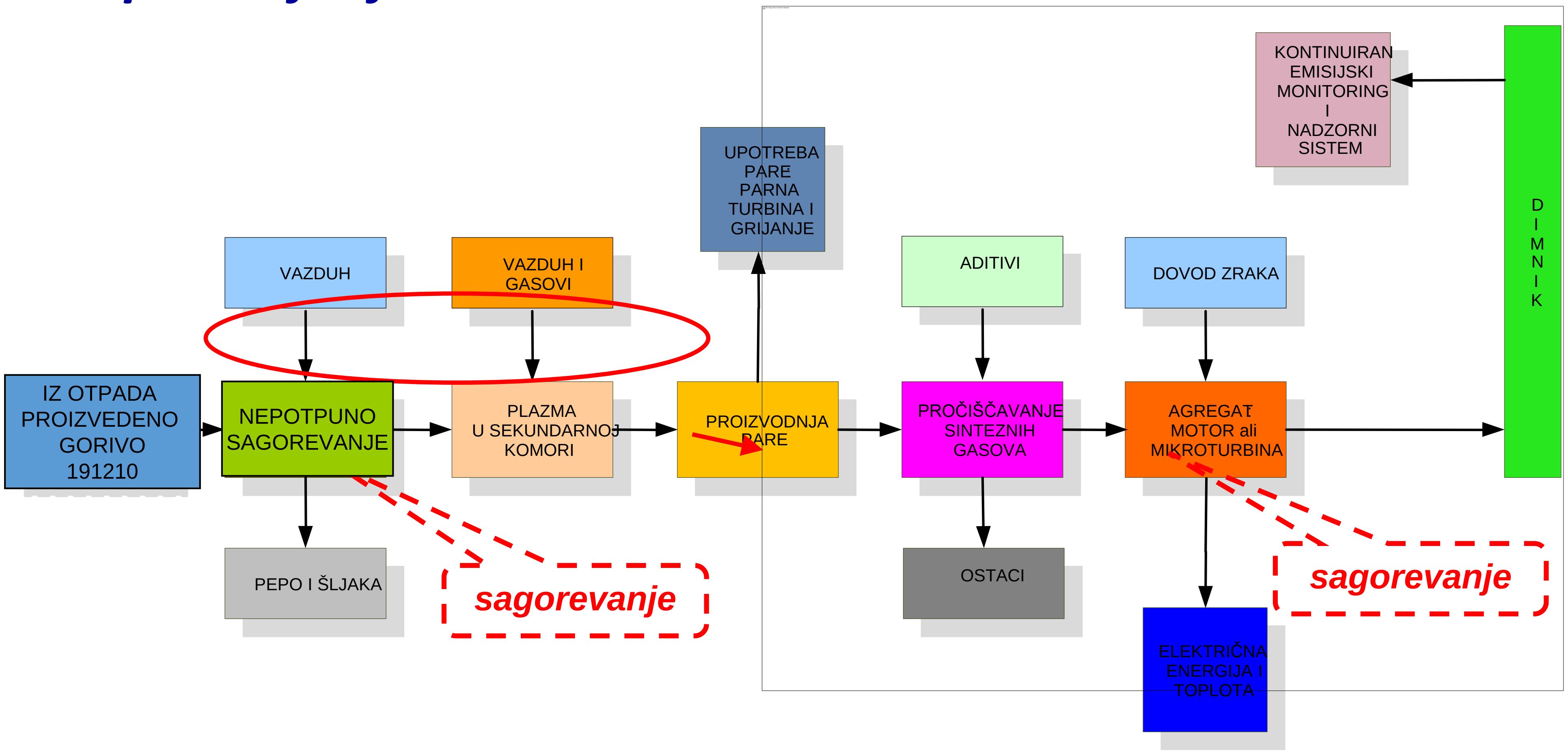
Proizvodnja etanola, metanola

Pyrolyzer—Mitsui R21

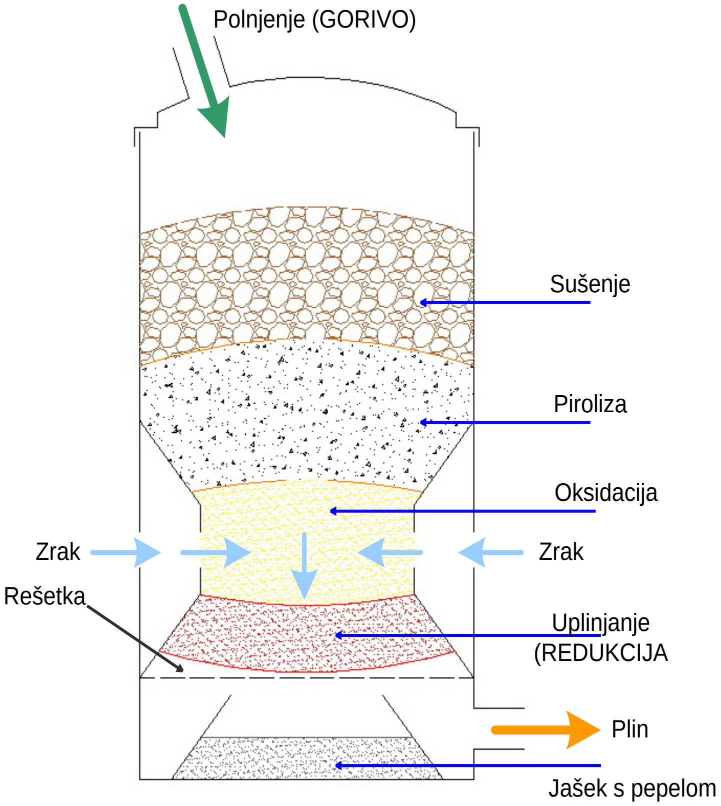
Piroliza i sagorevanje sinteznog gasa i/ili tekućeg goriva u toplotnim postrojenjima



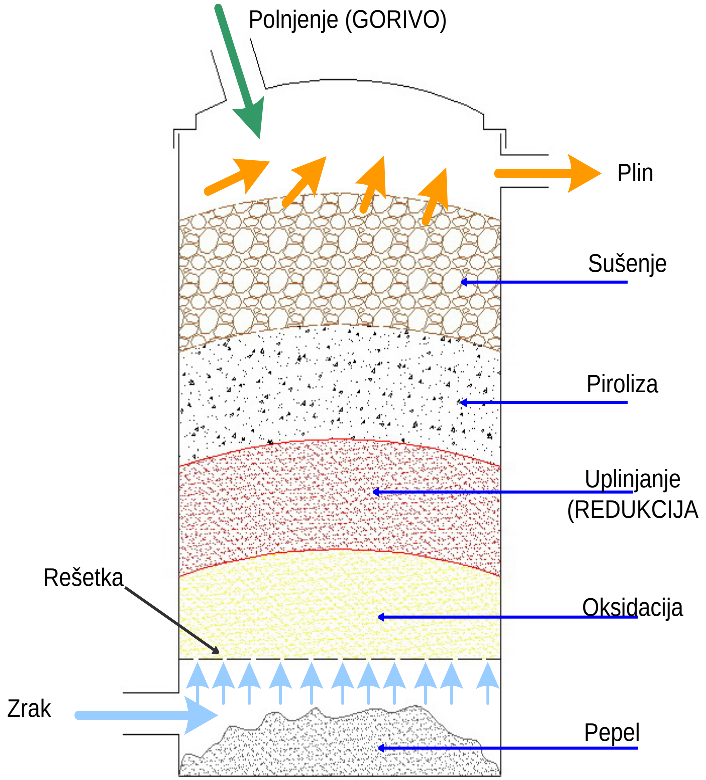
Nepotpuno sagorevanje i plazma gasifikacija sa sagorevanjem sinteznog gasa u toplotnim postrojenjima



Oksidaciona gasifikacija

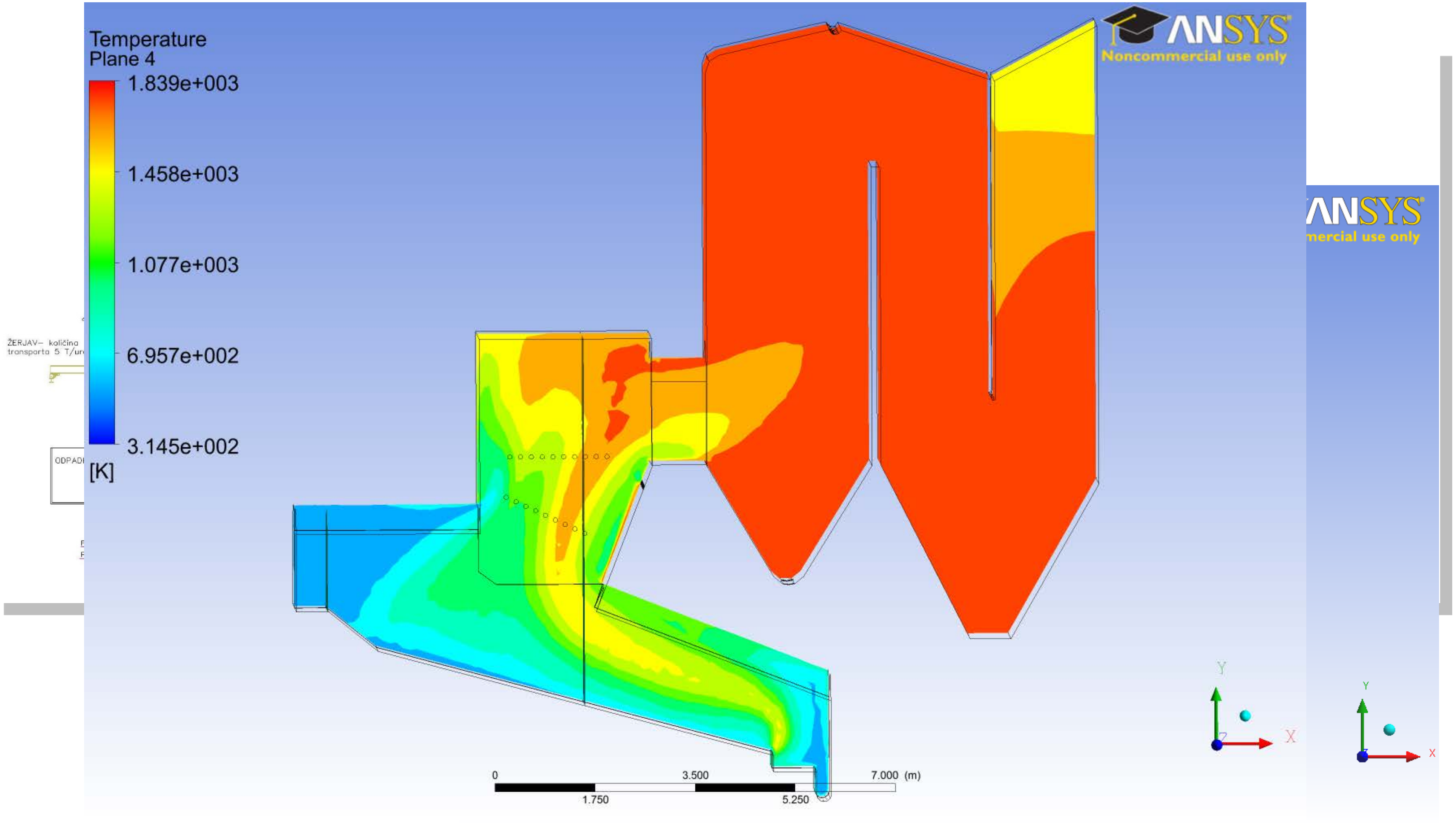


Istosmerni (dawndraft) sistem

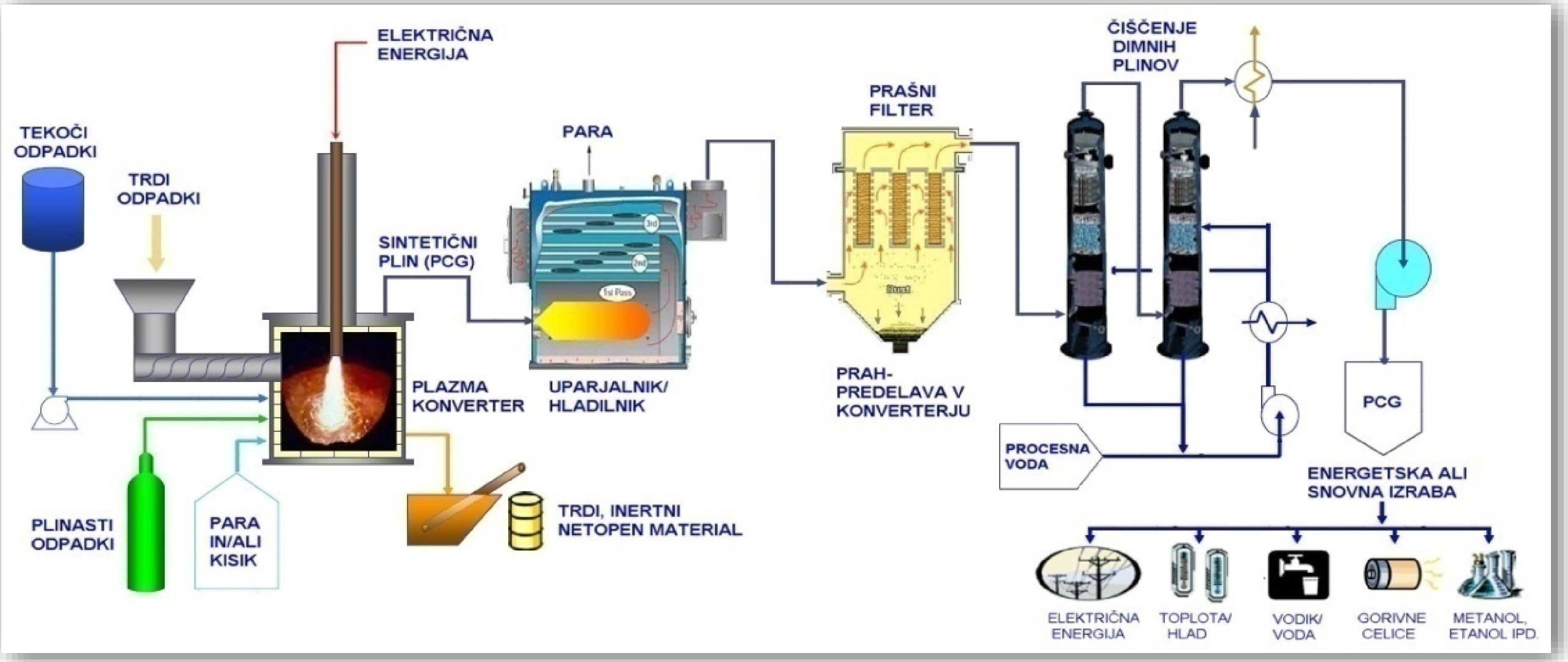


Suprotnosmerni (updraft) sistem

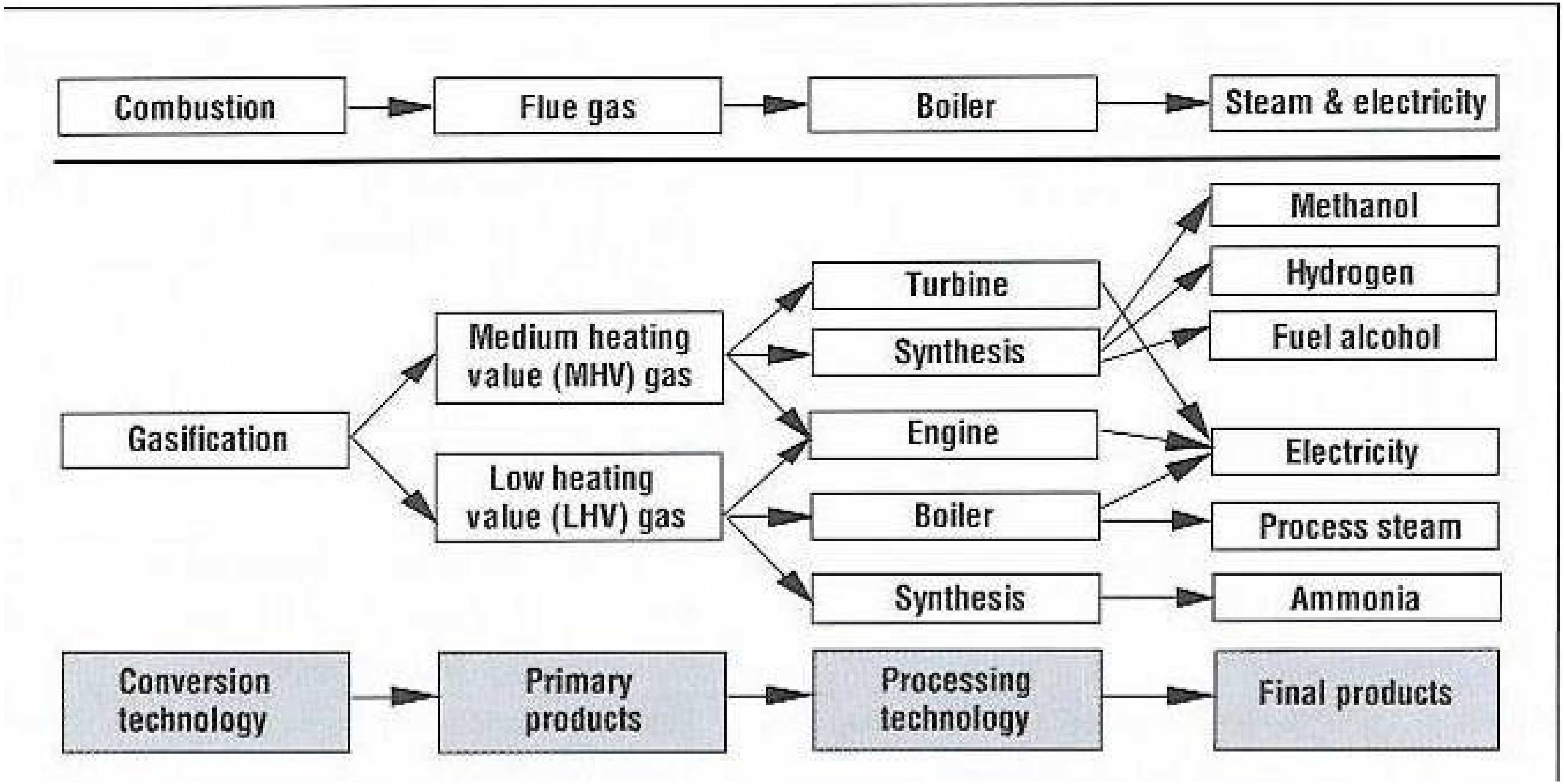
Oksidativna gasifikacija i sagorevanje u ložištu parnog kotla *(KIV)*

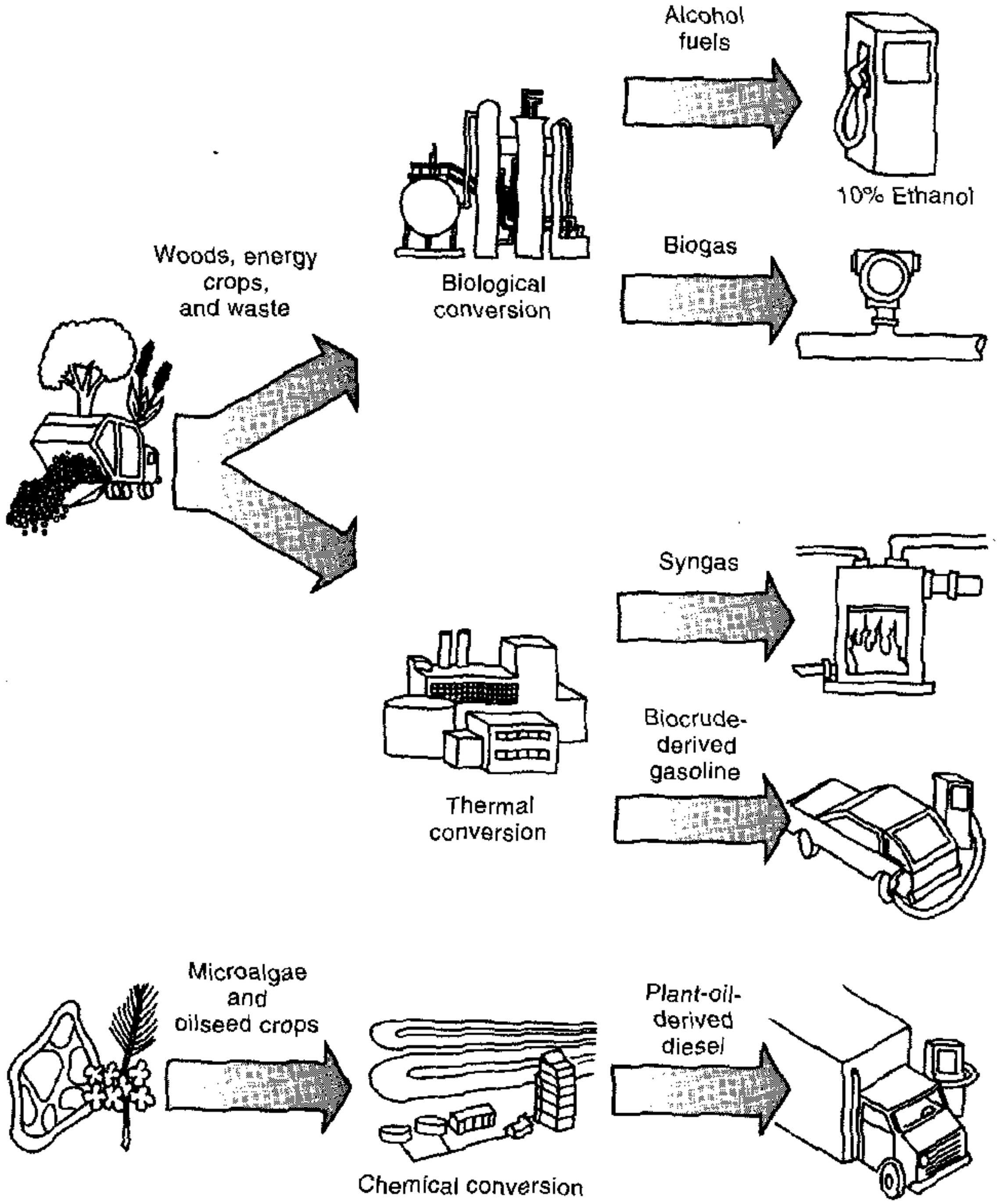


Plazma gasifikacija



Fleksibilnost gasifikacije





Konverzija biootpada u gorivo

Resultati:
Alcohol (Ethanol)
Biogas (Methane)
Syngas
Gasoline (Biocrude)
Diesel Fuel (Plant Oil)

Anaerobic digestion

Animal and plants wastes treatment – CH_4 production

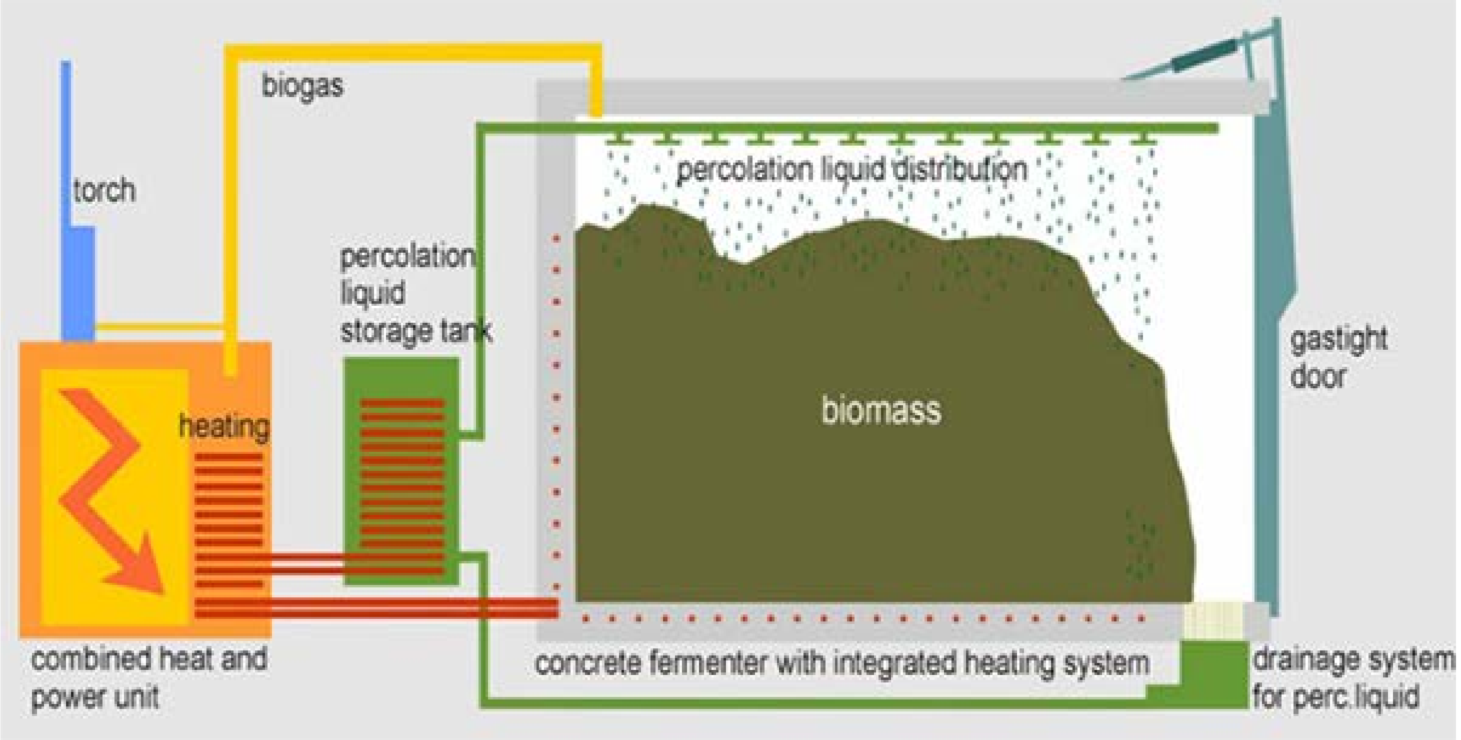
Manure
Olive mill
Waste/Waste water from food production (very high BPK)

CH4 production from sugar bagasse

Plastic materials from pyrolytic oil (waste wood)

AWM DRY FERMENTATION PLANT - MUNICH

Types of waste: Biowaste (Kitchen and Garden Waste)
Capacity: 25,000 tons/year
Combined heat & power plant (CHP) electric output: 3 x 190 kilowatt (electric)
Fermentation residues are processed into finished compost which is then returned to the biomass cycle as valuable fertilizer (ca. 9,000 tons/year)



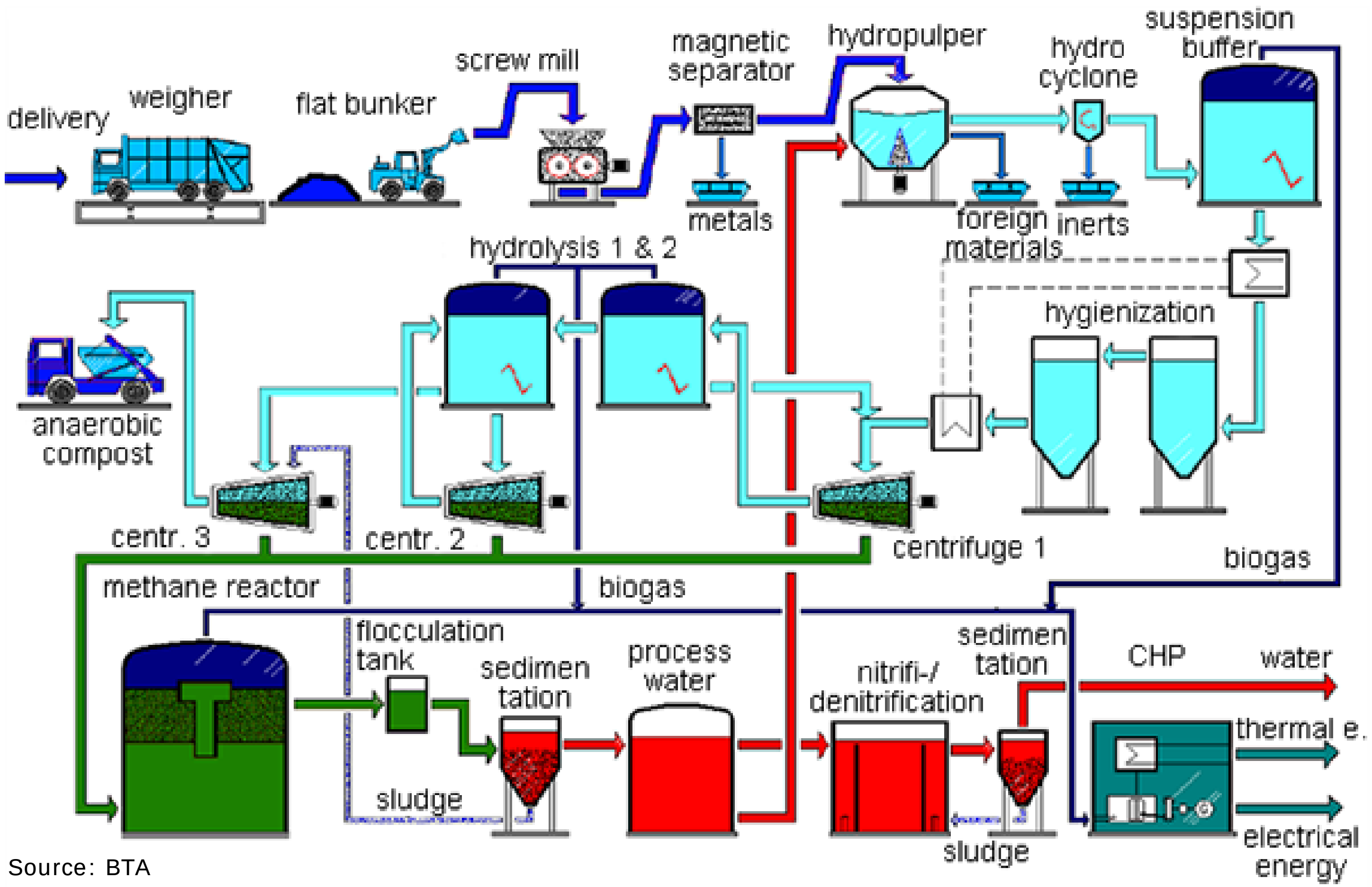
Source: BEKON, AWM München

Advantages:

- Simple technology
- Low maintenance costs
- Low process energy consumption
- Low susceptibility to interfering substances (e.g. foils or woody or fibrous constituents)
- Greatly reduced emission

KIRCHSTOCKACH MULTI STAGE WET FERMENTATION PLANT

Types of waste: Biowaste with a high content of garden waste (>30%)
Capacity: 30,000 tons/year
Biogas yield: 1.85 Million m^3/year (Heating value ~ 22 – 25 MJ/m^3)
Combined heat & power plant (CHP) electric output: 2 x 310 kilowatt (electric)



Source: BTA

Advantages:
- Short retention time
- High biogas yield
- High methane content in biogas
- Greatly reduced emission
- Heat generated is used by houses nearby

Instead conclusions: WTE EXPERIENCE WORLDWIDE

Grate Technology

- Proven technology
- Approx. 1,000 plants
- Normal size per line is 300 - 1000 tpd
- Few worldwide recognized equipment manufacturers
- Electricity production (per tonne of waste) for MSW 0,6-0,8 MWh/tonne
- High availability >8,000 h/y
- Gate fee 40 - 130 USD/t

Alternative Technologies

- Under Development - Number in commercial operation is unclear
- Typical capacity 25-250 tpd
- Many (>100) suppliers, many relative small
- Electricity production around 0-0,5 MWh/tonne (difficult to get real data)
- Lower availability – 5,500 h/y
- Requires homogenious waste input
- Gate fee 200-400 USD/t

Photos of WTE Plants

Umeå Energi AB, Sweden, 1999, Capacity 1 x 19.8 Mg

mcos

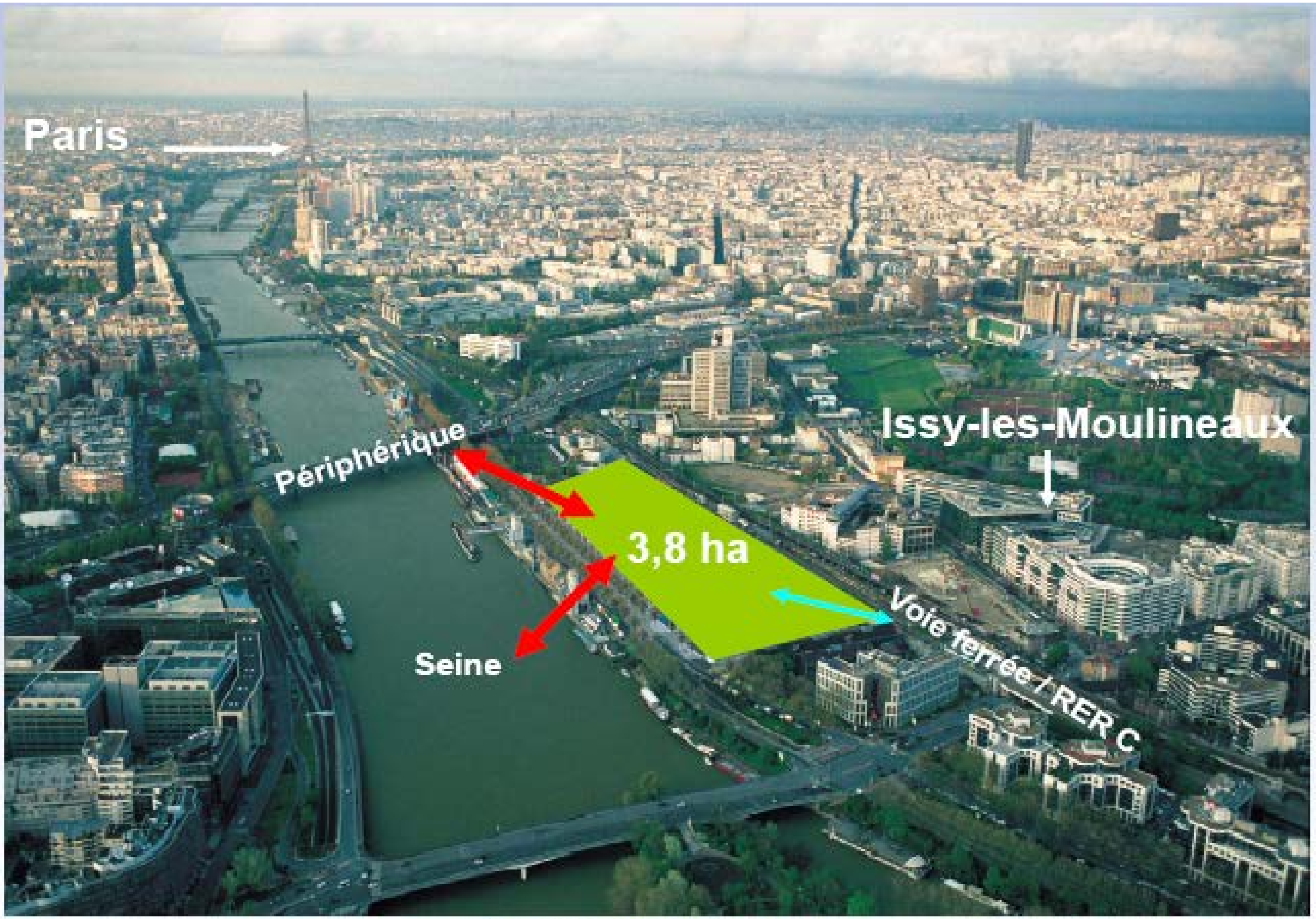
Spittelau - Vienna

Spittelau - Vienna

Brescia - Italy

Oreade – Le Havre France

“Isséane” Plant - Paris



"Isséane" Plant - Paris

Alkmaar WTE , Netherlands

Isle of Man

Uppsala, Sweden

mcos

Liberec, Czech Republic, 1999, Capacity 1 x 12 Mg

mcos

Geneva, Switzerland, 1993, Capacity 2 x 20.8 Mg

mcos

MHKW Pirmasens, Germany, 1998, Capacity 2 x 12 Mg

mcos

CTD du Vert-le-Grand, France, 1998, Capacity 2 x 14 Mg

mcos

Rouen, France, 2001, Capacity 3 x 14.5 Mg

mcos

Noord Holland Alkmaar, Netherlands, 1995,
Capacity 3 x 18.5 Mg

mcos

Saitama Tobu, Japan, 1995, Capacity 4 x 8.3 Mg

mcos

mcos

International WTE PLANT

Barcelona, Tersa WTE Plant
with district heating & district cooling

Photos of WTE Plants

Uppsala, Sweden

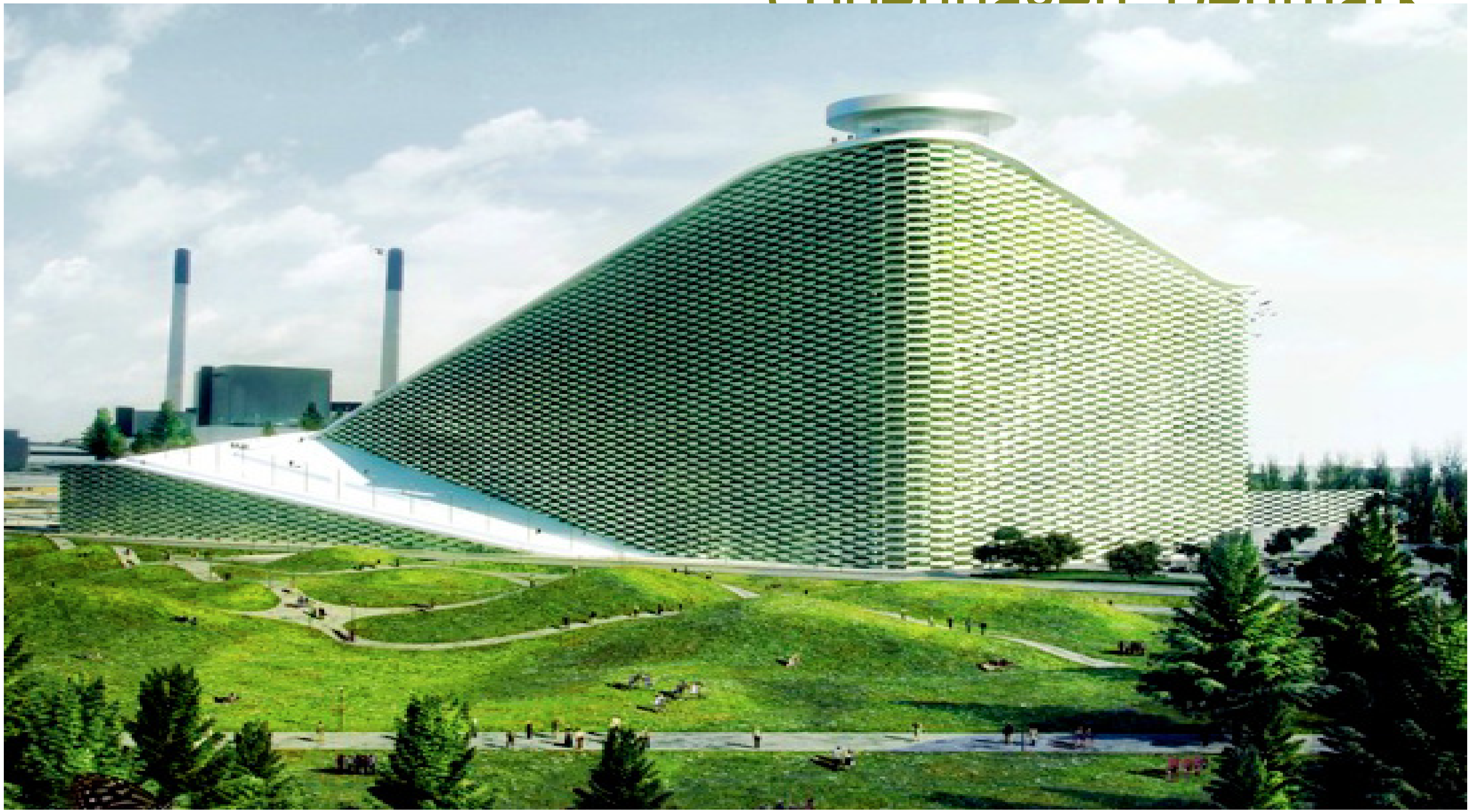
Photos of WTE Plants

Alkmaar WTE, Netherlands

Photos of WTE Plants

Budapest WTE, Hungary

Copenhagen, Denmark



Key considerations

- Waste reduction and avoidance by generators should always be a priority
- Need to consider residues from treatment processes and their disposal
- Thermal treatment is the best available technology for some organic hazardous wastes - providing that it is designed, managed and operated properly
- There is often opposition from the public and from environmental groups, largely based on dioxin concerns

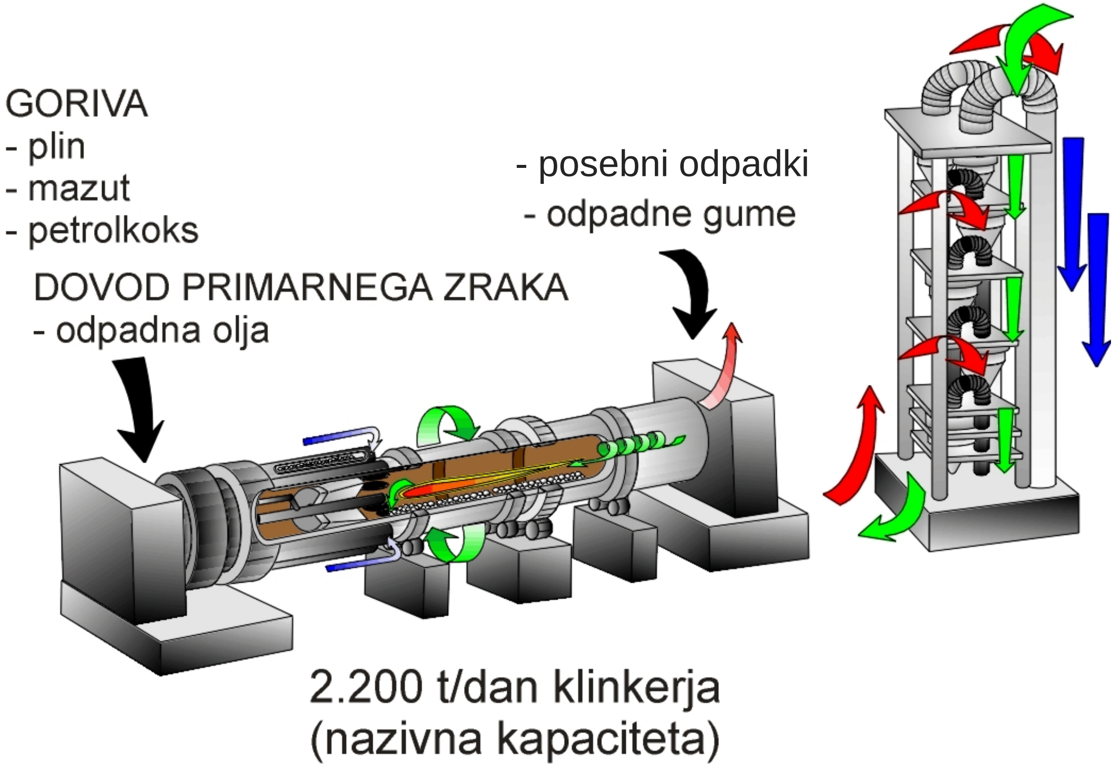
Key considerations

Thermal treatment:

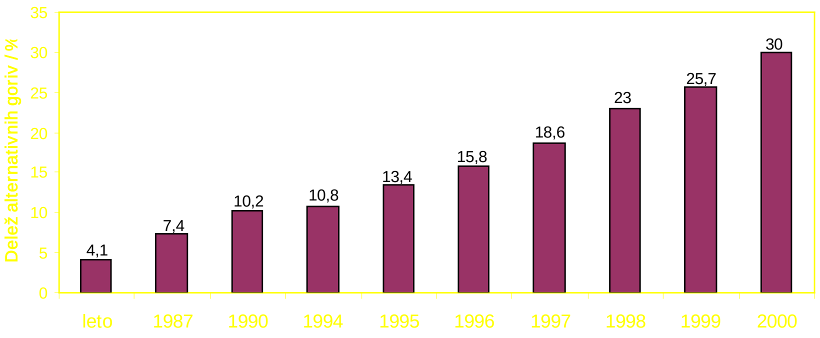
- **is suitable for organic wastes**
- **includes different technologies, all require high capital investment**
- **is highly regulated, requires high operating and safety standards**
- **needs skilled personnel**
- **has medium to high operating costs**
- **generates useful energy**
- **has by-products which need careful handling**
- **often attracts opposition**

Co-incineration in cement plants

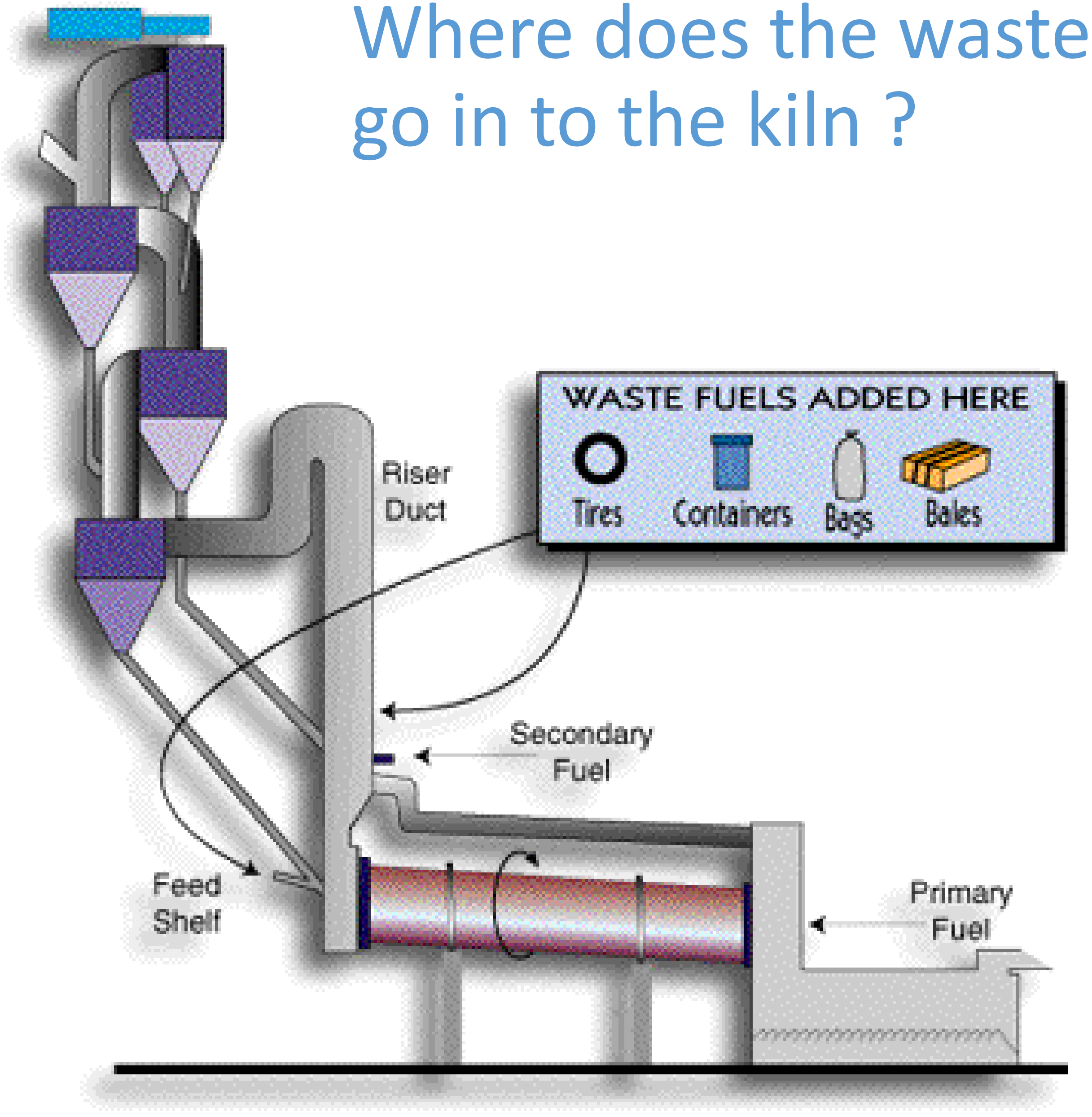
Co-incineration in cement plants



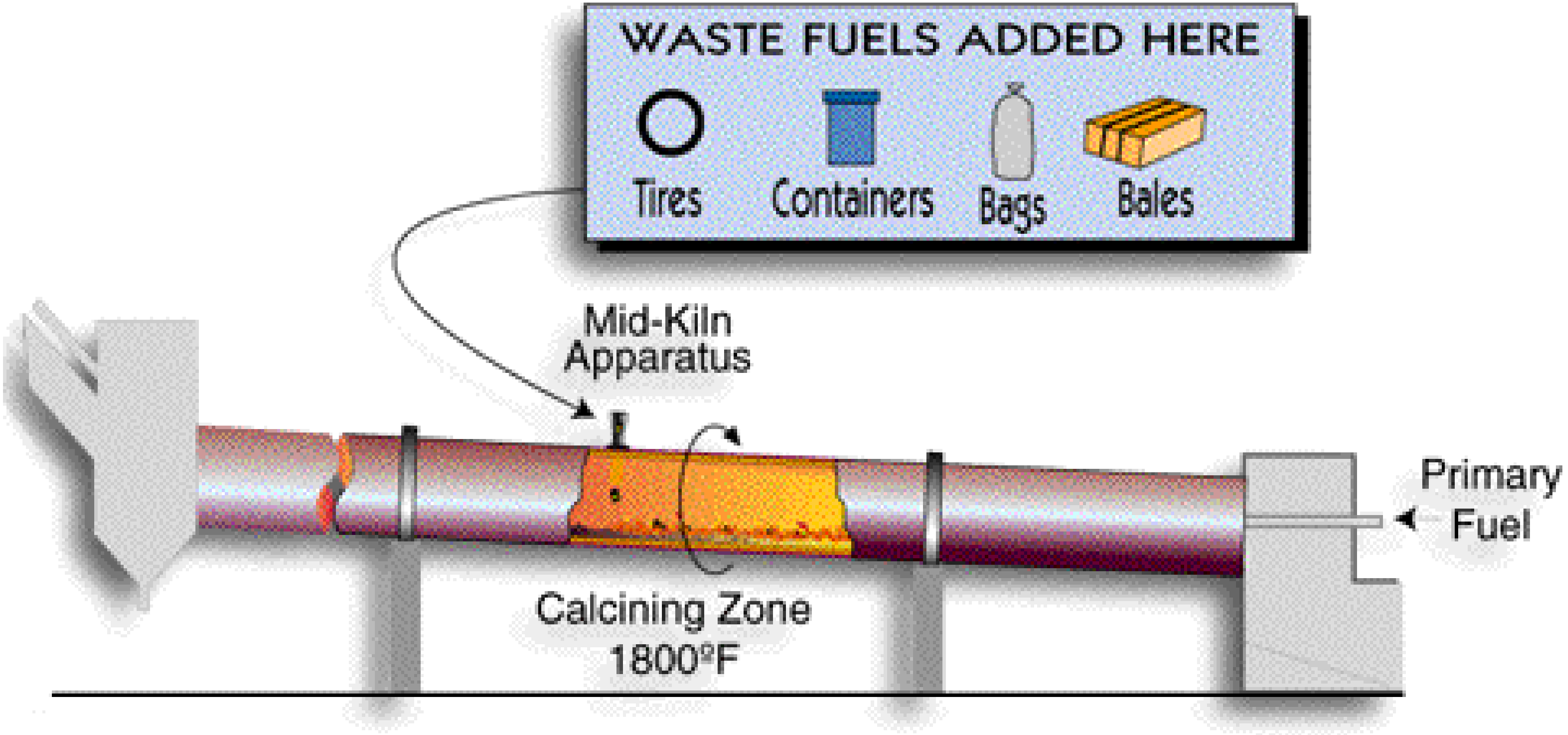
Naraščanje uporabe alternativnih goriv v nemških cementarnah



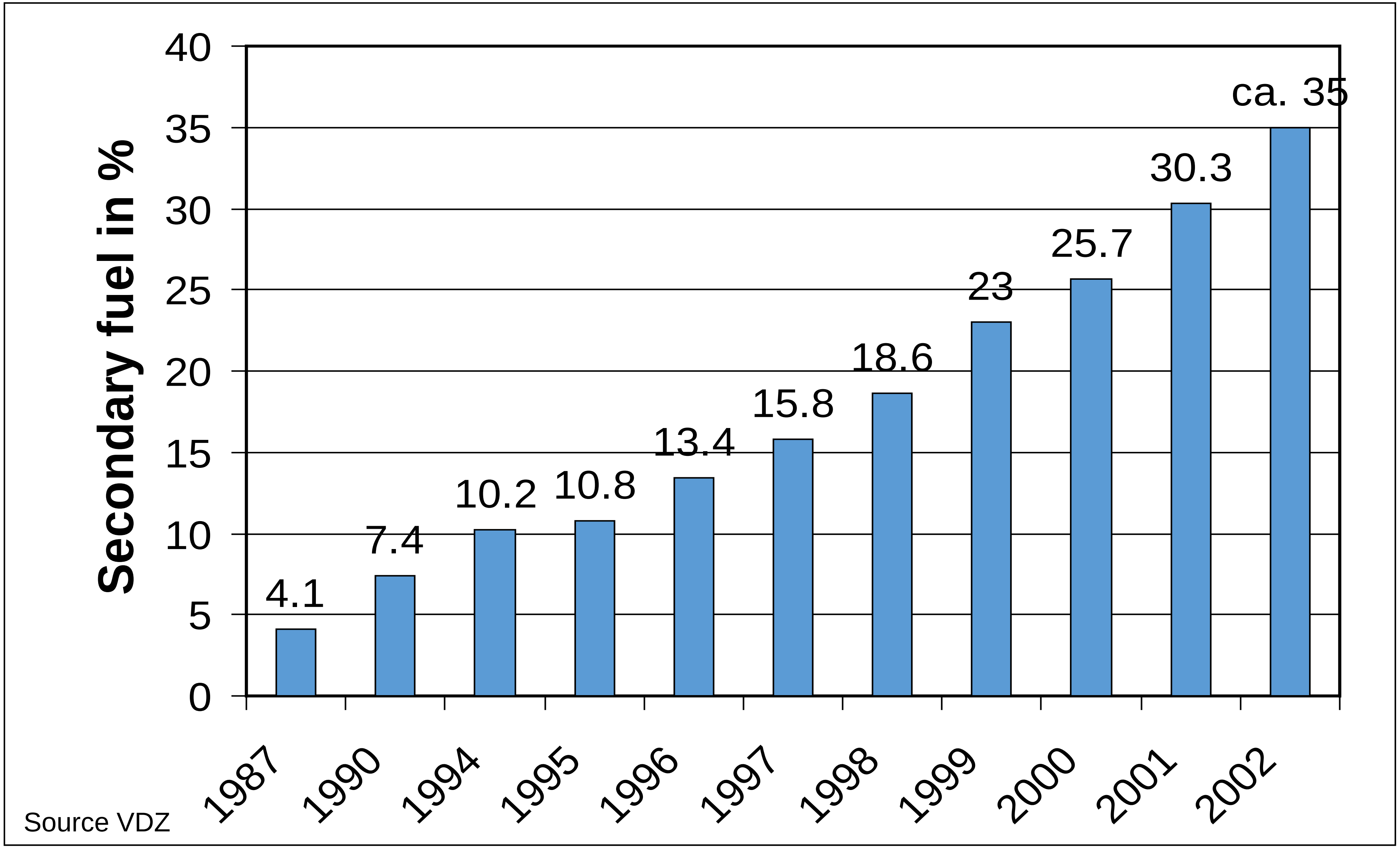
Where does the waste go in to the kiln ?



Where does the waste go in to the kiln ?



Use of Alternative Fuel and Raw Material in Cement Kiln (Germany)



Use of Alternative Waste Material in Cement Kiln (EU)

Alternative Fuel	Mj/kg	1000 t/a
Animal meal / bone meal	24	760
Tyres	26	500
Waste oil / oiled water	33	380
Solvents and others	21	260
Plastics	25	210
Paper / cardboard / wood	18	180
Impregnated saw dust	12	170
Coal slurries/distilation residues	24	110
Papers / sewage sludges	6	100
Anodes / chemical cokes	28	90
Refuse Derived Fuel (RDF)	11	40
Other non-hazardous wastes	19	750
Other hazardous wastes	22	530
Total		4,080

Source: Preliminary data: CEMBUREAU

Negative Waste List For Cement Kilns (HOLCIM)

- HOLCIM has developed a negative list
- The fate of other heavy metals in the waste fractions should be evaluated.

Banned wastes	Undesired HM in clinker	Emission values	Occupat. health and safety	Preferable recycling options	Impacts on kiln operation
Electronic waste	x	x		x	
Whole batteries	x	x		x	x
Bio-active medical waste			x		
Mineral acids and corrosives		x	x		x
Explosives	x		x		x
Asbestos			x	(landfills)	
Radioactive waste	x		x		
Unsorted garbage	x	x		x	x

SRF: composition and uses

Derived from
- ✓ dry fraction from Municipal Solid Waste (MSW)
- ✓ chlorine-free plastic waste and rubber
- ✓ dry fraction from Industrial waste

Solid Recovered Fuel (SRF)

In order to deliver
- ✓ high and constant quality (High Quality SRF)
- ✓ calorific value close to coal levels (more than 15000 kJ/kg)

SRF potential uses

Uses of SRF

DIRECT USE

- ➢ **COAL**
- ➢ **PETCOKE**
- ➢ **LIGNITE**

Using in conjunction with coal and petcoke in:
- ➢ Coal fired power plants **(10%)**
- ➢ Cement kilns **(over 40%)**
- ➢ CHP ind. Boilers **(12%)**

VIA GASIFICATION

- ➢ **COAL**
- ➢ **GAS**
- ➢ **OR EMULSION**

Using in conjunction as syn-gas in power plants **(10%)**

SRF: drivers

INDUSTRY ISSUES	DRIVERS	SOLUTION PROVIDED BY SRF
Landfill Directive	Diversion biomass	MSW, with its biomass content, is not disposed in landfill, but recovered as energy
Renewable Energy Sources (RES) Directive	Biomass content	Energy production through SRF co-firing contributes to reach the Directive targets
Best Available Practice	Energy/climate change (Emission Trading Directive)	1 ton of SRF (through its production from MSW and its co-firing) reduces emissions of CO_2 by not less than 1 ton CO_2
Energy cost	Oil/gas/coal, CO_2	SRF has the lowest production cost amongst RES and lowers electricity production costs

GERMANY: some experiences of SRF co-firing (2006)

- Hard coal, RWE Gerstein, 220 kt/a
- Lignite, Vattenfall Jänschwalde, 400 kt/a
- Lignite, RWE Berrenrath, 70 kt/a
- Cement kiln: operations of many use 900 - 1200 kt/a in Germany
- CHP, Neumünster, 150 kt/a

* Source ERFO, 2006

Production locations Vagron and Wijster

The pressed bales of paper/plastic fraction.

Bales ready for transport.