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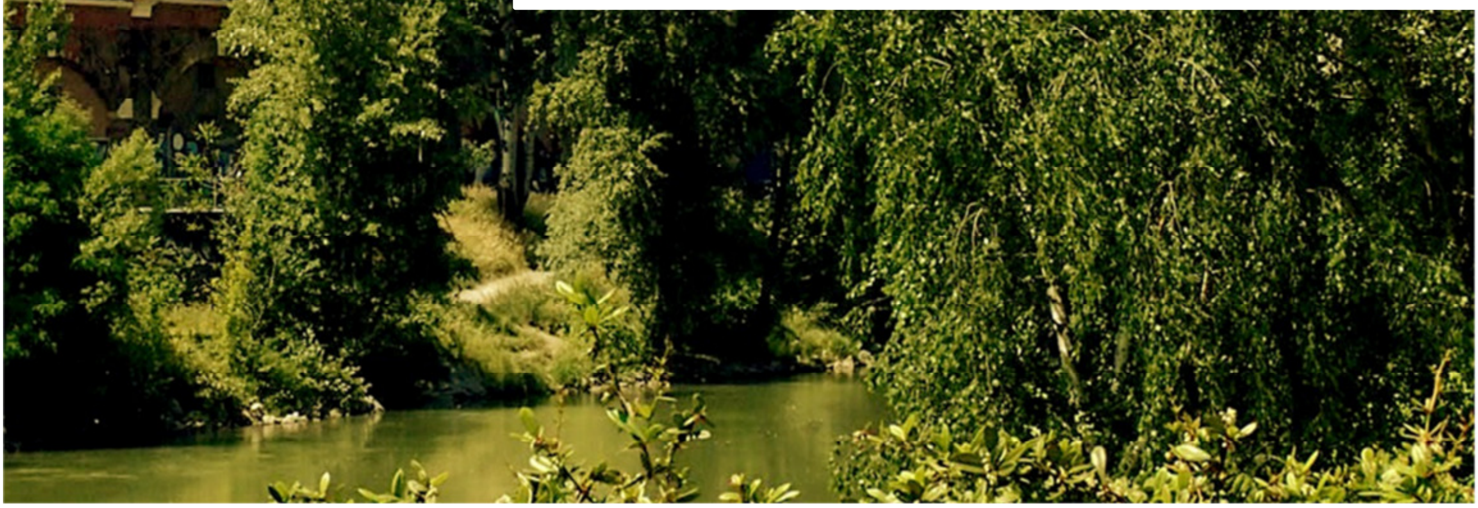
WASTE – TO – ENERGY IN AUSTRIA
WHITEBOOK
FIGURES, DATA, FACTS



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PREFACE

IN FULFILLMENT OF THE OBJECTIVES AND PRINCIPLES UNDER THE AUSTRIAN WASTE MANAGEMENT ACT, only pre-treated waste with very low organic matter content may be legally landfilled in Austria as of 1 January 2009. This requirement has already been defined in the Waste Management Guidelines 1988.

In order to comply with these specifications in particular residual waste requires thermal treatment, in some cases following appropriate pre-treatment.

As early as 1999, a White Book entitled "Thermische Restmüllbehandlung in Österreich" ("Thermal Residual Waste Treatment in Austria") was published to give interested members of the public and experts insight into the subject in an understandable way. This White Book is now in its third, extended edition. The aim of this brochure is to provide the reader with an easily comprehensible yet technically well-founded presentation of the main conditions and procedures of thermal waste treatment, and to provide answers to frequently asked questions.

Due to the technological progress of waste incineration plants, both in incineration technology and flue gas cleaning, thermal processes now rank among the treatment methods with the lowest emission levels overall. Thermal waste treatment plants with cogeneration plus year-round heat utilization in industrial areas ensure thermal waste treatment capacity for residual waste and save sustainably the consumption of fossil fuels, leading to a substantial reduction in greenhouse gas emissions.

Sustainable waste management must build on the principle of higher quality in order to protect the environment and, in doing so, ensure self-sufficiency in waste disposal, which is best done at the local level. Due to its potentially significant role in achieving greenhouse gas reductions, optimizing waste management has also become a matter of global importance.

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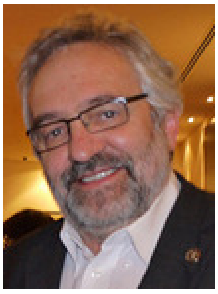
INTRODUCTORY REMARKS ON THE INTERNATIONAL EDITION

IN THE PUBLIC DISCOURSE, the understanding of waste treatment has greatly improved since the publication of the first edition of the White Book in German. In the 1990s, public disputes arose and frequently thousands of protest letters were received every time the construction of a waste incineration plant was planned in Central Europe. Today, however, well-planned projects at suitable sites, where the local population and other interested parties have been properly informed in advance, can be given the go-ahead in the first phase of the official approval process, encountering very little, if any resistance (e.g. recent examples in Linz and Frohnleiten). These new facilities allow Austria to process its waste for optimum recovery while reducing its greenhouse gas emissions to an absolute minimum.

According to the EU Directive 2008/98/EC, economic instruments can play a crucial role in attaining waste prevention and waste management objectives. Therefore, the use of these instruments should be encouraged at the appropriate level. However, the Directive underscores that it is at the discretion of Member States to decide whether or not they choose to make use of such economic instruments. Austria has been using this economic instrument since 1984 by offering financial subsidies for specific investments in environmental protection and in the form of a landfill fee under the Act on the Remediation of Contaminated Sites (ALSAG) since 1990. Critical conclusions and valuable recommendations are now available on a senior expert level regarding the optimum design for efficiency and control against misuse of economic instruments based on more than 30 years of experience in Austria and neighboring countries in Central Europe.

The shipment of waste across borders currently poses a particular challenge, as environmental standards differ significantly across various EU Member States – especially since many countries still dispose organic residues and other combustible wastes in landfills. Joint efforts will have to go into raising waste management to a more uniform standard throughout the European Union and into ensuring that Austria's efficient thermal waste treatment plants can operate at their full capacity. This is necessary in order to comply with the legal obligations to conserve resources and to increase energy efficiency, and to reduce emissions across all countries according to a global perspective.

“Circular Economy” includes energy from waste as a means for efficiency in recovery operations (although the discussions on “linear” vs. “circular” might lead to the concept of “spiral development” with a progressive linear development observable from a larger distance over a longer period of time and a circular development in a very shortsighted view). As stated in recent EU communication “even in a highly circular economy there will remain some elements of linearity as virgin resources are requested and residual waste is disposed off”. Nevertheless, efficiency in the management of limited resources must comply with the valid 1st and 2nd Law of Thermodynamics, which are the basis for competent engineering and systems design. In addition, principles of ethics and complete economic analyses including external costs (such as adverse health impacts, environmental degradation with loss of biodiversity and quality of living conditions) are vital for sustainable development on our planet earth.



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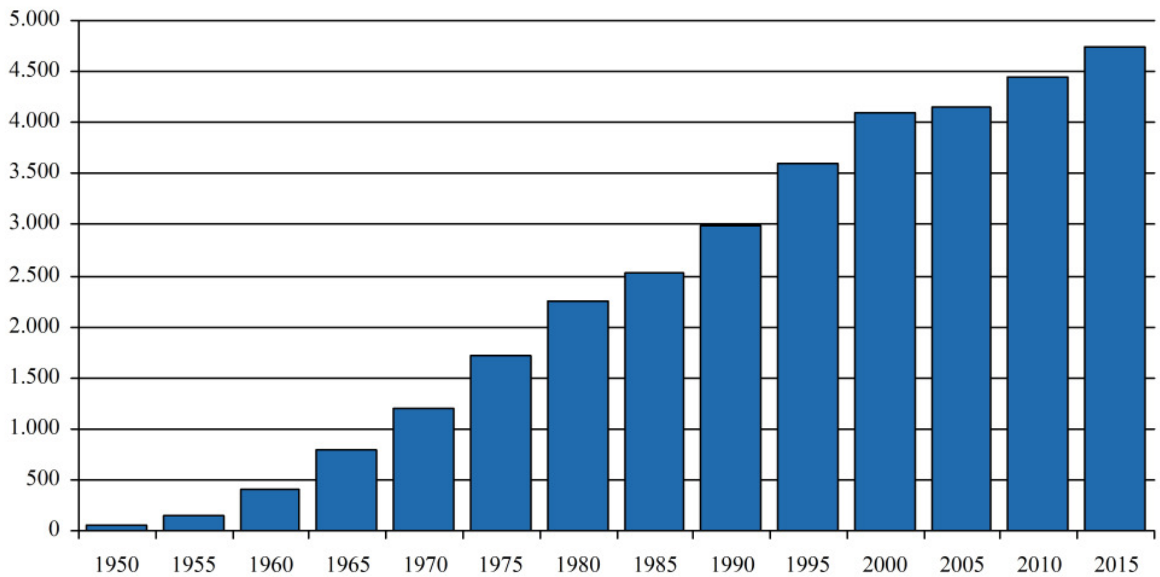
WHY DO WE HAVE A WASTE PROBLEM THAT NEEDS TO BE ADDRESSED?

GLOBAL POPULATION GROWTH AND TECHNOLOGICAL PROGRESS have facilitated substantial growth in the production of goods and, therefore, an increase in material wealth for the population of industrialized countries. However, it should be noted that all raw materials and fuels extracted from the environment turn into emissions (atmospheric emissions, waste water, heat loss, noise) or waste at some point. The aim is to keep the volume and impact of these emissions at a minimum.

One example of how modern civilization hoards vast amounts of materials which need to be disposed of at a later point in time, is the growth in the number of cars and estate cars in Austria since 1950; this is shown in the figure below:

Growth in the supply of cars and estate cars in Austria since 1950

Figures in 1,000 units



Source: Statistik Austria, 2014; W. Kletzmayr, 2015

Assuming an average life of 12 to 15 years, the disposal of old cars – and the corresponding potential amount of waste – can be determined ahead of time. Cars do not only produce waste during disposal. The operation of cars, too, generates waste such as used oil and tires.

When changing oil, the waste oil must be properly disposed of. Waste oil can be used as a waste-derived fuel, and, thus, as an alternative to fossil fuels in suitably equipped facilities. The options for used tires are material recycling (e.g. retreading or recycling of its component materials – rubber, steel and textile fibers) and energy recovery (e.g. use as waste fuel for the secondary firing of cement kilns).
Ever since the "economic miracle" of the 1950s and 60s in Western Europe and North America, but also in the current globalization of the economy, a growth process driven by economic interests has led to a dramatic multiplication in the flows of materials and goods.

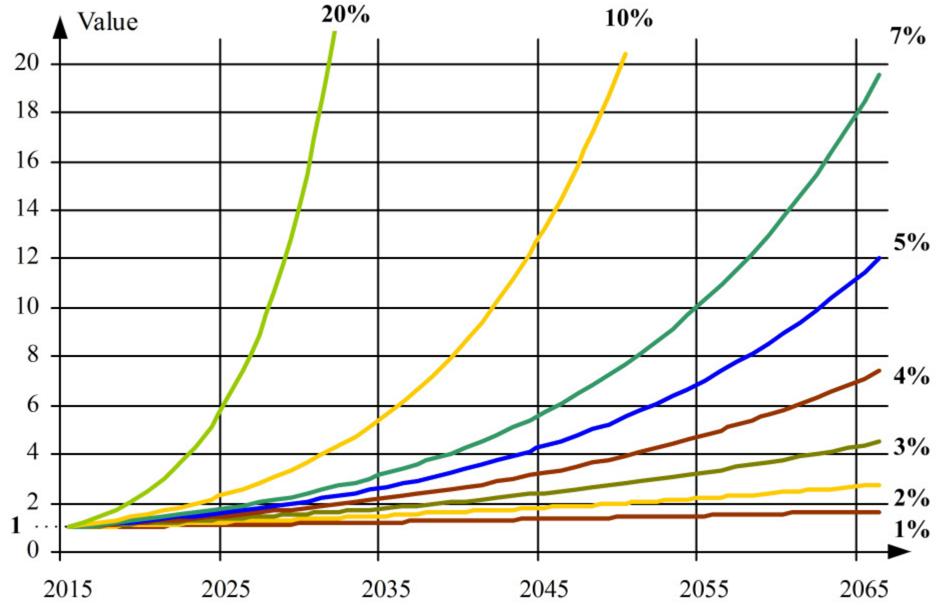
Relationship between the growth rate and the corresponding time for the material and goods flow to double in volume

Growth per year in %	0.1	0.5	1	2	3	4	5	7	10	20
Years required for the flow volume to double	700	140	70	35	23	18	14	10	7	3.5

Note: Growth of only 0.1 % results in a doubling approximately every 700 years. If growth is 10 %, the volume doubles in as little as 7 years.

Source: UV&P, 1999

Exponential growth in relationship to the annual growth rate



If the growth rate is set at solo with an initial value of "1", the growth in a time period of 50 years is determined by the assumed growth rate (e.g. interest rate).

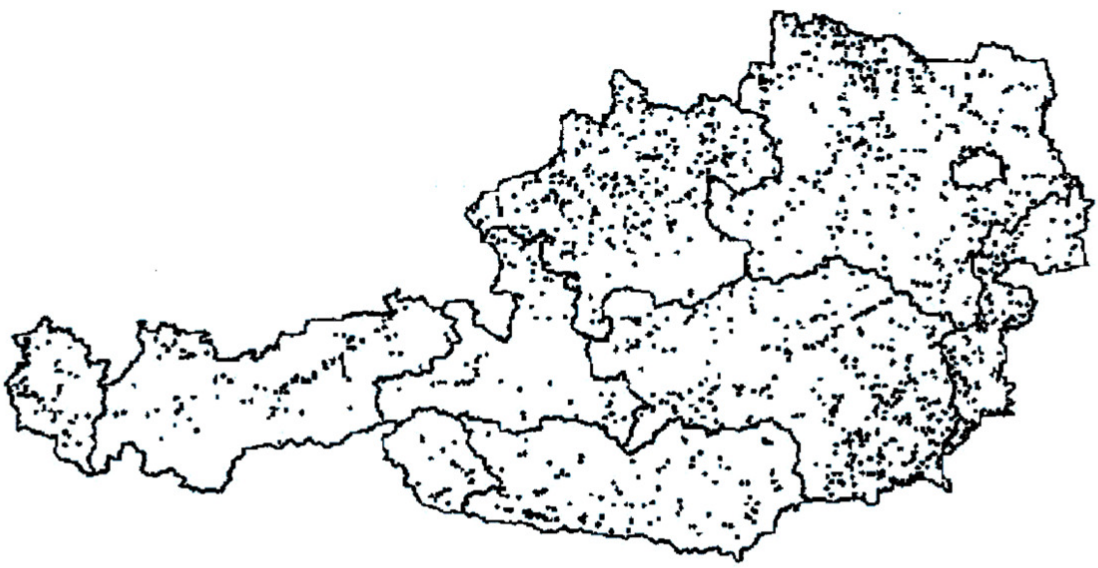
Source: UVP, 2015

Products create waste during raw material extraction, production, trade, shipment, distribution and use – before ultimately becoming waste themselves. The generation of waste, therefore, is a mirror image of economic growth. Entertainment and communication technology (e.g. mobile phones) are current examples with growth rates exceeding 20% per year. At the same time, the useful life of many of these products is in decline (e.g. fashion trends, design for obsolescence).

In 2014, consumers alone generated roughly 42 million tons of e-wastes worldwide (http://www.step-initiative.org/overview-world.html). Such waste contains both valuable and hazardous materials that require special handling and treatment methods to avoid environmental contamination and detrimental effects on human health.

PROPER DISPOSAL OF WASTE means ensuring that environmentally hazardous substances are systematically "taken out of circulation" and are subjected to the necessary treatment.
The products of modern consumer society contain a vast array of materials and substances which can cause serious damage to the environment if handled carelessly. Examples of such substances are lubricating oils and fuels which, if finely enough dispersed, can pollute a volume of water that is one million times their own volume.

Legally registered landfills in Austria 1984 (about 1.800 sites)



Source: ÖBIG, 1985: Abfallerhebung 1984 in den Gemeinden

For these reasons, the potential pollutants (e.g. halogenated organic compounds or toxic inorganic compounds and metals) contained in everyday commodities (from video tapes, CDs, DVDs, batteries, screens, fluorescent light tubes to motor vehicles) must be collected and converted, destroyed, or concentrated and further processed through targeted waste treatment to allow for environmentally sound landfill of residues in a chemically innocuous form (i.e. less reactive, e.g. insoluble in water, incombustible and non-putrefactive).

WASTE HAS ALSO BECOME A SIGNIFICANT PROBLEM DUE TO ITS SHEER VOLUME. Experience shows that the landfill of waste results in serious environmental damage (leachate, odor problems, air pollution by fumes and particulates, greenhouse gas emissions, etc.), even if technical measures are implemented. It also limits the potential uses of a site and the surroundings for generations. In the past decades, different types of waste have been deposited in a multitude of landfills situated across Austria.
Many of these old landfills should technically be considered as "reactor landfills" and, thus, as latent contaminated sites for future generations, since they retain their reactivity for hundreds of years. Existing landfills had to be adapted one step at a time to comply with the stringent requirements for operation of new landfills (see Landfill Ordinances of 1996 and 2008). In view of this and in application of the precautionary

principle, it has been necessary to ensure the timely availability of the required technical waste treatment capacities.

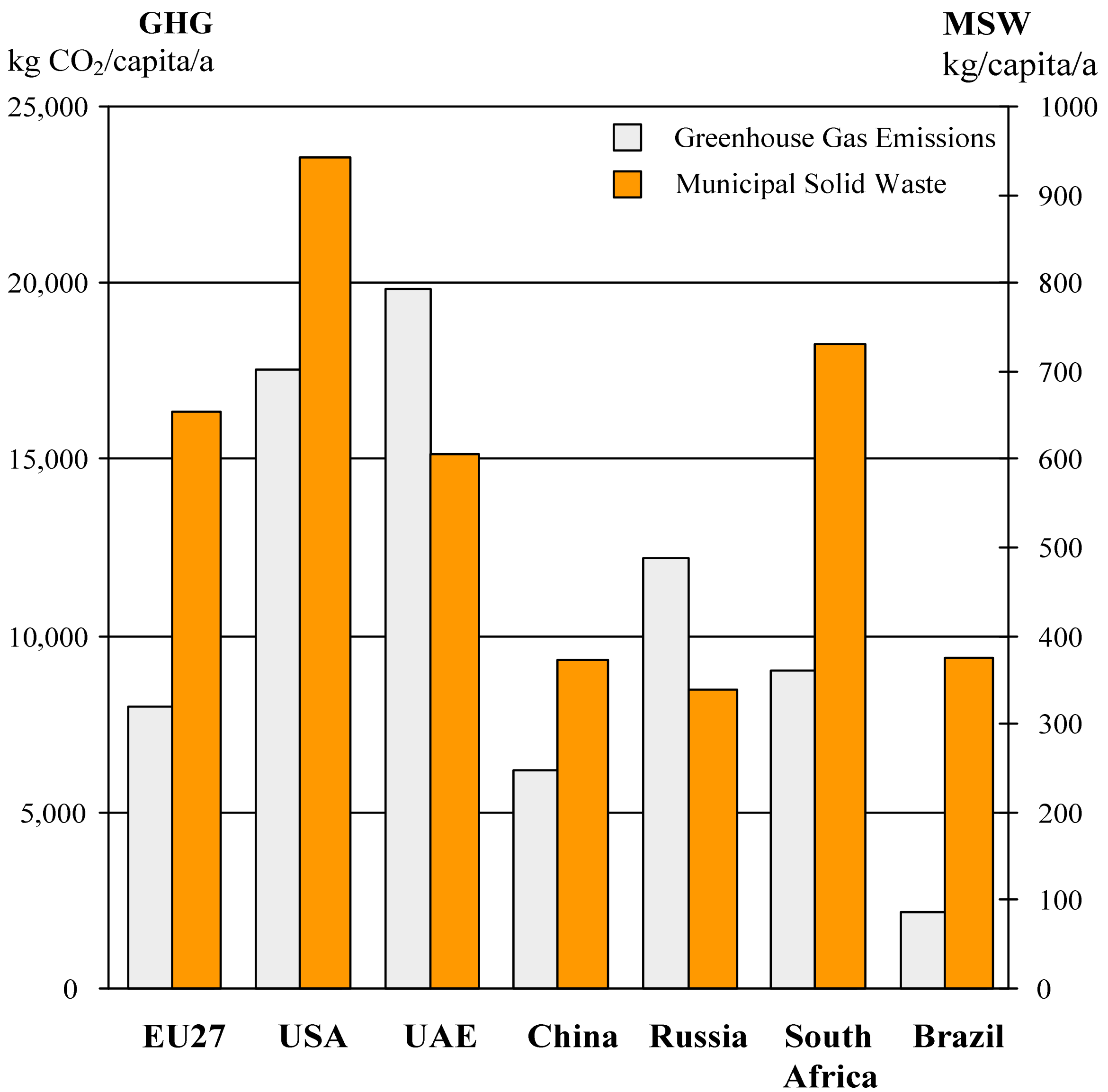
Example for municipal landfills in Austria with legal exemption from the State Governor until the end of 2008

WASTE DISPOSAL as well as consumption of energy and raw materials and emissions of greenhouse gas may differ significantly between different cultures and different regions according to their status of development. This is indicated by the following graph for specific greenhouse gas emissions (in kg per person and year) and for recorded quantity of collected municipal waste (in kg per person and year) for different regions at the current status. It may be true that in some regions waste collection services are not available (causing littering in nature, discharge into rivers, or dumping in the oceans) or some solid wastes are composted or incinerated at an individual level, causing significant environmental pollution.
It should be noted that the Peoples Republic of China has now become the world's largest polluter regarding greenhouse gas emissions, although per capita the emissions are significantly higher in the United Arab Emirates and in the United States of America according to their overall lifestyle and consumption.

Due to the expected increase of population and the growing per capita income, additional amounts of municipal, industrial and hazardous wastes are generated. It has been estimated that urban food waste will increase by 44% from 2005 to 2025 globally. If present waste management trends are maintained, dumped or landfilled food waste is predicted to increase the landfill share of global anthropogenic Greenhouse Gas emissions from 8 to 10 % (ISWA, 2015).

GHG emissions and collected municipal solid waste per capita in selected global regions

Figures in kg per capita and year



Source for GHG: World Bank, 2015
Source for MSW: World Bank, 2012

THE MOST DRAMATIC MISMANAGEMENT OF SOLID WASTE on a global level is ultimately the disposal in rivers, lakes, and oceans, which will inevitably lead to a long-term ecological disaster, particularly by the increasing amounts of plastic materials and its decaying products and residues, which can become fatal for natural ecosystems and ultimately for human health and life. Thus, the treatment of the – obviously unavoidable - increasing amounts of plastic wastes will be necessary by both recycling of separately collected specific materials and by recovery of energy from contaminated and mixed plastic wastes in technical systems with emission control described in this White Book on Waste-to-Energy in Austria.

According to estimates provided by the Waste Atlas 2014 report ((http://www.atlas.d-waste.com) the 50 biggest dumpsites worldwide affect the lives of 64 million people (a population the size of France). 38 of these dumpsites are close to water sources such as rivers, lakes, oceans, posing a threat to marine and coastal life. Obviously, although unquantified, the contribution of dumpsites to marine litter is substantial (ISWA 2015).

Floating Waste in the Danube River as observed by J.Neubacher Traveling by Stand Up Paddelboard from Germany to the Black Sea in 2014

WHAT ARE THE OBJECTIVES AND PRINCIPLES IN WASTE MANAGEMENT?

WASTE MANAGEMENT AFFECTS ALL AREAS OF BUSINESS AND LIFE, because waste is created in the production, trade, and shipment of goods and services, as well as in their consumption.
The Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 (see also excerpts in Appendix 1) on waste stipulates that waste prevention ought to be given top priority in waste management and – if and to the extent that these are the best options available based on environmental considerations – that re-use and recycling of materials should take preference over energy recovery from waste. Prevention measures should take into account the entire life-cycle of products and services rather than just their waste phase.

In its Resolution of 24 February 1997 on a European Community strategy for waste management, the Council confirmed 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.

In 2014, the European Union adopted the Communciation "Towards a circular economy: a zero waste programme for Europe" to establish a common framework to boost recycling, create jobs and economic growth, and reduce the emission of greenhouse gases and environmental impacts. For its implementation the following fundamental requiremenst must be considered (Neubacher, 2014: Circular Economy and Waste):

- The 1st Law of Thermodynamics (e.g. complete mass and energy balances)
- The 2nd Law of Thermodynamics (e.g. increase of Entropy, thus downcycling only)
- Fundamental Economic Decisions (e.g. comparison of Net Present Values)
- Macroeconomic Effects (e.g. Macroeconomic losses by external costs)
- Ethics (rules to live by – e.g. The 10 Comandments given through Moses)

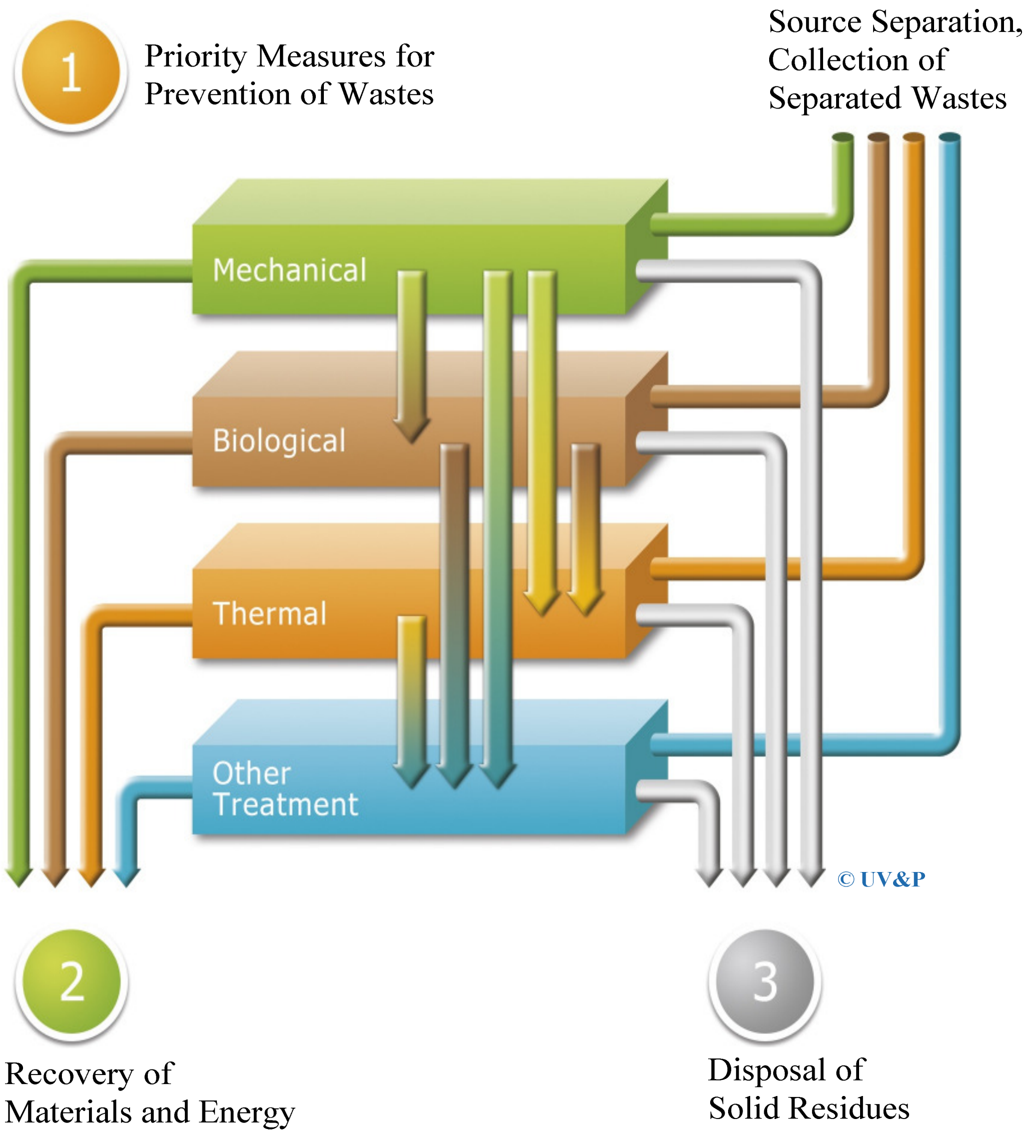
Put simply, the objectives given in the 1988 Guidelines for Waste Management in Austria are:
- environmental compatibility
- resource efficiency by careful management of raw materials and energy resources
- minimization of use of landfill space (disposal of untreated wastes will be allowed only for an additional 10 to 15 years in already existing landfills, i.e. until 1988 to 2003)
- waste treatment prior to landfill in order to prevent hazards for future generations (precautionary principle)

THESE AIMS AND PRINCIPLES are stipulated in the Austrian Waste Management Act since 1990 in Section 1. An important prerequisite for the best possible use and treatment of waste is that the different types of waste are collected separately according to their component materials and substances, or that sorting takes place subsequent to collection. To this end, a number of ordinances were issued in recent years based on the Austrian Waste Management Act.
In order to achieve the objectives, the Landfill Ordinance in 1996 issued stringent quality requirements for waste intended for landfill and for residues from waste treatment. This also includes the strict limitation of

total organic carbon (TOC) – which is an indicator for biochemical and oxidative convertibility and therefore, of formation of landfill gases and organically contaminated leachate from landfills.
Since 1 January 2009, the law only permits appropriately treated and low-reactivity residues from waste treatment to be landfilled in Austria. Appropriate intermediate storage, up to a maximum of 3 years of specific wastes intended for further use or recovery, and intermediate storage up to a maximum of 1 year of wastes intended for disposal are not considered landfilling.

The following illustration represents the integrated system for sustainable waste management by prevention and source separation and collection of separated wastes for technical treatment in order to achieve the recovery of materials and energy and – to the extent necessary – the controlled disposal of treated, non-hazardous, solid residues in landfills.

Future-oriented concept for integrated and sustainable waste management



Source: UV&P, 1999

WHY CAN ORGANIC WASTE NO LONGER BE LANDFILLED AS OF 1 JANUARY 2009?

THE OBJECTIVES AND PRINCIPLES are stipulated in the Waste Management Act and specified in more detail in the Landfill Ordinance. As a principal result, waste containing more than 5% TOC may no longer be landfilled in Austria. This means that residual municipal waste and residues from sewage treatment may no longer be landfilled without prior treatment! Limited exemptions apply for waste that has been subjected to extensive mechanical-biological treatment. Such pre-treated residues need to be deposited in separate cells called mass waste landfills, which also require measures for treatment of remaining gas emissions.

As early as 1998, the Federal Minister for Environmental Protection, Youth and Family stated the following in the Federal Waste Management Plan:

> Not only out of ecological but also out of economic considerations (investment security, distorted competition), we must thwart any speculation by those with a duty to dispose of waste – both in the municipal and private sector – that the provisions of the Landfill Ordinance or related amendment to the Austrian Water Act will be softened by succumbing to the normative force of the factual.
>
> Technically speaking, waste owners and waste disposers are given the possibility to store their waste for a limited period of time if they are unable to meet the deadline. However, such intermediate storage results in additional cost. Options to export waste for disposal in thermal waste treatment plants equipped with state of the art technology will most likely not be curtailed, or a time limit will only be imposed. They will entail a charge and increased shipment costs.

THE MAIN PARAMETERS FOR THE ASSESSMENT of waste characteristics for landfill disposal are the total content of potential pollutants (e.g. of organic carbon, metals, and water-soluble components expressed as evaporation residue) and the aqueous eluate (water-soluble components of pollutants contained in waste).

If necessary, residues with higher salt or water-soluble heavy metal content can be used for the backfilling of cavities in underground salt caverns (backfilling, underground disposal). Since water does not naturally enter watertight salt caverns, residues with water-soluble pollutants can be safely stored there. Moreover, hazardous waste can be packed in chemically stable sacks (“Big Bags”) made of tear-resistant plastics.

Types of landfills according to the Austrian Landfill Ordinance

Classes / subclasses of landfills	Waste classification
Excavated-soil landfills	Deposition of uncontaminated excavated material and uncontaminated soil components
Inert-waste landfills	Deposition of inert waste, uncontaminated excavated material and uncontaminated soil components
Landfills for non-hazardous wastes	
a) Demolition debris	e.g. asbestos waste in separate cells
b) Residual material	Residues from thermal processes must be deposited in residual-material landfills
c) Mass waste	Deposition of wastes that have undergone mechanical-biological treatment
Landfills for hazardous waste	Deposition of hazardous wastes is only permitted in underground landfills

Source: Landfill Ordinance 2008 (Federal Law Gazette No.2008/39)

Selected limit values for different landfill sub-classes for non-hazardous waste

Parameter	Unit	Landfill Class					
		Demolition debris		Residues		Mass waste	
		Total	Eluate	Total	Eluate	Total	Eluate
Electrical conductivity	ms/m		300		1,000		
pH value			6 - 13		6 - 12		6 - 13
Evaporation residue	mg/kg d.s.		25,000		60,000		100,000
Arsenic (As)	mg/kg d.s.	200	0.75	5,000	2	500	25
Lead (Pb)	mg/kg d.s.	500	2		10	5,000	50
Cadmium (Cd)	mg/kg d.s.	10	0.5	5,000	1	30	5
Total chromium (Cr)	mg/kg d.s.	500	2		10	8,000	70
Chromium VI (Cr)	mg/kg d.s.		0.5				20
Mercury (Hg)	mg/kg d.s.	3	0.05	20[1)]	0.1	20	0.5
Zinc (Zn)	mg/kg d.s.	1,500	20		50	5,000	200
Ammonium-N	mg/kg d.s.		40		300		10,000
Cyanide (CN)	mg/kg d.s.		1		1		20
Hydrocarbon index	mg/kg d.s.	1,000	50	5,000	100	20,000	200
Organic component (TOC)	mg/kg d.s.	30,000	500	50,000	500	50,000[2)]	2,500[2)]

[1)] If Hg is present in the form of low-solubility sulphide compounds, a mercury content of up to 100 mg/kg d.s. is permissible. Where Hg is present in the form of low-solubility sulphide compounds and the waste has been stabilized or rendered immobile, a mercury content of up to 3,000 mg/kg d.s. is permissible.
[2)] TOC does not apply to wastes that have undergone mechanical-biological treatment. Exceptions for wastes in accordance with Sec. 7 (7) Landfill Ordinance 2008 (DeponieVO 2008).

Source: Landfill Ordinance 2008 (Federal Law Gazette No. 2008/39)

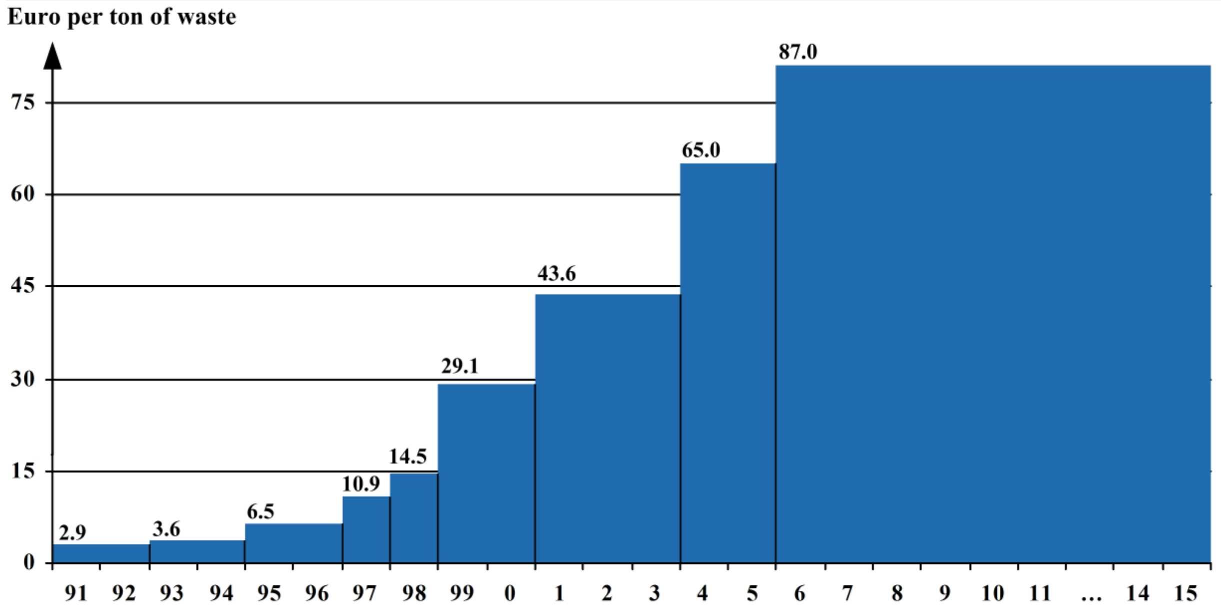
WHAT IS THE IMPACT OF THE "ALSAG - FEE" ON WASTE MANAGEMENT?

THE ALSAG (ALTLASTENSANIERUNGSGESETZ) - FEE IS A LANDFILL TAX earmarked for the clean-up of old landfills and contaminated sites specified in the Act on the Remediation of Contaminated Sites.

The Landfill Ordinance of 1996 and the Water Act Amendment of 1997 have de facto put an end to landfill disposal and the associated environmental problems in Austria. As expected, implementing such a profound change encountered considerable resistance. Landfill operators offered remaining landfill space at "dumping" prices before the legal regulations (such as the ban on the landfill of untreated waste) came into effect. This was done out of economic considerations and ran counter to the intended waste management effect.

Economic instruments strongly influenced, and to a large extent, provided necessary financial security for development and investment in waste management over the past 20 years in Austria (since the issuance of the Waste Management Guidelines 1988). The objectives of the AlSAG fee are two-fold: on the one hand, it takes on a regulative function (providing an economic incentive to prevent, recover and treat waste); on the other hand, it channels funds from waste producers to be used for the exploration, the safeguarding and the remediation against severe emissions and environmental pollution with health hazards from landfills and contaminated sites. A minimum lead-time of 4 to 8 years is needed to plan and build waste treatment plants (using various different technologies) which of course requires necessary funding for the overall project. Therefore, it is important that the legal and economic framework for investments can be determined in advance and that it remains predictable and stable.

Development of AlSAG-fees since 1990: example of „garbage" in Austria



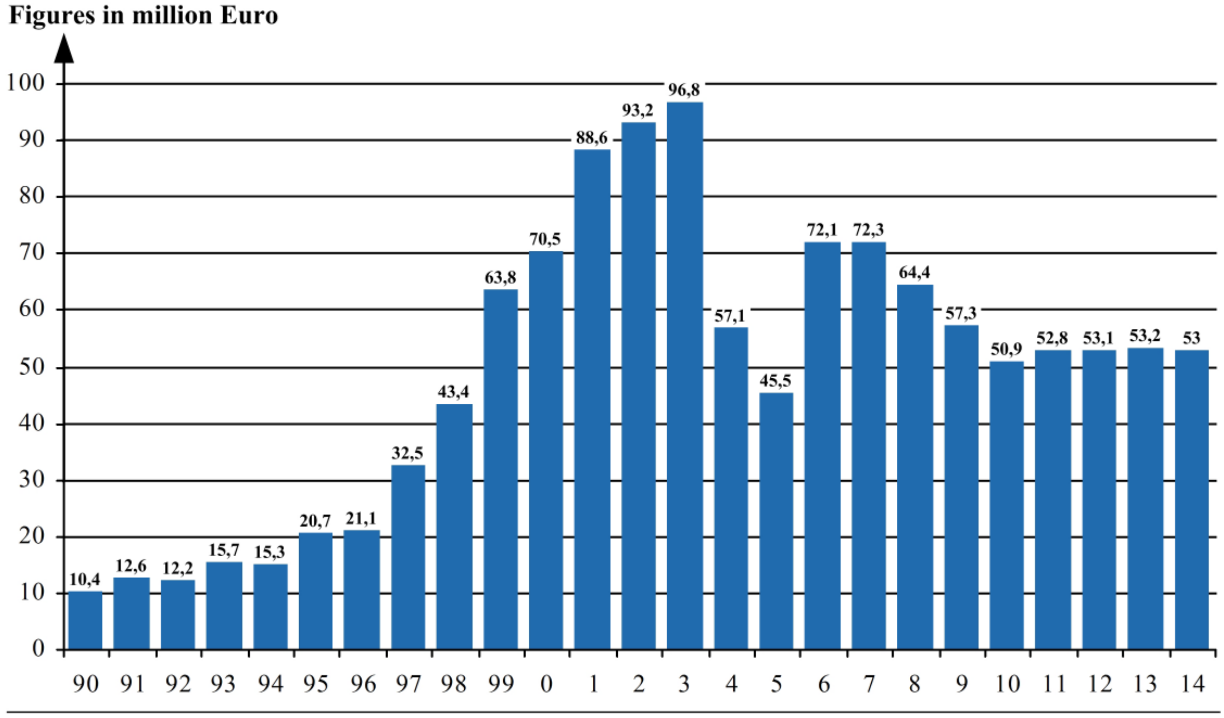
Source: UV&P, 2015

An efficient landfill tax should take the following aspects into account:

- tax progression according to the quality of waste to be landfilled
- tax progression according to the technical quality and mode of operation of the landfill
- foreseeable increase over a planning period of at least 10 years (incl. legal certainty for at least a further 10 years of operation and its effective execution).

The following figure depicts the annual revenue from ALSAG fees paid since 1990. Despite rising rates per ton of waste, the total revenue shows a decline due to the reduction in the landfill of untreated wastes since 2004. This development was intentional and reflects the regulative effects as the “invisible hand” originally described by A. Smith in 1776.

Total sum of AlSAG-fees in Austria per year



Source: BMLFUW, 2014

Other countries have also introduced landfill taxes to flank and galvanize the development of their waste management programs.

In the UK, for instance, a landfill tax is payable for waste which has not been pre-treated. This tax has been introduced by the Finance Act in 1996 to reduce the amount of waste sent to landfills by better reflecting the environmental cost of this form of waste management. The landfill tax was raised by approx. 10 Euros per ton every year, and amounted to approx. 110 Euros per ton in 2014.

HOW DOES WASTE INCINERATION FUNCTION?

DURING INCINERATION, hydro-carbon compounds (organic substances) are oxidized under high temperature, converting them into carbon dioxide and water vapor. They are subsequently released into the atmosphere through the chimney as part of the cleaned flue-gas.
Sewage sludge from municipal waste water treatment is sanitized using thermal treatment before the inorganic residues are subjected to further treatment or recovery. Waste incineration allows the destruction of organic pollutants and substances. It is used to treat waste, on the one hand, and to generate energy from waste (electricity generation and usable heat and cooling energy) on the other hand.
Waste incineration considerably reduces the amount of landfill space used. The remaining solid residues are either recycled or deposited in safe landfills in their controllable, low-reactivity form.

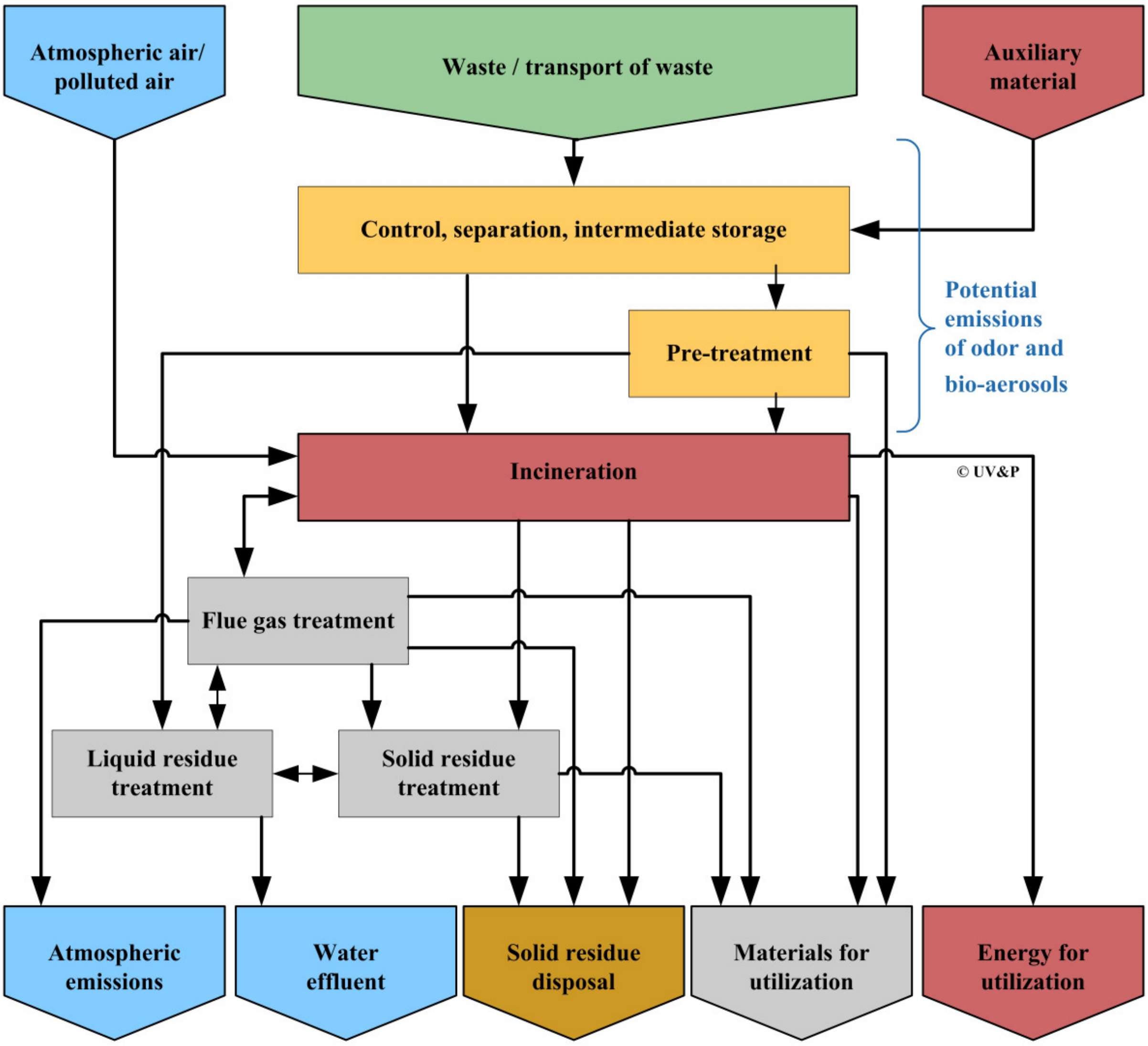
1. THE INCINERATION PROCESS

THE INCINERATION PROCESS consists of four consecutive – or sometimes simultaneous – stages which take place adjacent to each other:

- **Drying:** First water (H_2O) is evaporated to turn the humid fuel into a "dry substance".
- **Degasification:** As further heat is added, volatile organic substances (low-temperature carbonization gas) escape. The solid residue is then referred to as “pyrolytic coke” or “coke”.
- **Gasification:** Solid carbon is then converted into combustible carbon monoxide (CO) utilizing a gasification agent (e.g. H_2O, CO_2 or O_2). The solid residue left over once gasification is complete is referred to as “ash” (or slag, bed material, fly ash).
- **Oxidation:** The combustion of the (combustible) gases CO and hydrogen (H_2) to convert them into CO_2 and H_2O. This is accompanied by high release of heat. Oxidation requires oxygen (e.g. from air). For complete incineration, excess air is required, which presents itself as residual oxygen in the off gas from incineration.

THE COMPLETENESS OF INCINERATION essentially depends on the temperature, the available reaction time and good turbulence in the gaseous phase, with sufficient availability of oxygen. These criteria – temperature, time and turbulence – are often referred to as the “3 T´s” of complete incineration.
Waste incineration using current state of the art technology usually requires a minimum temperature of 850°C at a residence time of 2 seconds and good turbulence, with a system-specific minimum oxygen content (e.g. at least 3% excess oxygen in the off gas after incineration in a fluidized-bed system).
Waste incineration plants are not just the incinerator with generation of energy; they must also include reception, intermediate storage and pre-treatment of waste and treatment of flue gases as well as liquid and solid residues.

Overall scheme for thermal waste treatment



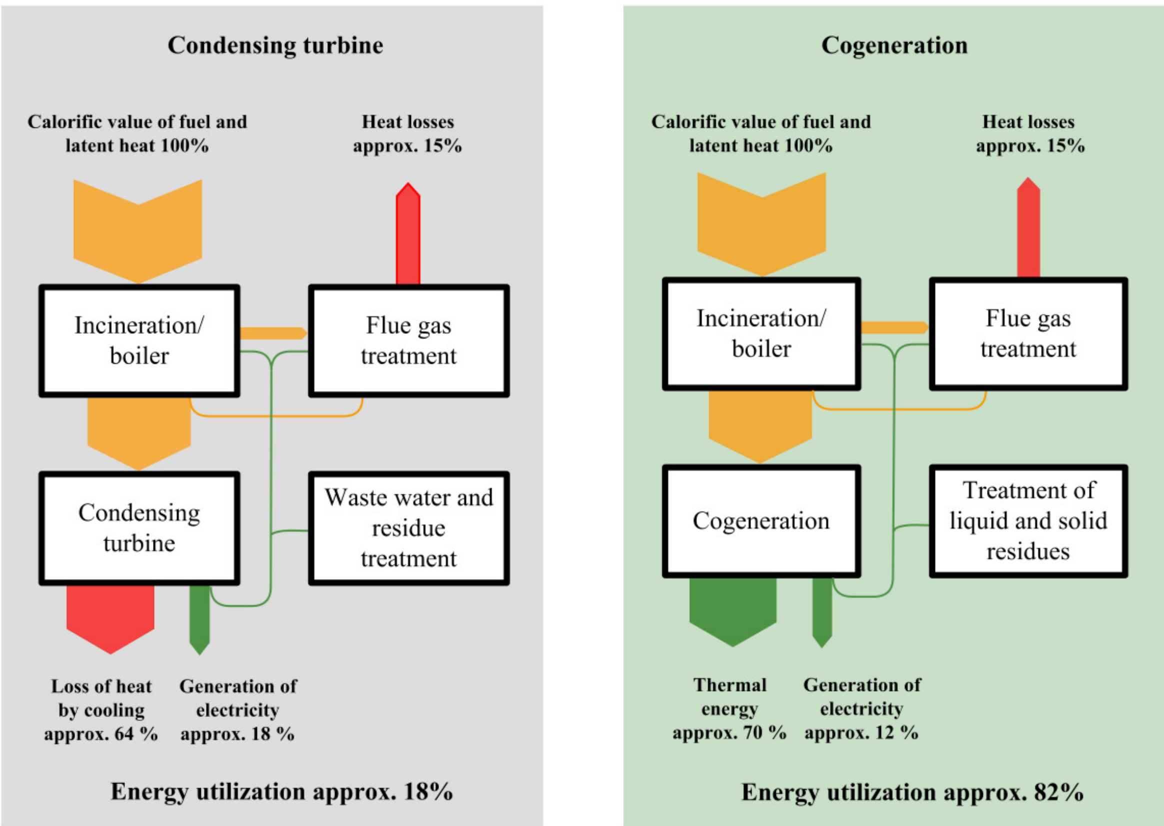
Source: UV&P, 1994

2. ENERGY RECOVERY IN THERMAL WASTE TREATMENT

NEW THERMAL WASTE TREATMENT PLANTS should only be constructed either at sites connected to industrial production facilities which require year-round heat supply, or at sites which are connected to a sufficiently powerful regional district heating network (or district cooling network if needed; see "Cooling Generation with Waste Incineration", BMLFUW, 2014). Waste incineration plants with cogeneration of thermal power (heating, cooling) and electricity can achieve an optimum energy efficiency of some 80% in total, depending on the plant design. By comparison, plants that solely generate electricity (no heat usage) only achieve an efficiency of approximately 20%. However, using suitable heat pumps, thermal (or cooling) output can exceed the input electricity threefold, making thermal waste treatment plants that only generate electricity useful for power generation. The electricity consumed by the thermal waste treatment plant itself amounts to approx. 3% to 6% of the thermal energy input.

THE FOLLOWING DIAGRAM is a simplified comparison of the energy flows inside and across the boundaries of a waste incineration plant equipped with a condensing turbine with those of a cogeneration plant for electricity and thermal energy (e.g. heating steam for industrial production).

Site-specific options and limitations for utilization of energy



Source: UV&P, 1994

WHAT BASIC REQUIREMENTS SHOULD ALL WASTE INCINERATION PLANTS MEET?

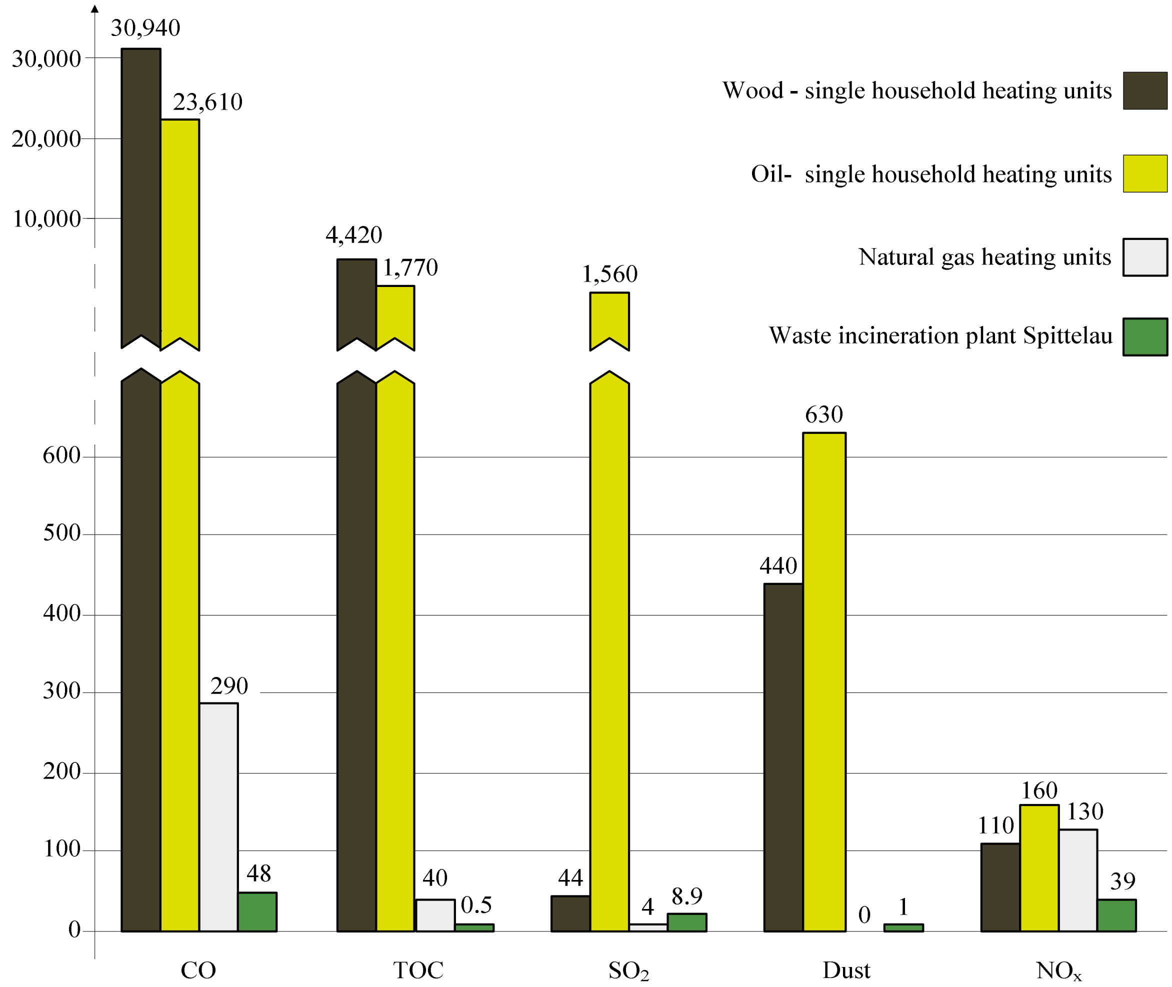
THE ENVIRONMENTAL COMPATIBILITY OF WASTE INCINERATION PLANTS can be ascertained by using plant equipment and operating processes that comply with the state of the art for environmental protection. Therefore, waste incineration plants can generally be constructed at any industrial site. The site and operating conditions, however, should be chosen in such a way as to ensure energy recovery throughout the year (see also “Leitlinien zur Abfallwirtschaft” [“Guidelines for Waste Management”], 1988). The potential sites chosen for a thermal waste treatment plant are then tested for suitability using variant analyses and testing by the official approval procedure (the Environmental Impact Assessment Act [Umweltverträglichkeitsprüfungsgesetz UVP-G] is fully applicable whenever 100 tons or more of waste are incinerated per day).
The site requirements are not only determined by ecological considerations, but also considerably depend on economic aspects, to ensure that treatment costs remain at an acceptable level. The following site requirements should be considered:

- Year-round heat requirement at a high efficiency (cogeneration to provide electricity, process heat, district heating, district cooling
- Reduction potential for environmental stress (e.g. replacement of old boilers, utilization of polluted air from existing production facilities for the operation of the incineration plant, improvement of transport infrastructure, etc.)
- Spatial planning requirements, including planning restrictions for protected and recreational areas
- Suitable meteorological (and topographical) conditions on the site
- Discharge possibilities of treated waste water (with its content of chlorides) from off-gas cleaning into a large river or sea – or an effluent-free process
- Good transport links and favourable site in the main disposal area (including railway connection)
- Existing infrastructure (e.g. transport facilities, laboratory, fire fighting team) and technical installations (e.g. turbine and generator, water supply, off-gas chimney)
- An experienced technical team for plant operation and maintenance.

FOR THE SAKE OF AIR QUALITY, choosing sites for thermal waste treatment plants in urban centers with year-round district-heating requirement (and uncoupling district cooling on days with high air temperatures) is highly advantageous.
As shown by the following diagram for Vienna's district heating system, at the same level of thermal demand, providing heat through a district heating system feeding on waste incineration plants adds up to far lower pollutant emissions than using decentralized firing based on biomass or fossil fuels.

Comparison of specific atmospheric emissions from heating systems

Pollutants in tons per year based on same thermal output in Vienna

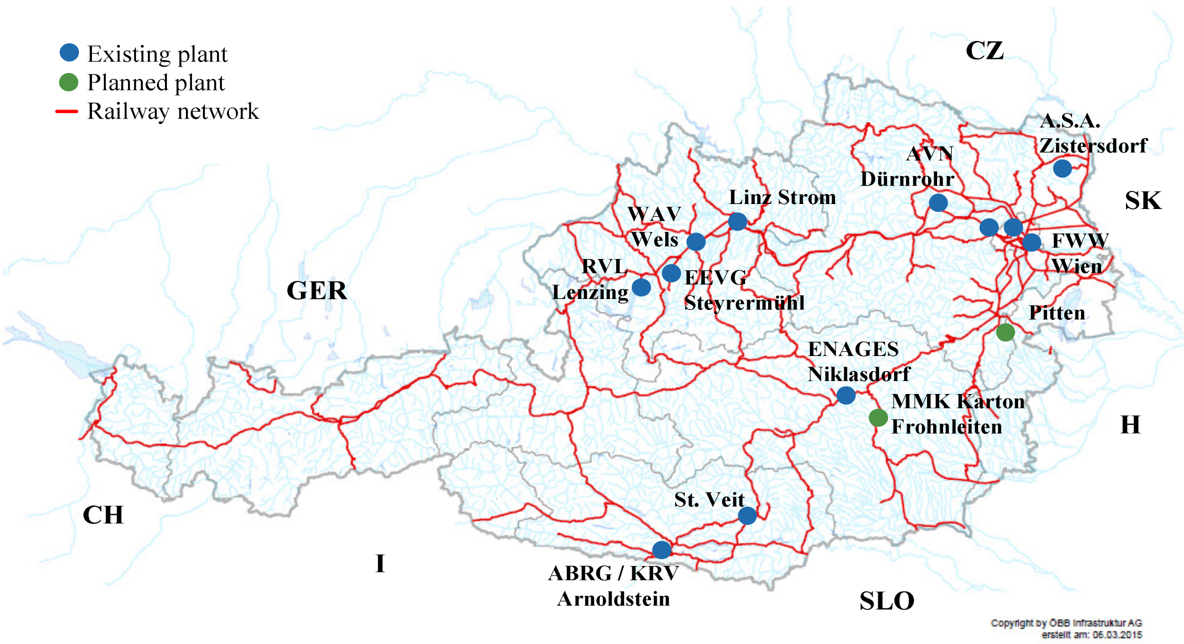


Source: Kirchner, Effiziente thermische Abfallverwertung Hand in Hand mit optimaler städtischer Energieversorgung am Beispiel Wien; IIR Konferenz: Effiziente Abfallbehandlungsmethoden der Zukunft, August 2008

A FURTHER ESSENTIAL SITE REQUIREMENT is the existence of a suitable system of transport logistics and intermediate storage facilities for waste and residues which must meet ecological and economic criteria.

Waste should preferably be shipped by train. This is why all thermal waste treatment plants with cross-regional catchment areas planned in recent years were connected to the railway network (incl. Lenzing, Niklasdorf, Dürnrohr, Linz, Frohnleiten, Pitten).

Existing and planned thermal waste treatment plants with railway network connections



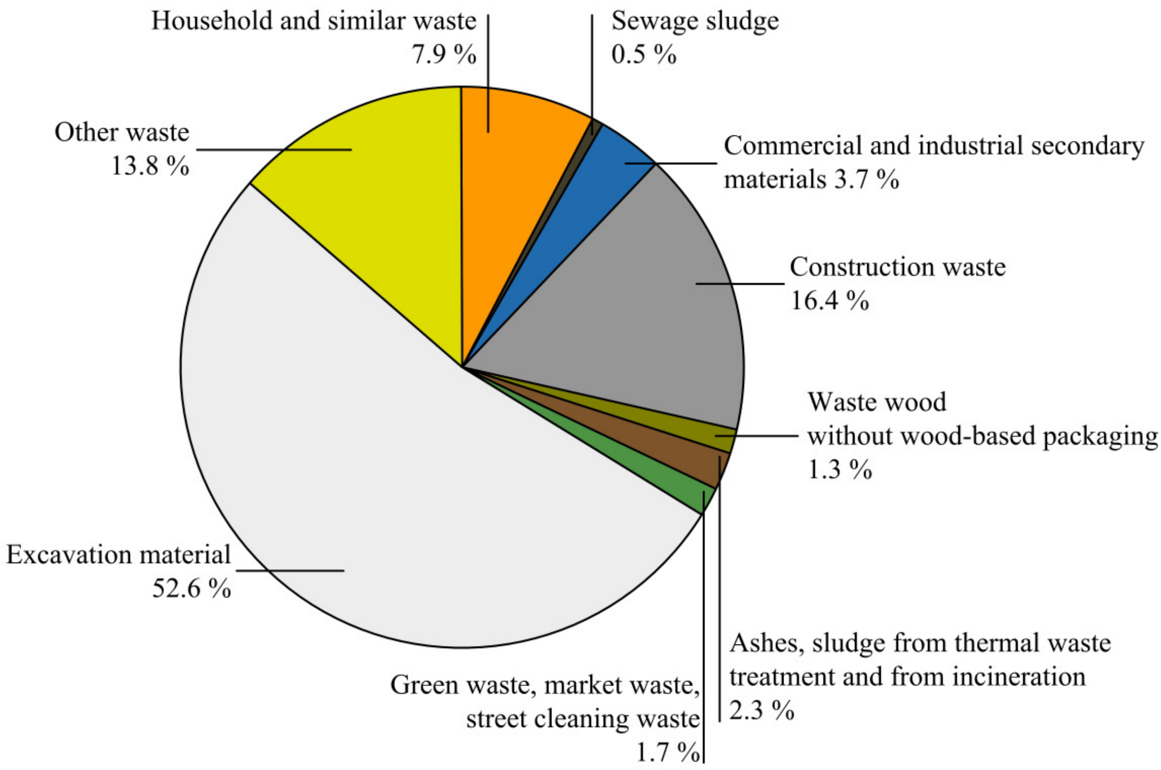
Source: ÖBB, 2015 and UV&P, 2015

Unloading possibilities for waste shipped by train to EVN Abfallverwertung (automatic unloading of containers by crane or unloading by truck)

HOW MUCH WASTE IS GENERATED IN AUSTRIA?

PROPER WASTE MANAGEMENT requires the collection of various wastes and their material-specific treatment. The following chart shows the composition of the approximately 50.8 million tons of waste generated in 2013. This equals 6 tons of waste per inhabitant and includes approximately 480 kg waste from households and similar establishments.

Composition of waste generated in Austria in 2013



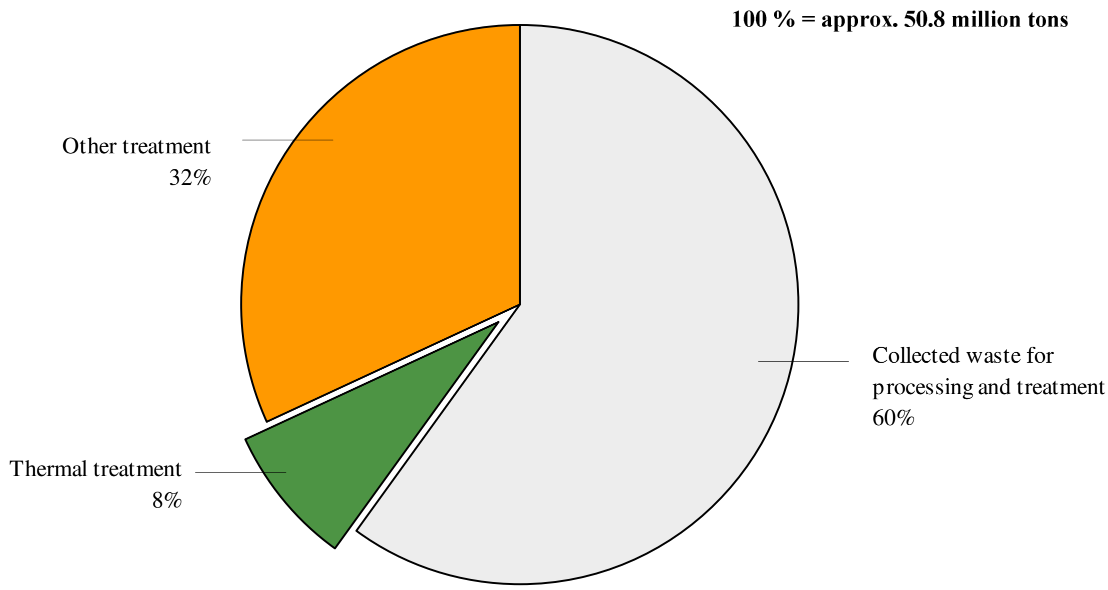
Source: BMLFUW, Statusbericht 2014

The waste statistic does not account for certain residues from agriculture and forestry, such as manure, urine and organic material suitable for composting, if subjected directly to legitimate use in the agricultural or forestry sector. Dead rock from mining and radioactive substances are also excluded as a rule.

Despite a multitude of prevention measures, the amount of waste produced in Austria has been growing for decades due to increase in material wealth and population. Excavated material, e.g. from building and road construction, accounts for the largest share. But the volume of other types of waste is also increasing. Landfill disposal is the only area that shows a strong decline due to material-specific treatment and recovery measures.

ACCORDING TO THE AUSTRIAN FEDERAL ENVIRONMENT AGENCY DATABASE, Austria has approximately 2,400 plants for the treatment of the various types of waste. A significant proportion of the waste is recovered or treated internally at the source. A total of approximately 70 plants are used for the thermal treatment of the various specific types of waste. Depending on the material, approximately 8 % of the total waste volume is thermally treated or incinerated every year.

Proportion of thermal treatment compared to total amount of generated waste in 2013



Source: BMLFUW, Statusbericht 2014

WHAT IS “RESIDUAL WASTE”?

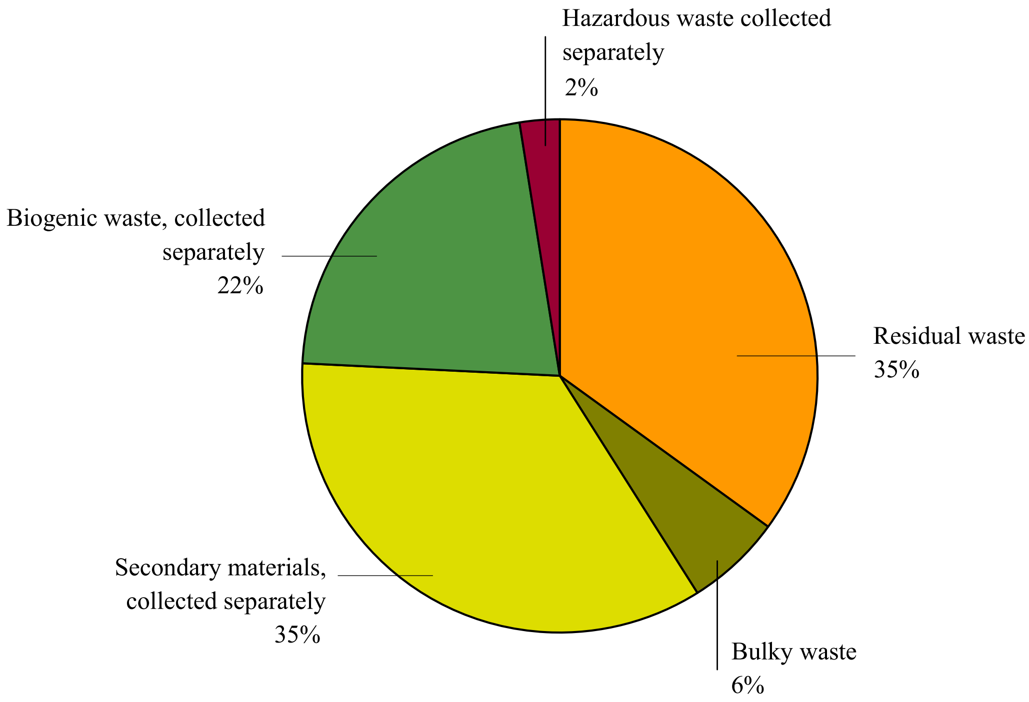
RESIDUAL WASTE REFERS EXCLUSIVELY TO THAT PART OF WASTE FROM PRIVATE HOUSEHOLDS AND OTHER ESTABLISHMENTS which is collected as "residual waste" in standardized waste containers by public waste collection services. This is a heterogeneous mix of various types of materials which may vary strongly in composition and volume depending on regional and seasonal factors (rural or urban settlement structure, average size of households and consumption behavior, proportion of commercial enterprises, seasonal tourism, etc.).
In some areas, district heating plants have a non-negligible effect on waste volume and composition. The link-up to a district heating network, as well as the use of natural-gas and heating-oil boilers, prevent the environmentally unsafe burning of waste wood and other high-calorific wastes (e.g. cardboard, paper) in household burners.

Households also produce other waste that is collected separately from residual waste:

- separated waste (e.g. paper. glass, metals, plastics, old clothing) and organic waste
- bulky waste, which is collected separately due to its size/bulkiness
- legally defined hazardous household wastes (e.g. batteries, fluorescent light tubes)
- electric and electronic appliances, used cars.

Household and similar waste

approx. 4 million tons in 2012



Source: BMLFUW, Statusbericht 2013

Some 60% to 70% of residual waste is biologically degradable (including humidity). Approximately 10% to 20% consists of plastics and approximately 10% consists of inert materials, including glass. About 3% to 4% consists of metals and 2% is hazardous household waste – in chemical terms. One ton of residual waste typically contains 1 g to 3 g of mercury, approximately 10 g of cadmium and some 3 kg to 5 kg of sulfur, as well as 6 kg to 12 kg of chlorine. These substances are found in practically all fractions of residual waste in a variety of chemical compounds. For this reason, the requirements for technical systems ensuring safe residual waste treatment are highly complex.

Residual waste composition in 2004

Fraction	Mass (%)
Organic / biogenic waste	37
Paper, cardboard and cartons	11
Hygiene products	11
Plastics	10
Composite materials	8
Textiles	6
Glass	5
Inert materials	4
Metals	3
Hazardous household wastes	2
Fine / coarse fractions	2
Wood – leather – rubber	1

Source: Federal Waste Management Plan 2006

Net share of packaging materials in residual waste in 2013

Fraction	Mass (%)
Beverage packaging	
- Glass	1.7
- PET / other plastic packaging	1.8
- Composite materials	0.9
- Metal	0.7
Other packaging	
- Paper	4.7
- Glass	1.5
- Plastics	6.8
- Composite materials	1.3
- Metals	1.3
Total	20.7

Source: Technisches Büro Hauer, 2015

Example of separate waste collection

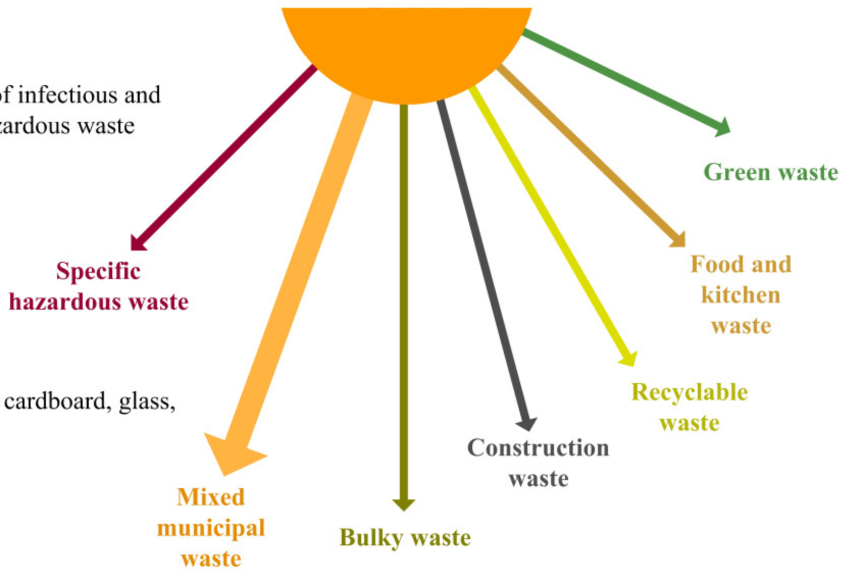
WHY CAN WASTE SEPARATION ALONE NOT SOLVE THE PROBLEM?

SEPARATING WASTE AT THE SOURCE does nothing to reduce the total volume of waste generated.
For years, total municipal waste generation has exhibited a tendency toward growth. In the early 1990s, a temporary decline in residual waste was achieved by making Austrians more aware of the necessity to prevent and separate at the source specific waste materials (paper, glass, metals, and plastics) and biogenic waste for recycling.
The measures available to boost efficiency gains in separate waste collection in Austria are all but exhausted, to the point that the amount of residual waste is exhibiting a tendency to increase again (see graphic on p. 90) .

Separated collection of municipal waste

Specific treatment and utilization of:

- Separate collection and treatment of infectious and other hazardous organic waste (hazardous waste incineration)
- Mixed municipal waste (garbage)
- Bulky municipal waste
- Construction and demolition waste
- Materials for recycling (e.g. paper, cardboard, glass, PET)
- Green waste
- Food and kitchen waste
- Materials for specific treatment (e.g. batteries, tires)



Source: UV&P, 1994

Once the separately collected waste fractions have undergone further sorting (recovery of potential recyclables), the non-recyclable waste components are in need of thermal treatment (e.g. fluidized-bed incineration with cogeneration of electricity and year-round utilization of heat), prior to the disposal of the final solid residues in compliance with the strict limitations on landfilling in Austria.
Sustainable waste management compares somehow to walking on two legs (i.e. material and energy recovery): Equally strong legs will allow for best overall performance in walking.

Required thermal waste treatment for residues following separate collection and sorting

Description*)	Residues (%)	Definition
Waste paper, waste cardboard	approx. 5 - 15 %	Sorting and waste paper processing
Plastics used for packaging, composite board	approx. 30 - 70 %	Contents of „Gelber Sack" („yellow bag") and „Ökobox" („eco box")
Waste glass, composite glass	approx. 2 - 10 %	Labels, plastics, composite foils
Construction waste	approx. 10 - 40 %	Wood, sawdust, packaging, plastic tubes or pipes, foils, carpets
Organic waste	approx. 5 - 10 %	Plastics, low-degradable materials
Bulky waste	approx. 70 - 90 %	Not including metals and recyclable materials
Scrap tires	approx. 2 - 100 %	Approx. 2% filter dust after material recycling, 100% when incinerated in cement clinker production
Residual waste	approx. 50 - 98 %	Not including metal component, potential rot loss during treatment (MBT)

Source: UV&P, 2007

MATERIAL RECOVERY OF WASTE PAPER AND CARDBOARD requires separate collection, sorting, mechanical treatment, and removal of fiber fractions for re-use in paper or cardboard machines (recycling). This process leaves approximately 10% residues (rejects, sludge from waste water treatment), which should be thermally recovered.

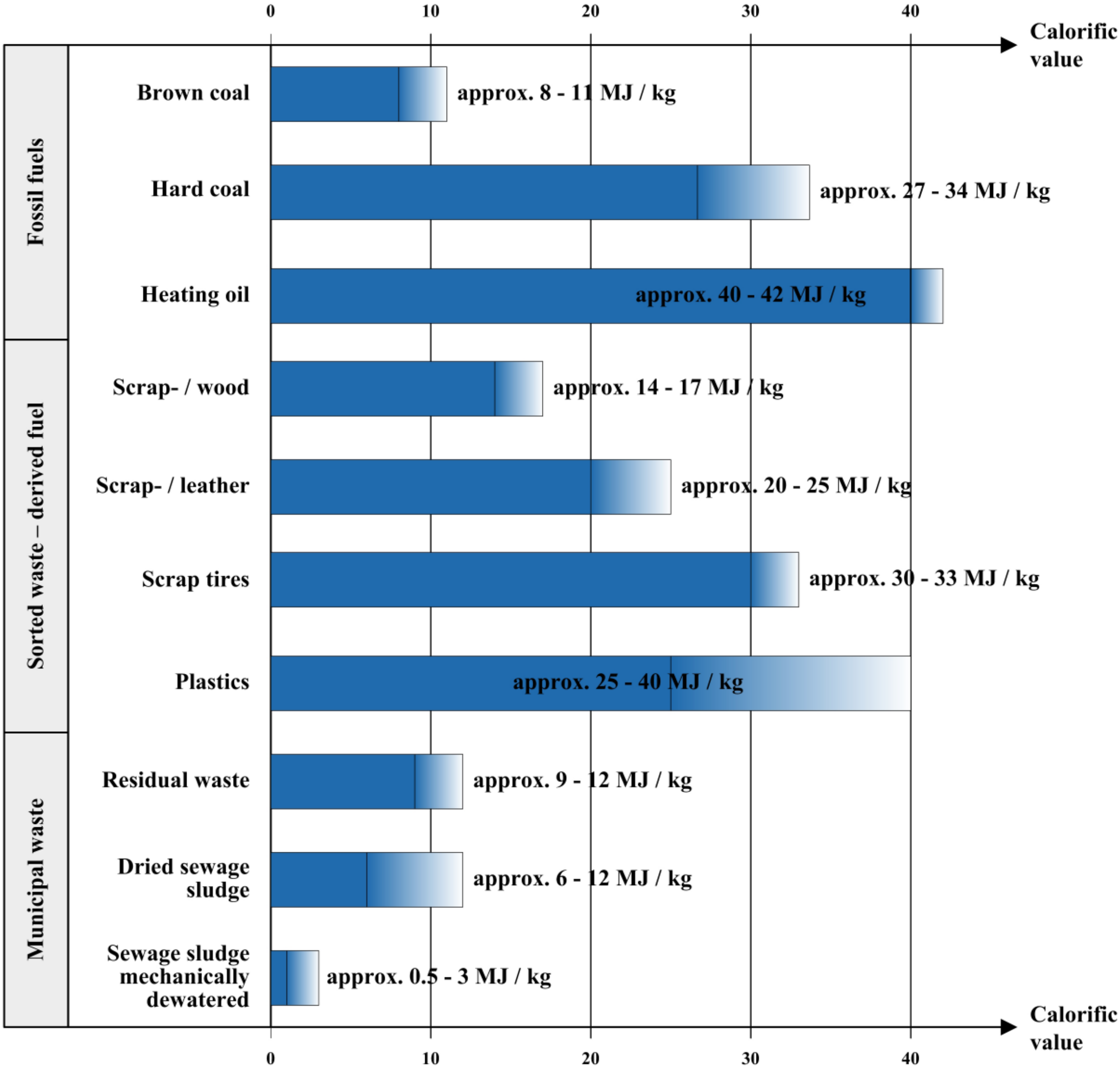
Due to its composition, residual waste may no longer be landfilled in Austria. Residual waste may, however, be subjected to mechanical treatment and divided into fractions so that only a residual component in the range of approximately 98% (if only the metal parts are recovered for material recovery) to approximately 50% must be thermally treated (if the metal parts are recovered, the organic materials that make up the majority of the fine fraction are subject to biological treatment and the rotted residues are landfilled).

For the sake of continuity in the security of disposal and for the purpose of the precautionary principle, the availability of the required waste treatment plants for material recycling and energy recovery must be ensured when and as needed as well as their compliance with the state of the art (after all, hospitals and dental surgeries are not planned and built after patients have started feeling pain).

CAN RESIDUAL WASTE BE INCINERATED WITHOUT AUXILIARY FUEL?

YES. Despite the separate collection of different waste fractions, the typical calorific value of residual waste continues to rise and is at approximately 10 to 11 MJ (Mega Joules) per kilogram. This means that 1 ton of residual waste is roughly equal to 1 ton of brown coal or 250 liters of heating oil in terms of calorific value.

Comparison of the typical calorific value of different fuels and wastes



Source: UV&P, 2009

THE CALORIFIC VALUE of residual waste fluctuates over time and differs by region. This is especially true of rural regions with solid fuel heating where residual waste has a lower calorific value since wastes with high calorific value are incinerated (e.g. cardboard, waste wood taken from bulky waste) and due to the ash fraction from regular fuels (e.g. firewood, coal). Nevertheless, experience has shown this calorific value is still sufficient to allow the expedient use of the energy content of residual waste in suitably equipped incineration plants.

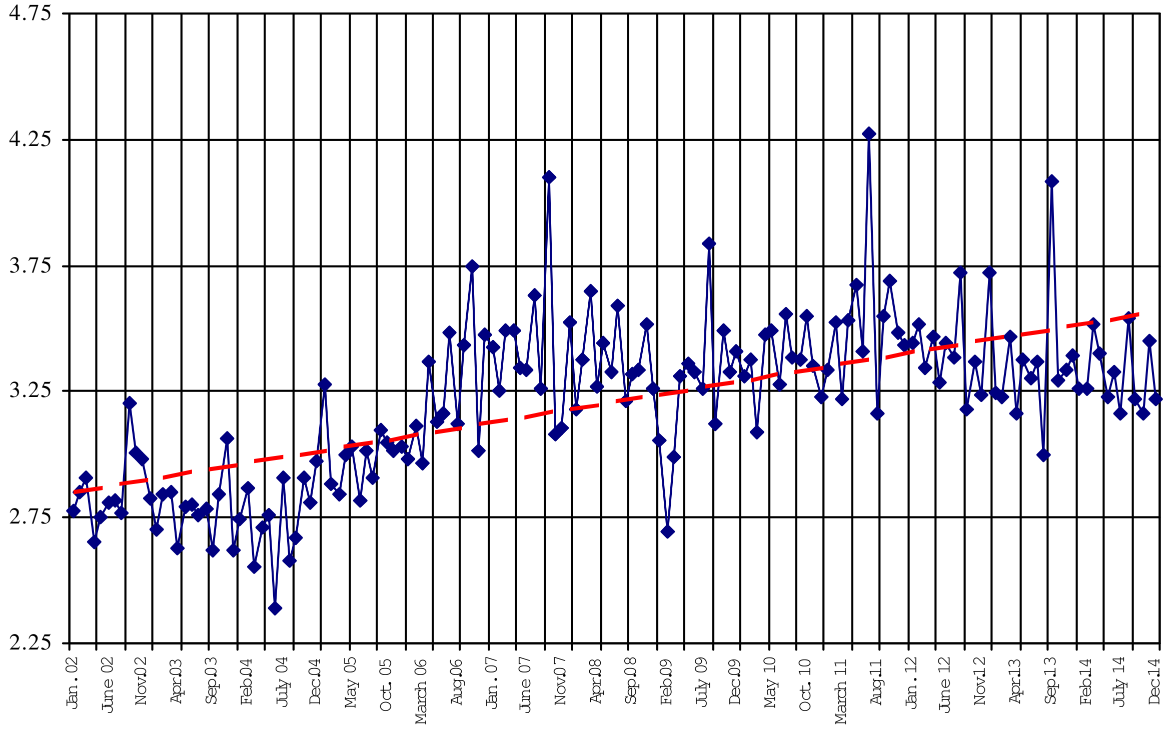
The exact range of calorific value for auto-thermal combustion (combustion without auxiliary fuel) depends on the plant technology used and control of the incineration process. While a typical grate firing facility requires a minimum calorific value of approximately 7 MJ per kg for auto-thermal combustion, a suitably configured fluidized-bed incineration plant can achieve this starting from approximately 3 MJ per kg.

The evolution of the calorific value of waste over a number of years with its strong seasonal fluctuations can be observed in the example of the Flötzersteig waste incineration plant located in Vienna’s western catchment area given in the illustration below.

Another typical example is the changes from 1970 to 1990 in Milano, Italy, when the generation of municipal waste quantity and its specific calorific value increased each by 100 % (from about 250,000 to 500,000 tons per year and from 5 to 10 MJ/kg in two decades).

Waste incineration plant Flötzersteig as an example of tendential development of the calorific value in Austria

Specific steam production (= amount of produced steam in tons per ton of waste input per month)



Source: MA 48, 2015

WHAT TYPES OF WASTE SHOULD BE INCINERATED?

IT SHOULD BE NOTED THAT THROUGHOUT THE EU "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" (Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on Waste).

Residual and other mixed wastes with high calorific value (e.g. residual municipal waste) can and should be thermally treated in suitably equipped plants at appropriate sites for recovery of energy.

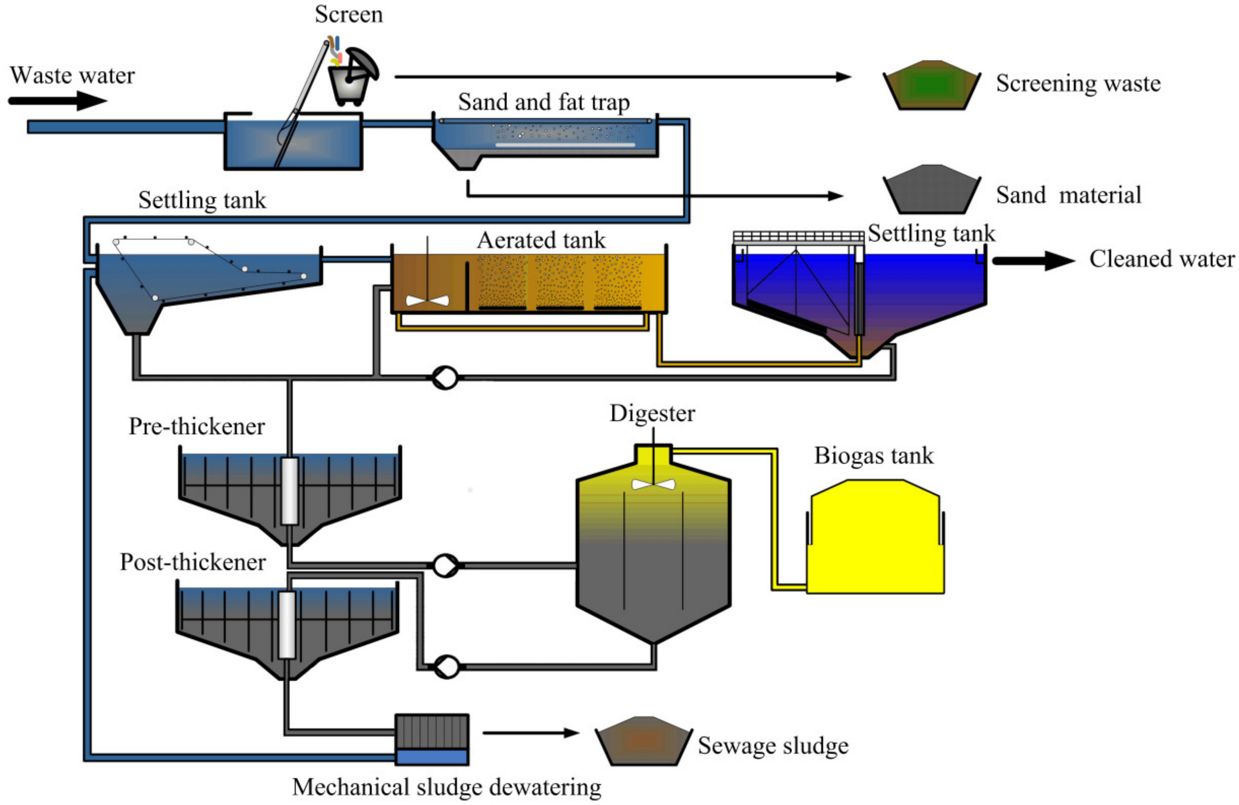
The question of whether a certain type of waste should be materially recycled or incinerated for energy recovery can only be answered on a case-by-case basis, as the specific waste composition and available treatment technologies must be considered with special attention on mass and energy balances, resource conservation, and environmental impacts. Specific waste materials such as paper, cardboard, glass, PET containers, and scrap metal, as well as green waste (which can be used to make high-quality compost), should be separately collected and recycled.

At any rate, thermal treatment becomes necessary whenever organic pollutants contained in the waste are to be destroyed as this may be necessary due to the extensive requirements for disposal of solid residues in landfills. Residues from municipal waste water treatment plants, for instance, inevitably fall under this requirement, since they cannot be used for agricultural purposes due to their composition and since they pose a potential environmental and health hazard.

Large amounts of the following types of waste with relevant organic constituents are generally treated by incineration for energy recovery:

- Residual waste and similar commercial waste (municipally collected household refuse)
- Pre-treated bulky waste, commercial, production, and construction specific waste
- Residues from municipal and commercial waste water treatment
- Waste wood and other waste products from wood processing
- Residues from waste material recycling (e.g. rejects)
- Shredder residues from the scrap industry
- Waste oils, wastes containing oil and contaminated organic solvents
- POP wastes (e.g. DDT, HCB, PCB)

Specific residues from municipal waste water treatment



Source: UV&P, 2009

SCREENING RESIDUE from municipal waste water treatment is a typical example of waste subjected to thermal waste treatment. As material wealth and the awareness for hygiene increase, the amount of solid wastes disposed of over toilets and the public sewage system (e.g. wet wipes, water-resistant hygiene products, etc.) is steadily increasing – resulting in an increase in screening residue. These “delicate” wastes (similar to other potentially infectous wastes from medical facilities) require special handling by automated, closed systems as indicated by the separate receiption and feeding sytem at the waste-to-energy plant in Linz with a separate receiption hall, special shredder and a closed system with a piston type pump to feed the pretreated waste into the fluidized bed for controlled combustion.

Screening residue from the cleaning of municipal waste water

RHKW Linz Screening residues line: Separate reception hall with air control and shredding machinery with closed conveying

CAN CERTAIN WASTES BE CO-INCINERATED IN INDUSTRIAL FURNACES?

THE QUALITY OF THE WASTE USED AS FUEL must be suitable for the industrial furnace (calorific value, chemical composition, storage stability, dosability, etc.), the incineration requirements must be met (control technology, minimum temperature and minimum residence time, minimum oxygen content, etc.), and the required atmospheric emission and residue treatment must be ensured, including monitoring by measurement. Certain wastes can be converted into quality-assured waste fuels through appropriate sorting, separating and processing steps.

DUE TO THE CONSTANTLY CHANGING COMPOSITION with unknown and sometimes strongly fluctuating contents of harmful substances, waste incineration plants need to fulfill stricter requirements than power plants and industrial furnaces in which specific fuels are fired.
Co-incineration of certain waste fuels in suitable industrial production plants can be an economically and ecologically expedient way to complement dedicated waste incineration plants.

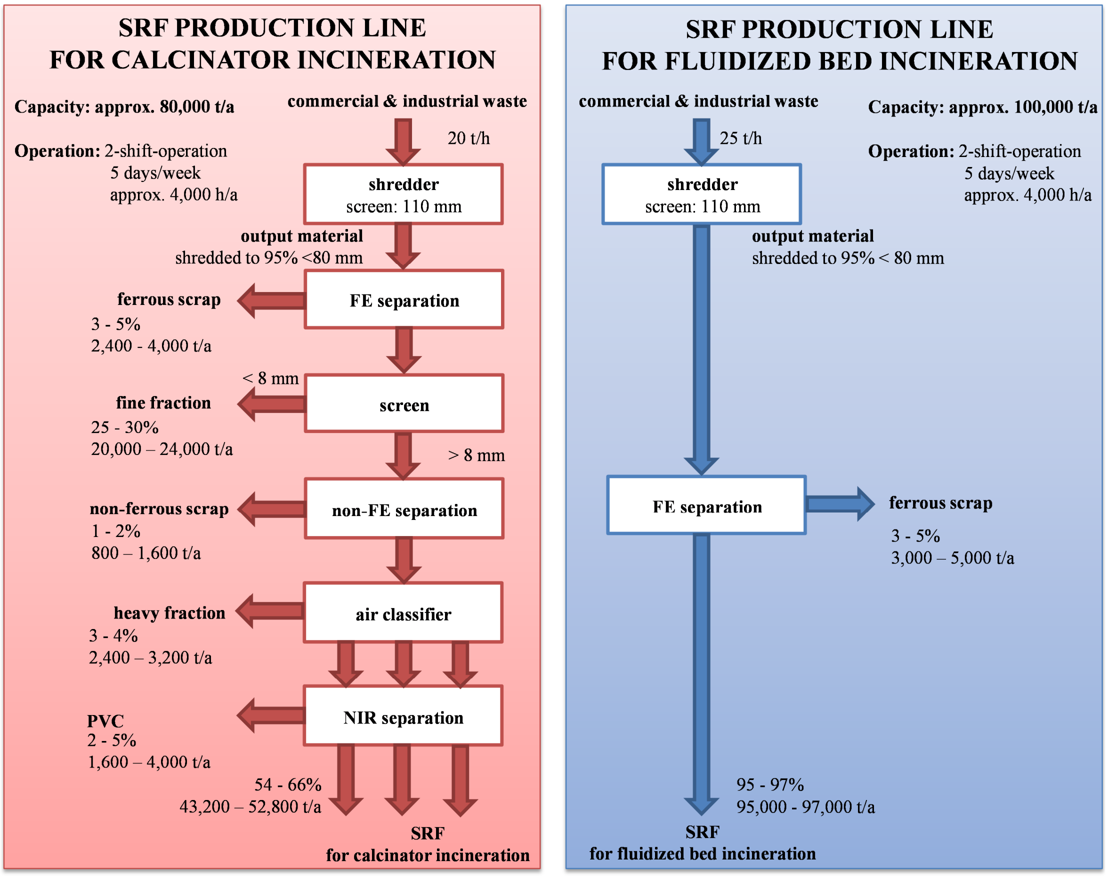
Example for co-incineration or use of waste fuels in industry

Waste	Production process	Notes
Processed plastics	Cement kiln	Main firing, precalciner
Used oil, halogen-free solvents	Cement kiln	Only in main firing
Shredded tires	Cement kiln	Only in secondary firing
Light fraction from packaging waste collection	Blast furnace	Pelletization and feeding via tuyere
Sawdust and wood shavings contaminated with organic chemicals	Cement kiln	Only in main firing

Source: ÖNORM S2108-1, 2006

THE PULP, PAPER AND TIMBER INDUSTRY uses large-scale furnace systems for cogeneration of electricity and heat, in which internal by-products and specific waste products from the production process are also used as fuel. Sawdust, paper pulp sludge and sludge from waste water treatment in paper and cardboard industry as well as milled Styrofoam can be used as pore-forming agents in brick production, if appropriate combustion for the off-gas is implemented in order to limit organic emissions to the atmosphere. Industrial production processes require a high availability in steam production throughout the year, thus it is necessary to operate the waste-to-energy facility with coal in case of disruption in waste fuel supply. For this purpose it is best practice to use fluidized bed systems with mechanical pretreatment in order to reduce the particle size to the technical requirements of the specific fluidized bed system (e.g. maximum allowable size by screening at 100 mm). For this purpose it would be most economical to apply an appropriate single step machinery. A significantly higher requirement of mechanical pretreatment and sorting is required to achieve the necessary quality of SRF (solid recovered fuel) for cement clinker production (calciner) as illustrated in the scheme below. The utilization of high calorific liquid wastes such as waste oils and non-halogenated organic solvents requires special handling and can be cost-effectively performed in the mainburner of a cement kiln.

SRF production lines for calcinator and fluidized bed incineration



Source: UNTHA shredder technology, 2015

Example of pre-treated waste fuel instead of heating oil as support fuel in the sewage sludge incinerator (input material for fluidized boiler WSO3 in the waste incineration plant Simmering in Vienna)

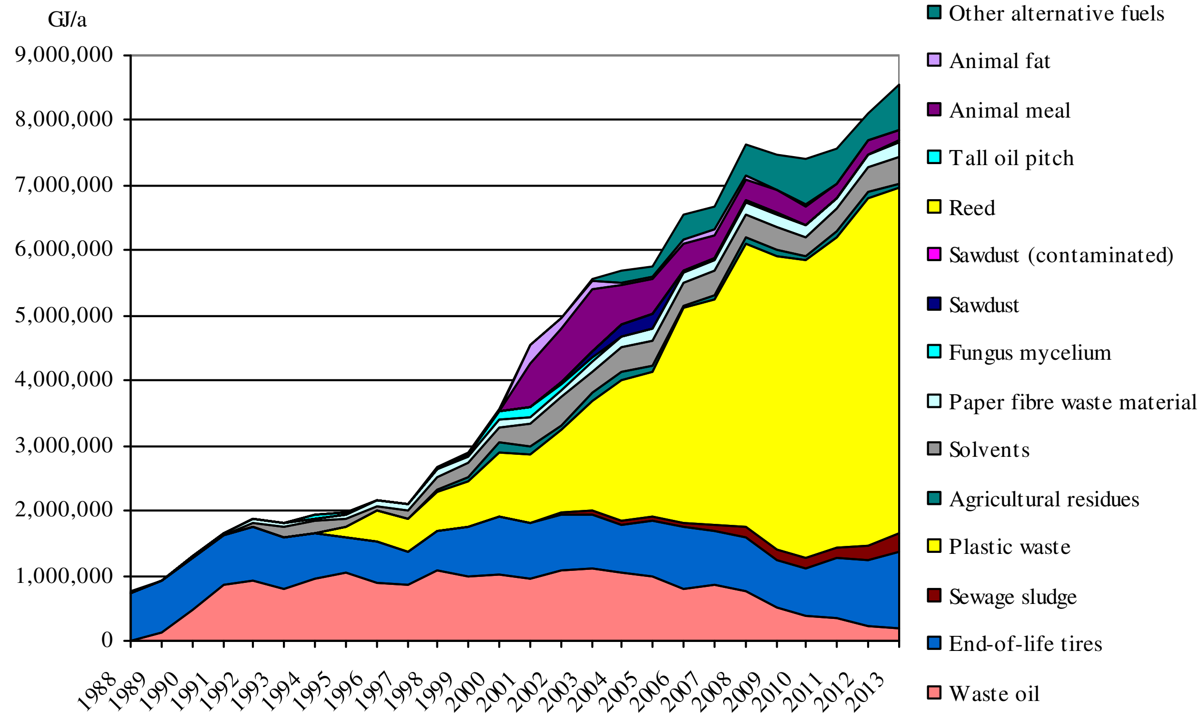
THE REQUIREMENTS FOR USE OF WASTE FUELS in waste co-incineration plants in Austria are described in the Requirements for Use of Alternative Fuels in Waste Co-incineration Plants ("Anforderungen für den Einsatz von Ersatzbrennstoffen in Abfallmitverbrennungsanlagen" by the Federal Ministry of Agriculture, Forestry, Environment and Water Management 2008).
The aim of these guidelines is:

- to protect human life and health against harmful effects that can arise from the use of waste fuels, and prevent environmental pollution,
- to ensure the industry-specific use of waste fuels of a quality that prevents, to the extent possible, pollutants from entering the end products,
- to determine what constitutes the state of the art for the use of waste fuels,
- to ensure a uniform quality assurance system.

THE REQUIRED MINIMUM QUALITY IN WASTE FUELS for use in co-incineration plants depends on the type of the subsequent thermal process. These guidelines draw a distinction between facilities for cement production, power plants and other industrial co-incineration plants. Generally, the extent of waste probing and analyses is determined by the potential properties of the waste (based on the generation and origin of the waste) on one hand, and the technical equipment and plant's mode of operation on the other, with special consideration for requirements in shipment, pre-treatment and intermediate storage. Co-incineration of residual municipal waste and sewage sludge in industrial furnaces designed for conventional fuels is not possible as these plants are not technically equipped for this purpose (e.g. capture of mercury, control and destruction of POPs)!

Development of the utilization of waste fuels in the Austrian cement clinker industry 1988 - 2013

Alternative fuels 2013: approx. 483,700t
Substitution of primary fuels 2013: 72.4%

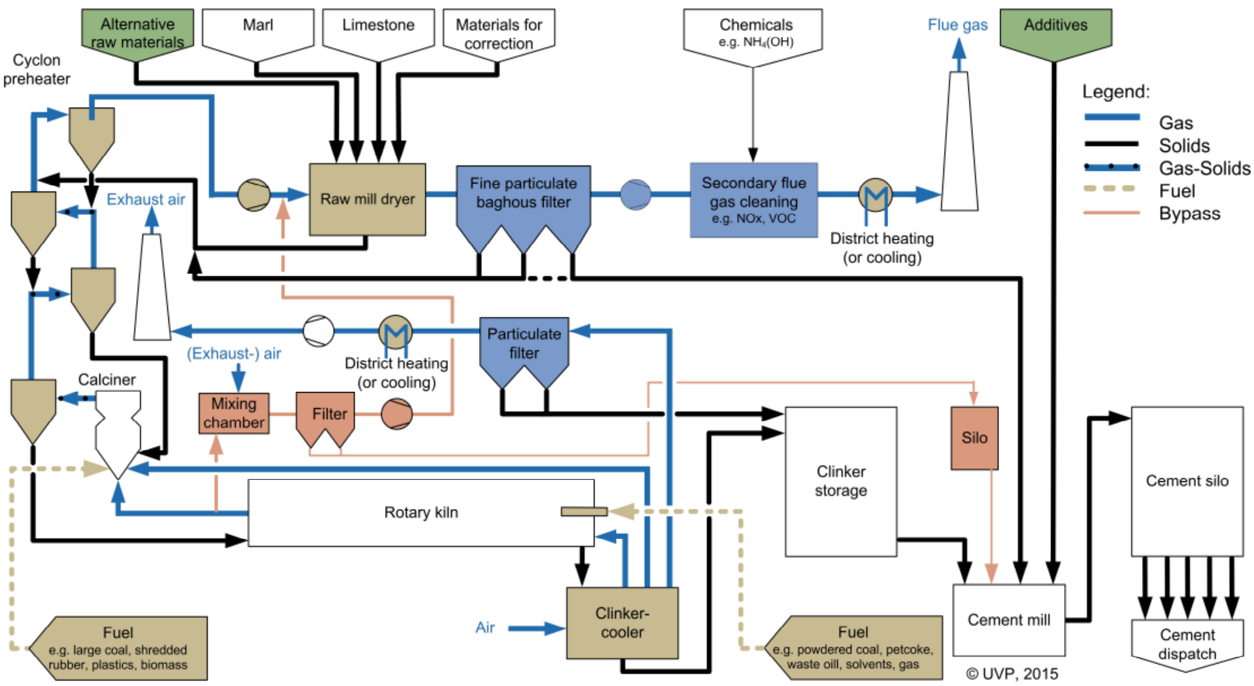


Source: VÖZ Vereinigung der Österreichischen Zementindustrie, 2015

Station for reception of waste oil and non-halogenated organic solvents for thermal treatment at the cement plant in Gmunden

The following scheme illustrates the complexity of cement and cement clinker production, which may vary according to chosen technology and available raw materials and specific wastes for recovery. There is an absolute need for strict emission control and internal control of "cycles" (formed by volatile compounds such as chlorides and heavy metals), possibly requiring a so-called bypass.

Illustration for the complexity of resource and energy efficiency in cement and cement clinker production



WHAT KIND OF PROVEN WASTE INCINERATION TECHNOLOGIES ARE AVAILABLE?

VARIOUS TRIED-AND-TESTED PROCEDURES are available for thermal waste treatment. The following waste incineration technologies differ in the way the air and fuel are fed into the incinerator:

- **Grate firing systems** (air flows from underneath through the solid particulate fuel placed on top of the grate),
- **Fluidized-bed incineration** (intense gas turbulence keep the suspended, small-piece fuel in hot sand and incineration gas in a "fluidized", dynamic state of movement),
- **Dust firing systems** (the finely ground fuel is transported pneumatically in the gas flow with simultaneous incineration),
- **Rotary kiln with afterburner** (various types of solid, pasty and liquid wastes can be treated in the slowly rotating kiln. The flue gas is subsequently burned with auxiliary fuel in the connected afterburning zone).

DECADES OF SUCCESSFUL EXPERIENCE have shown that the simplest way to incinerate mixed residual waste is in a grate firing system. Alternatively, residual waste can be used in fluidized-bed incineration following mechanical processing. Separately collected plastics, rejects from waste paper recycling, mechanically de-watered sewage sludge, and mechanically processed waste fractions (e.g. shredder light fractions, etc.) with a low or exceptionally high calorific value can be used efficiently in the fluidized bed system. To do so the waste fuels must be provided in an easily dosable form and particles must be limited in size (e.g. 80 mm mesh).

Comparison of incineration technologies for thermal waste treatment

Parameter	Incineration technology		
	Grate	Fluidized-bed	Rotary kiln
Maximum thermal fuel capacity per line	approx. 90 MW	approx. 160 MW	approx. 40 MW
Excess air ratio (specific quantity of flue-gas)	medium	low	high
Acceptable range of calorific value for fuel	low	high	medium
Fuel processing requirements	low	high	medium
Controllability of incineration and shut-down operation	medium	high	low

Source: UV&P, 2009

Allocation of selected waste to incineration technologies as per state of the art

Type of waste	Incineration technology		
	Grate	Fluidized-bed	Rotary kiln
Residual waste	well suited	Pre-treatment required	suitable
Sewage sludge	limited in terms of quantity	well suited	suitable
Waste water rakings	suitable	Pre-tratment required	limited suitability
Crushed plastics	limited in terms of quantity	well suited	limited suitability
Whole tires	limited suitability	unsuitable	limited suitability
Shredder waste	limited in terms of quantity	well suited	limited suitability
Crushed waste wood	well suited	well suited	suitable
Lacquer and paint sludge	unsuitable	suitable	suitable
Hazardous wastes in small containers (e.g. laboratory waste)	limited suitability	unsuitable	suitable

Source: UV&P, 1999

MORE THAN A DOZEN FLUIDIZED-BED INCINERATION PLANTS are used for waste incineration or co-incineration in Austria:

- 4 fluidized-bed incinerators in Vienna
  (Simmering)
- 1 industrial fluidized-bed incinerator in Lower Austria
  (Pitten)
- 4 industrial fluidized-bed incinerators in Upper Austria
  (EEVG Steyrermühl, WRHV and RVL Lenzing, RHKW Linz)
- 3 industrial fluidized-bed incinerators in Styria
  (Gratkorn, Bruck/Mur, Niklasdorf)
- 4 industrial fluidized-bed incinerators in Carinthia
  (Frantschach, Arnoldstein, St. Veit/Glan, Fürnitz)

REQUIREMENTS AND FRAMEWORK CONDITIONS for the thermal treatment of the various wastes in accordance with the waste catalogue can be found in ÖNORM S2108-1 “Thermal Treatment of Waste".

WHAT DISTINGUISHES "NEW" OR "INNOVATIVE" TECHNOLOGIES FROM INCINERATION?

"INNOVATIVE" is a qualifier often used to describe newer – but not necessarily better – processes and developments. Conventional incineration technologies using grates, fluidized-beds or rotary kilns are, therefore, sometimes referred to as "conventional" or "old" technologies.

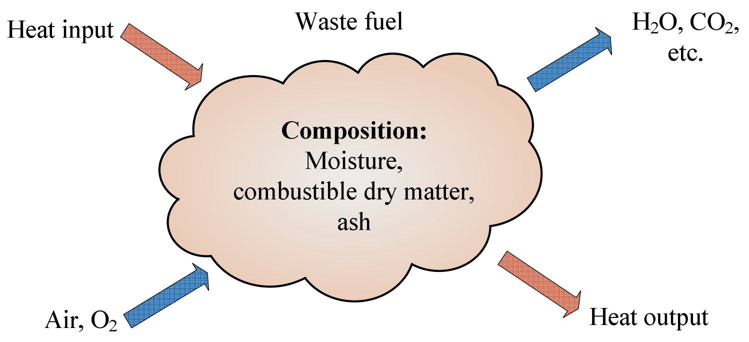
THE COMPLETE INCINERATION PROCESS can be divided into a number of sub-processes, which, depending on the task at hand and configuration, allow for various different "innovative" process combinations.

IN THE FIRST PHASE of a thermal treatment process, the fuel, i.e. waste, is dried. In the second phase, the waste undergoes degasification by further impact of heat and chemical cracking. Subsequently, the solid carbon undergoes gasification. Both the degassing and gasification stages produce combustible gas. During degassing, carbon or pyrolytic coke is produced as a solid residue. This can be in case of special fuels with high defined quality standards used for some material recycling purposes, but will ultimately also be incinerated (i.e. gasification and oxidation of combustible gases).

CONTINUOUS MEASURING AND RECORDING OF THE CARBON MONOXIDE (CO) LEVELS is expedient and indeed legally prescribed to ensure supervision of the completeness and quality of the incineration process.

The 4 phases of the incineration process

Mass- and heat transfer



1 Drying

2 De-gasification (pyrolysis)

3 Gasification of carbon:

$C + CO_2 \rightarrow 2\,CO$

$C + H_2O \rightarrow H_2 + CO$

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

4 Oxidation of gases at high temperature:

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

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

Source: UV&P 1992

1. PYROLYSIS

IN THE 1970S AND 80S – when technical alternatives to the conventional waste incineration technology were desired for various reasons – a vast number of different pyrolytic processes (smoldering instead of burning) were proposed for a variety of wastes, including residual waste.
However, compared to the "classical" technologies, the economic viability of "innovative" processes for the thermal treatment of residual waste and similar such mixed wastes in any permanently functioning installation has not been proven to date. Experience gathered to date with the known pyrolytic processes, as well as the energy scorecards completed for these, reveal significant shortcomings in the treatment of residual waste and similar mixed wastes as compared to incineration technologies such as grate and fluidized-bed incineration.

2. PLASMA TECHNOLOGY

PLASMA (simply speaking, a state of matter with electrons separated from the atoms) is created by use of electricity and allows for gasification at high temperatures of about 1,500°C. Throughout the last 25 years there have been various research and demonstration plants for specific wastes. The overall performance and energy balance for plasma systems has so far not yet proven to be economically viable in comparison to state of the art incineration.

3. USING OXYGEN INSTEAD OF AIR FOR COMBUSTION

THE LABEL "INNOVATIVE" is also sometimes applied to the use of oxygen or the enrichment of the incineration air with oxygen. However, this oxygen first needs to be provided by an air separator, which requires additional energy and adversely affects the energy scorecard.
The potential advantages of this process may be improvements in the slag quality (higher incineration temperature on grates through enrichment of the primary air leads to a more complete sintering and partial vitrification of the incineration residues), as well as a reduction in flue gas volume, allowing for an increase in the throughput of existing plants with such retrofitting (see for example the SYNCOM procedure of Martin Co. and the operation of KRV Kärntner Restmüllverwertung, Arnoldstein).

4. INNOVATIONS IN THERMAL WASTE TREATMENT

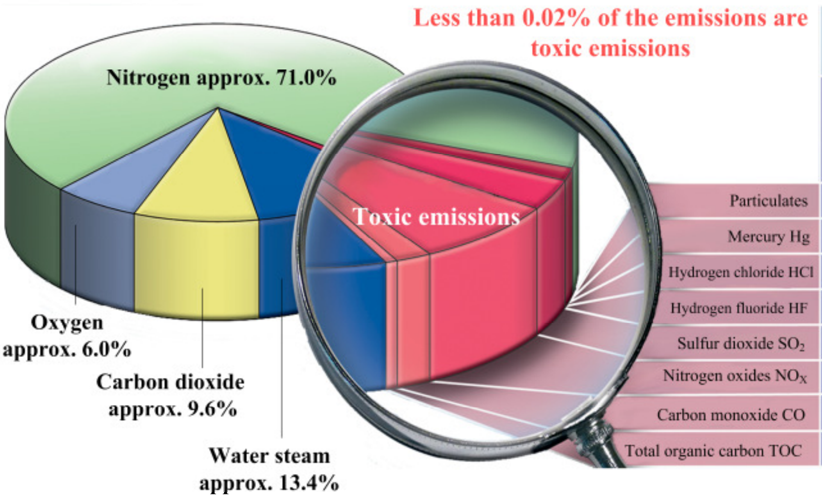
EACH PROJECT FOR THERMAL WASTE TREATMENT should be developed with creativity and innovative engineering skills. This applies particularly to optimized site selection and maximum energy efficiency with minimum consumption of optimally chosen additives, but also to the minimization and recovery of any residues produced. To increase the availability of plants and their energy efficiency, innovations are also needed for the continuous optimization of plant operation.

HOW IS FLUE GAS CLEANED?

EFFECTIVE ATMOSPHERIC EMISSION CLEANING is necessary because of the unavoidable formation of dust and gaseous air pollutants in the emission from waste incineration; even if incineration is complete (i.e. when the residual concentrations of organic carbon compounds and carbon monoxide in the flue gas are at an absolute minimum).

Gaseous pollutants can be divided into organic substances (i.e. unburned or organic carbon) and inorganic substances (e.g. carbon monoxide, sulfur oxide, hydrochloric acid, nitrogen oxide, and gaseous mercury). According to the legal requirements, the composition of cleaned off-gases is constantly monitored and recorded by continuously measuring their key parameters. These parameters are: particulates, total organic carbon (TOC), carbon monoxide (CO), sulfur dioxide (SO_2), hydrogen chloride (HCl), hydrogen fluoride (HF), nitrogen oxide (NO_x or NO + NO_2) and mercury (Hg). Additionally, the other heavy metals and "dioxin" emissions as well as ammonia are monitored in off-gas at regular intervals. The following example of RVL Lenzing provides a comparison between the emission standards requested by EU Directive 2000/76, the Austrian law, the project planning by UV&P in 1994, and the continuously measured values in 2014.

Control of cleaned flue gas from waste incineration (Example: RVL Lenzing)



Comparison of emission limits: Figures in mg/Nm³ (11 % O_2, dry)	EU-Directive 2000/76	AVV BGBl. 389/2002	RVL Lenzing Project 1994	RVL Lenzing Measured values 2014
Particulates	10	10	8	0.6
Mercury Hg	0.05	0.05	0.05	0.006
Hydrogen chloride HCl	10	10	7	0.2
Hydrogen fluoride HF	1	0.7	0.3	0
Sulfur dioxide SO_2	50	50	50	6.4
Nitrogen oxides NO_x	400	100*)	70	40.1
Carbon monoxide CO	100	100	50	3.2
Total organic carbon TOC	10	10	8	0.1

* if > 6 tons waste per hour

Source: UV&P 2015, Rosenauer 2008

A NUMBER OF DIFFERENT PROCESSES AND PLANT DESIGNS ARE AVAILABLE FOR FLUE GAS CLEANING. Depending on the task at hand (the spectrum of flue gas composition, the possibility for discharging water containing mineral salts, etc.), the plant design can be tailored to the specific needs of every scenario concerning chemical efficiency, consumption of energy and chemicals, as well as the volume and composition of resulting residues for recycling or disposal.

Multistage flue gas cleaning is useful for the safe adherence to low emission limit values, even if the flue gas figures are temporarily elevated or technical malfunctions occasionally occur.

PARTICULATE POLLUTANTS (dust) are usually removed using a fabric filter or electrostatic precipitator. Organic pollutants are reduced to a minimum by incineration, which should be as complete as possible, and they can be further reduced through downstream off-gas cleaning. Adsorption processes (e.g. entrained flow process, fixed bed filtration) and catalytic oxidations are available for this purpose.

THE FORMATION OF INORGANIC AIR POLLUTANTS depends largely on the chemical composition of waste for combustion and other fuels. Atmospheric emissions may contain inorganic pollutants such as sulfur oxides (from combustible sulfur) or halides (hydrogen chloride or hydrochloric acid from the incineration of PVC, hydrogen fluoride or hydrofluoric acid from the incineration of Teflon, and possibly hydrogen bromide and hydrogen iodine), all of which must be treated. These highly acidic gases can be efficiently separated in gas scrubbers. Recyclable substances are usually recovered in two separate stages using different process technologies. In special cases of waste-water-free flue gas cleaning processes a spray drier can be used to evaporate the removed scrubber fluid. Alternatively, a waste-water-free sorption process can be employed.

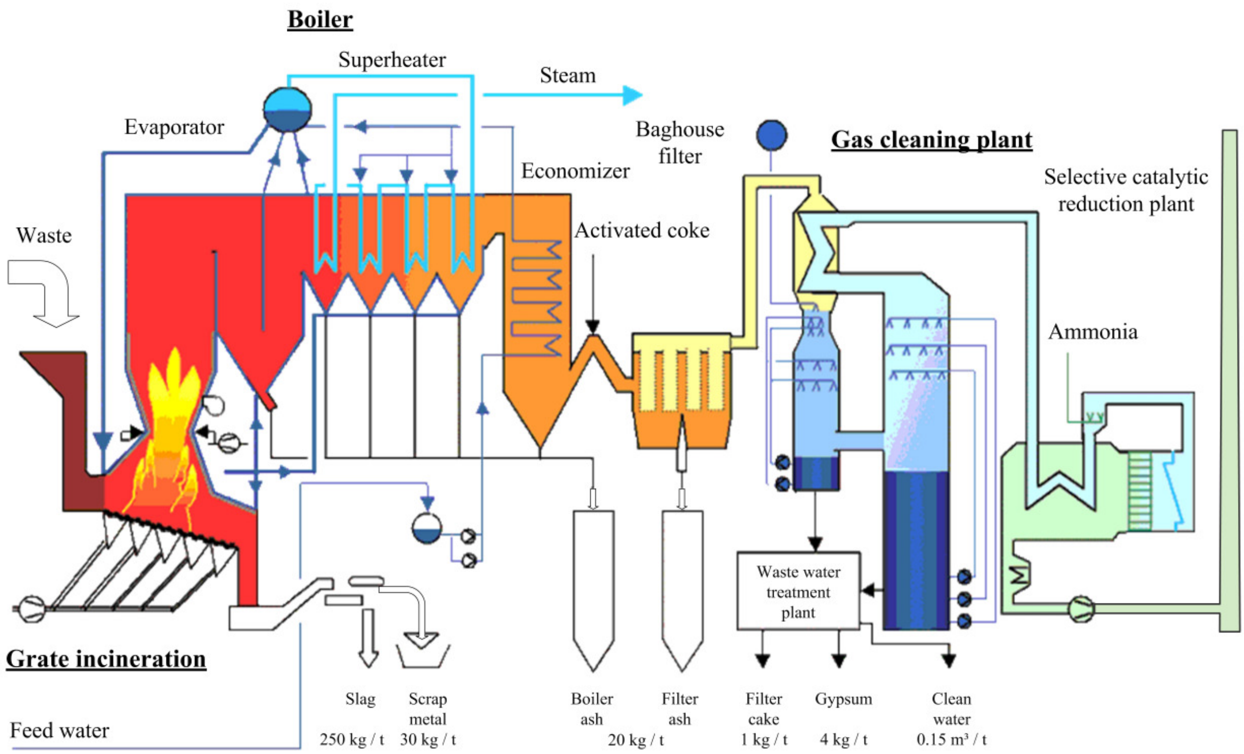
When incinerating nitrogen oxide compounds or during the thermal oxidation of atmospheric nitrogen, nitrogen oxides (NO_x, i.e. the NO and NO_2 compounds) are formed. These compounds can be reduced to less than 10% by using selective catalytic reduction (SCR) with a reduction agent (e.g. ammonia). Selective non-catalytic nitrogen oxide reduction (SNCR) is an alternative in cases where the requirements for reducing pollutants are less stringent. SNCR reduces the nitrogen oxides to approximately 50%, but this process works with a larger amount of the reduction agent and may result in the formation of laughing gas (N_2O).

Separation of vaporous mercury (the only metal that can exist in gaseous form in the atmospheric emissions flow at low temperatures due to its chemical properties) is achieved through adsorption. In this case, the above-mentioned adsorption of organic compounds of a higher molecular weight (e.g. the entrained flow process) also separates any vaporous mercury there may be.

AUXILIARY CHEMICALS SHOULD BE SELECTED ACCORDING TO ECOLOGICAL CRITERIA, particularly taking into consideration energy efficiency and by-products within the production process, as well as the environmental impact of residue disposal. As a result, the newer Austrian waste incineration plants tend to use limestone or lime milk instead of a sodium hydroxide solution or sodium hydrogen carbonate, as the latter two entail a much greater environmental impact in their production.

A TYPICAL EXAMPLE OF A MULTISTAGE OFF-GAS CLEANING SYSTEM is the grate firing plant of Abfall Verwertung Niederösterreich (AVN) at Dürnrohr (Lower Austria), which has been in operation since the end of 2003.

Concept of the grate incineration plant at Dürnrohr (Lower Austria)



Source: AVN Abfallverwertung Niederösterreich Ges.m.b.H.

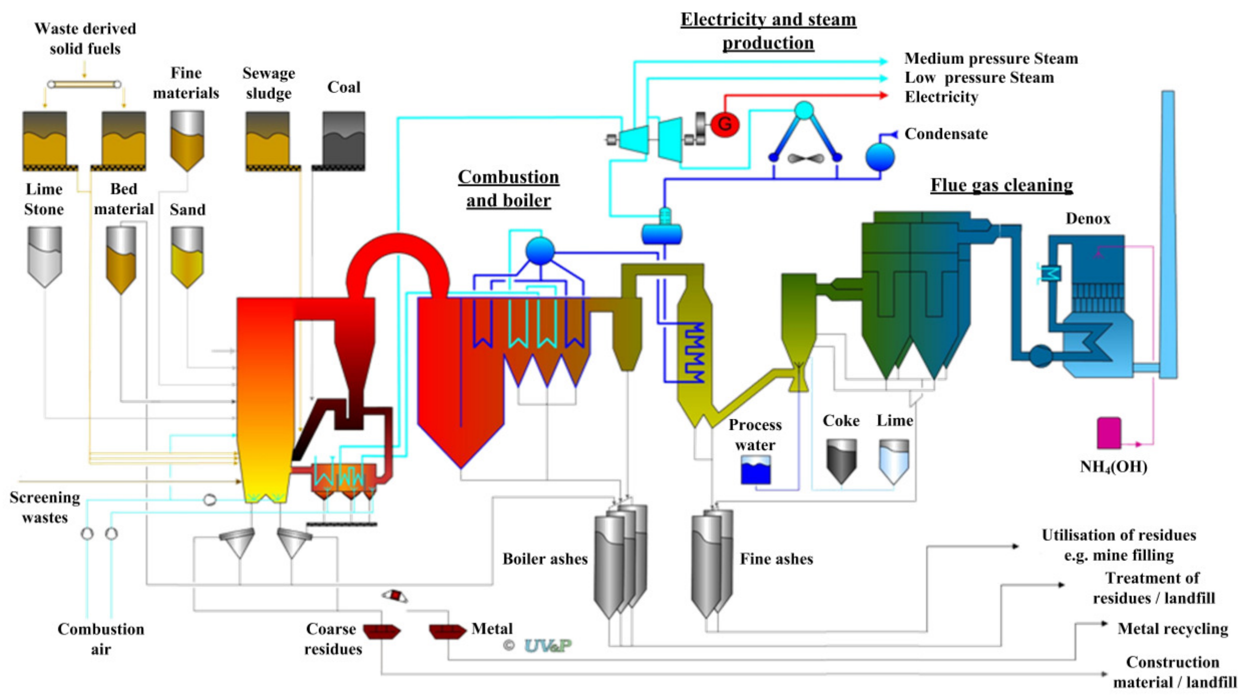
View of the EVN waste incineration plant linked to the neighboring coal-fired power plant Dürnrohr in Lower Austria

THE AMPLE DIMENSIONS OF THE COMBUSTION CHAMBER with the downstream afterburning zone ensure good turbulence, controlled temperature and residence time for optimum combustion, allowing CO and TOC, both of which are formed by incomplete incineration, to be reduced to a minimum.

TWO CONSECUTIVE SEPARATION STAGES are provided in addition to the optimized furnace to treat the pollutants mercury and "dioxins" (PCDDs and PCDFs: polychloric dibenzodioxins and dibenzofurans). Mercury is adsorbed both in the entrained flow reactor and at the first scrubber stage. PCDDs and PCDFs can also be adsorbed in the entrained flow reactor and oxidized in the selective catalytic atmospheric emission cleaning plant. Inside the entrained flow reactor, fine ash is injected into the continuous flow of flue gas, if need be with added calcium hydroxide and activated coke powder, bringing about the desired adsorption. HCl (hydrogen chloride) and HF (hydrogen fluoride) are separated in the first flue gas scrubber at a very low pH value. SO_2 (sulfur dioxide) is separated by adding lime in the second scrubber and discharged as usable gypsum. Any NO_x (nitrogen oxide) that has formed during incineration is reduced to nitrogen oxide (N_2) by the catalyst, which at 79% volume is the main component of our atmosphere.

ONE EXAMPLE OF A WASTE WATER-FREE PLANT DESIGN, which was necessary due to the specific condition of the site, is the planned fluidized-bed plant of RVH Reststoffverwertung Heiligenkreuz in the Federal Province of Burgenland. The plant employs a multistage off-gas cleaning concept that consists of a cyclonic dust collector, an entrained flow adsorber, a fabric filter, and a catalyst.

Concept of the fluidized-bed waste-to-energy plant at the Businesspark Szentgotthárd - Heiligenkreuz



Source: UV&P, 2007

WHAT EMISSION LIMIT VALUES APPLY TO WASTE INCINERATION PLANTS?

STRINGENT LIMITS ARE NECESSARY against noise pollution caused by plant operation and shipment, against odor formation during handling and intermediate storage of wastes, and particularly against atmospheric emissions from thermal treatment and further downstream for waste water from atmospheric emissions cleaning and emissions from the treatment of solid residues.
Over the last three decades, considerable progress has been achieved in the cleaning of atmospheric emissions from waste incineration plants. As a result of public protests by environmental activists, stringent laws and technological development, plants were significantly improved and the required environmental compatibility of thermal waste treatment was achieved.

Development of atmospheric emissions from waste incineration plants in Germany, Austria and Switzerland

	Dust	Cd	HCI	SO_2	NO_x	Hg	PCDD/F
1970	100	0.2	1,000	500	300	0.5	50
1980	50	0.1	100	100	300	0.2	20
1990	1	0.005	5	20	100	0.01	0.05
2000	1	0.001	1	5	40	0.005	0.05

NB: The figures (in mg / m_N^3, PCDD/F in (TEQ) ng / m_N^3) are in fact average emission figures measured over extended periods and should not be confused with the official regulations for half-hour emission limits.

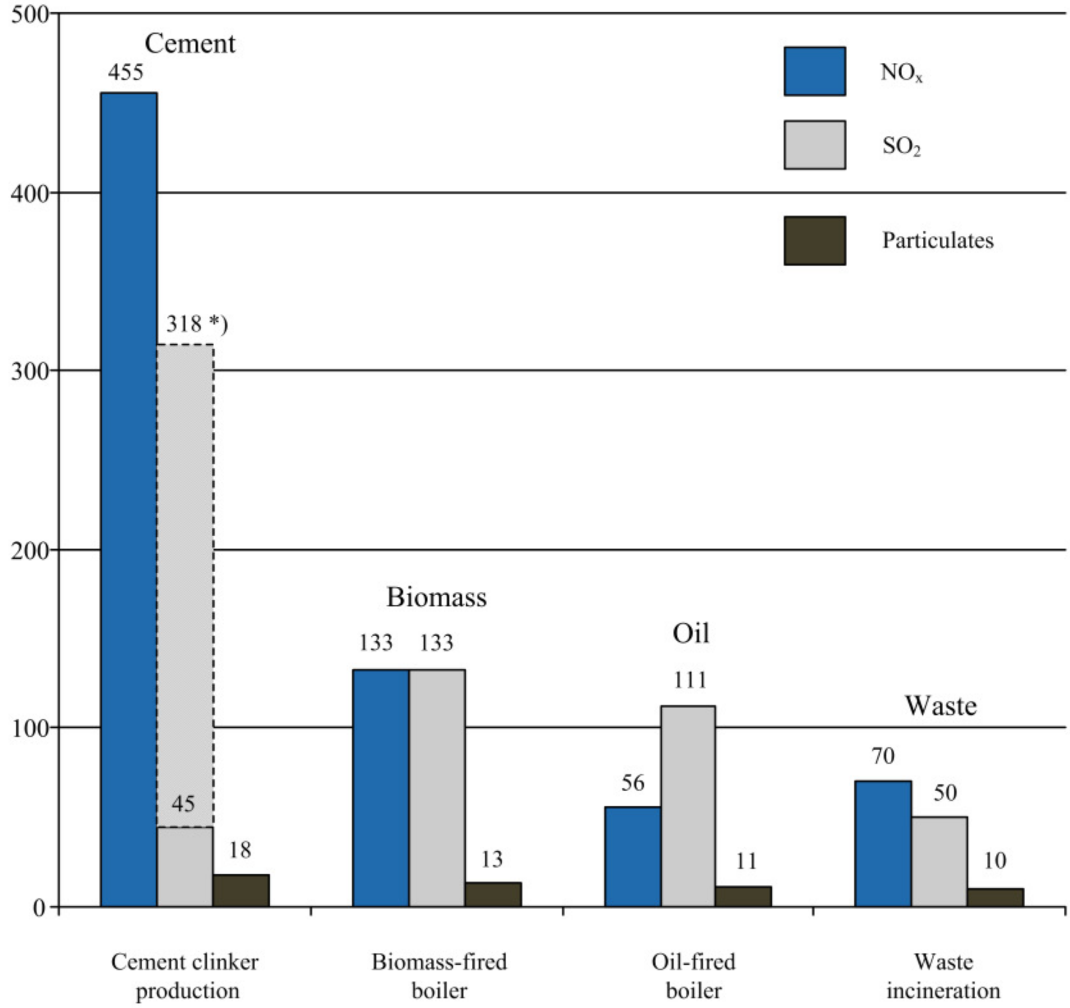
Source: Vogg, 1994 (1970 to 1990 figures); RVL, 2000

HOWEVER, in Austria, too, fears remain that waste is not always incinerated in appropriate plants but in industrial furnaces which were not built for this purpose and thus do not provide sufficient atmospheric emissions cleaning, or in domestic fuel, with emissions many times those of proper waste incineration facilities. In the worst case, incineration could happen through self-ignition of waste deposited in no longer legally authorized landfills.
Under current environmental laws, atmospheric emission standards applicable to thermal waste treatment plants must generally be much stricter than those for other incineration plants with the same thermal output (e.g. compared to cement kilns, to coal and oil-fired boilers).

ONE PLANNING REQUIREMENT UNDER THE WASTE MANAGEMENT ACT is that emissions of pollutants are always within the limits achievable under the state of the art or the best available techniques.
In line with the precautionary principle, waste management should also always be geared toward reducing the emission of air pollutants and climate-relevant gases to a minimum. It should be noted in this regard that laughing gas (N_2O), which may be emitted if waste treatment is not carried out properly, is a greenhouse gas whose impact is 300 times more serious than that of CO_2 and is capable of destroying stratospheric ozone.
One important fact for new projects, and one that plant operators need to keep in mind, is that the Austrian Air Emissions Ceilings Act (Emissionshöchstmengengesetz-Luft) required total nitrogen oxide emissions in the Republic of Austria – as in a number of other EU countries – to be lowered considerably from 2010 onward!

Comparison of legal emission standards for flue gas from new plants in Austria

Daily mean values for plants with a thermal capacity of 100 MW in mg / m^3_N at 11 % O_2, dry.



*) Special legal permit for up to 318 mg / m³

Source: UVP, 2015

This is complemented by Austria's extremely stringent legal obligation to reduce its CO_2 emissions. Thermal waste treatment – if the sites are chosen carefully and energy efficiency is achieved – has the potential to make a very valuable contribution towards this objective.

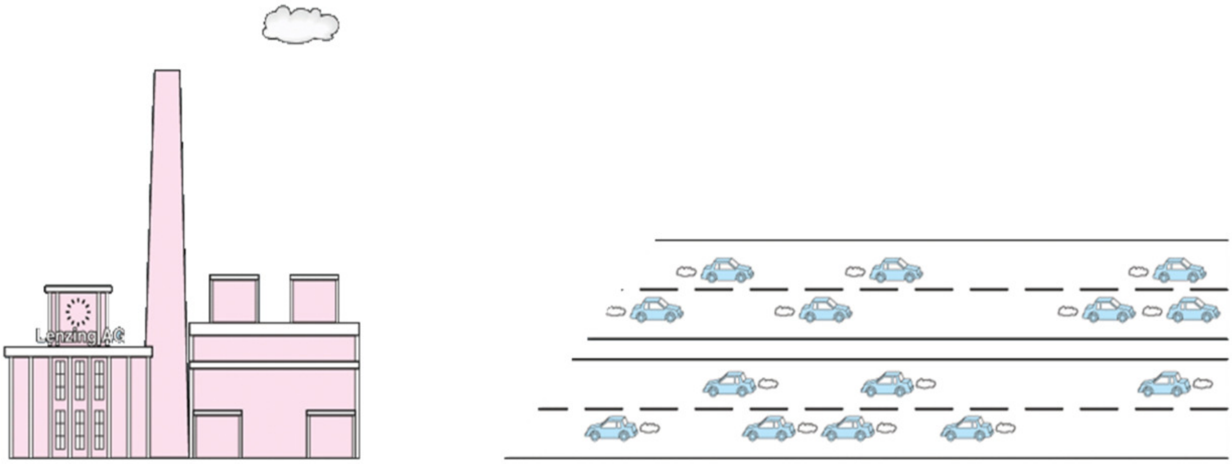
COMPARISON WITH MOTOR VEHICLE EMISSIONS

The comparison of emissions from thermal residual waste treatment with other emission sources paints a tangible picture of the dimensions involved.

In the course of the public discussions which formed part of the official approval procedure for the large RVL Reststoffverwertung Lenzing plant in 1994, it became clear that the plant's emission of organic compounds (a large number of different individual compounds) are comparable to those of approximately a dozen running passenger cars.

Comparison of organic pollutants from incineration plant RVL equals 14 running cars

Illustration for emission of organic air pollutants (example: RVL, 1994)

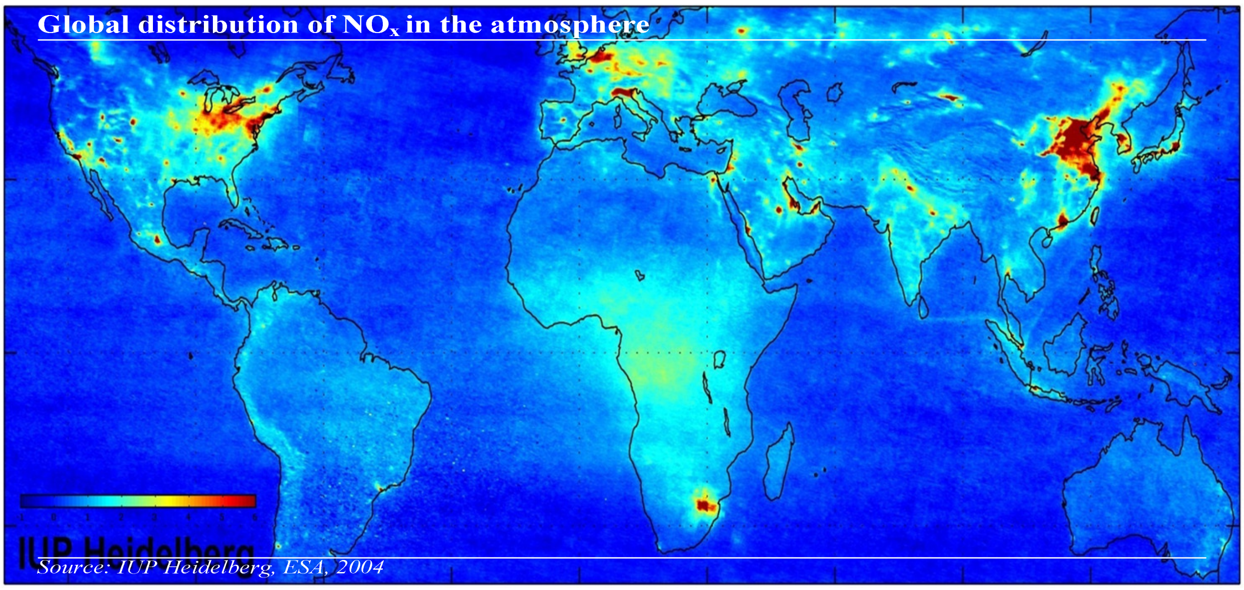


Calculation:
Car exhaust contains approx. 20 g C-org / kg fuel (Source: Schopp G., Ö. Chemz. 1993/9)
Flue gas of the incineration plant contains less than 1,980 g C-org / h
(Source: Gutachten ZAMG, 22.12.1993)

Source: UV&P 1994

Nitrogen oxides can be a significant problem for ambient air quality and, thus, a risk to human health and the environment as indicated in the graph below on the global concentration in various regions. Major problems are obviously in industrial and densely populated areas in China and the USA, but also in the larger region along the Po in Italy, in North-West Germany, Benelux and London, and partly also in Mexico, South Africa, Egypt, Arabia, Israel, Iran, Russia, India, and Japan.

Global distribution of NO_x in the atmosphere



Source: IUP Heidelberg, ESA, 2004

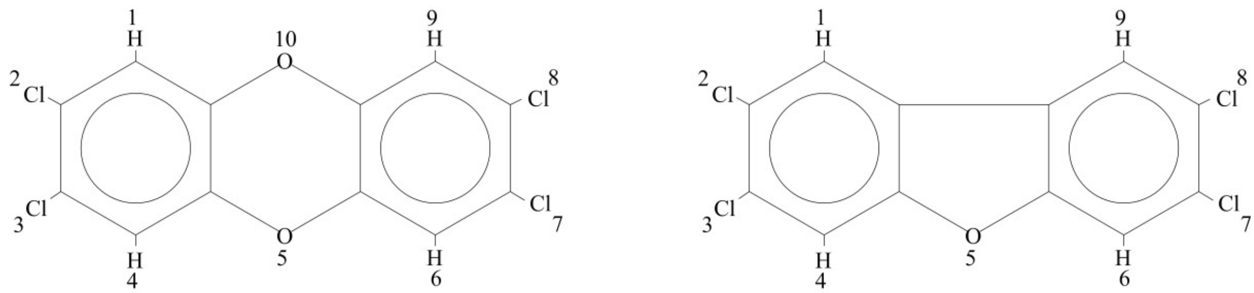
WHAT ARE “DIOXINS“?

“DIOXINS” have become synonymous with environmental and health risks caused by extremely toxic POP Persistant Organic Pollutants ever since the chemical reactor accident in Seveso in 1976 and the subsequently published book “Seveso gibt es überall” (“Seveso is everywhere”).

POLYCHLORINATED DIBENZODIOXINS (PCDDS) AND POLYCHLORINATED DIBENZOFURANS (PCDFS) – often simply referred to as “dioxins” and “furans” – can be found in the natural environment in varying concentrations, also in the atmospheric emission of incineration and smelting processes, in filter dust, cigarette smoke, in areas affected by bush and forest fires, in ambient and indoor air, in agriculturally used soil, in food, and even in human fat tissue.

DIOXINS AND FURANS are present in wastes such as residual municipal waste and sewage sludge and are usually destroyed during incineration. However, they can reappear in small concentrations during the cool-down phase following incineration (“de novo synthesis”) and thus in the atmospheric emission from the stack.

Chemical structure of PCDD and PCDF



2,3,7,8 – Tetrachloridibenzo-o-Dioxin

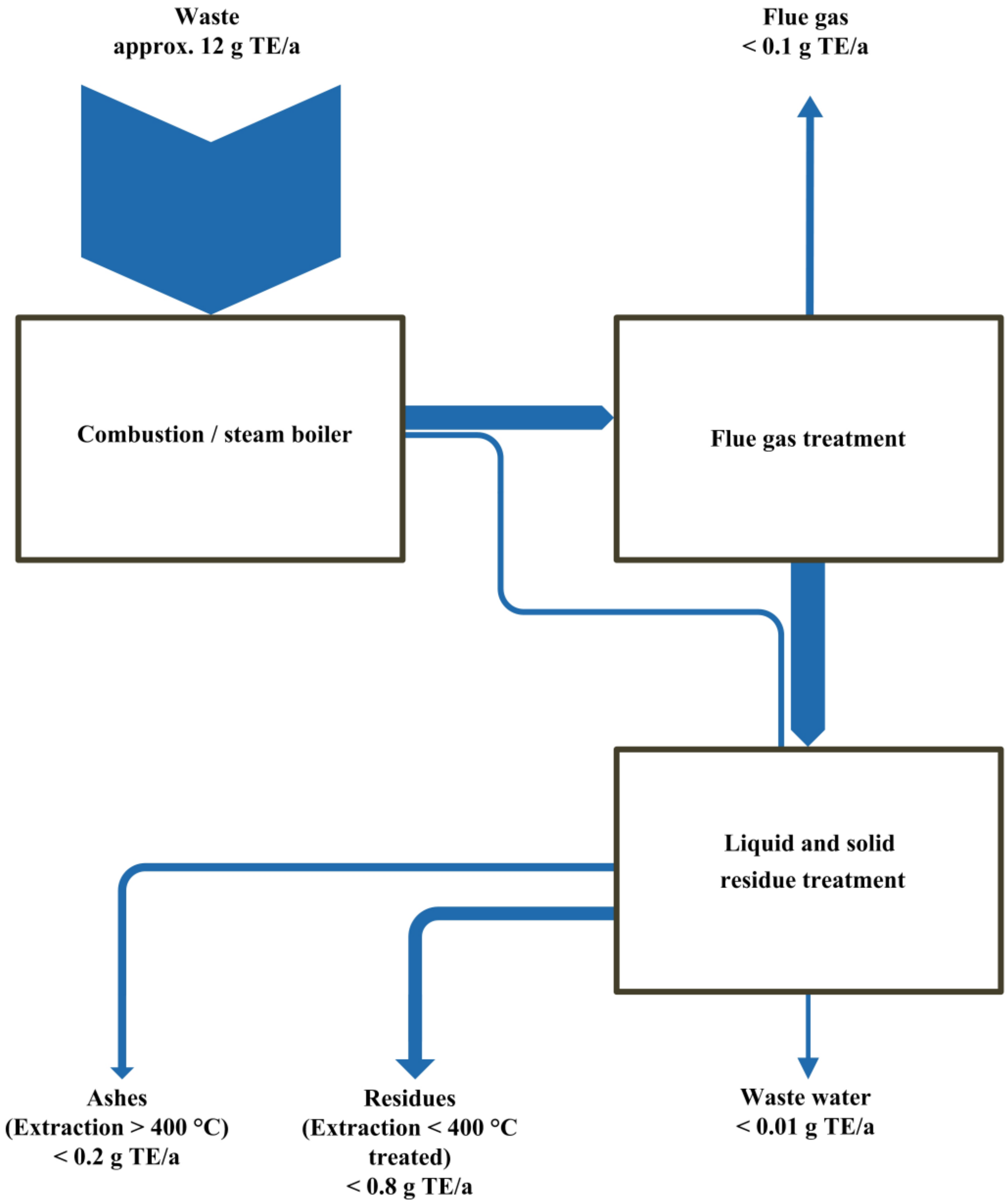
2,3,7,8 – Tetrachloridbenzofuran

Source: Umweltbundesamt, 2006

"DIOXIN VALUES" are indicated using an internationally accepted toxicity model which compares and evaluates the toxicity of the individual isomers against the 2,3,7,8-tetrachlorodibenzo-p-dioxin.
The legal limit value for emissions of dioxin and furan compounds of 0.1 nanograms of TE per standard cubic meter relates to the weighted figure for toxicity equivalents (TE). One nanogram (ng) is one billionth of a gram, or 0.000000001 grams. The emission limit for “dioxins” is also the reference parameter for halogenated and non-halogenated organic substances of a higher molecular weight such as PCBs (polychlorinated biphenyls), PAHs (polycyclic aromatic hydrocarbons) and possibly other POPs.

Illustration of a mass balance of „dioxins“ of a state of the art waste incineration plant

Figures in g TE/a (= toxicity equivalent per year)



The sum of the dioxin emissions is just a fraction of the amount of dioxin contained in non-treated waste

Source: UV&P, 1994

THE HEALTH RISKS OF TOXIC COMPOUNDS are evaluated with the utmost care. Due to the known effects, the formation and release of these compounds should largely be minimized as a precaution. To this end, legislators have issued stringent emission limits for these substances. As far back as 1988, Austria was the first country in the world to set a limit value for total “dioxin emissions” from waste incineration plants. Due to technological progress, dioxin emissions from waste incineration plants have been reduced by a factor of 1,000 (!) since 1980.

Thermal waste treatment plants operating according to the state of the art could be called “dioxin destruction machines” or “dioxin sinks”, since they destroy more dioxins than they produce.

It is now understood that many other processes such as iron and steel making, nonferrous heavy metal recycling (e.g. copper and aluminum) and uncontrolled combustion processes (e.g. forest fires and domestic fuels) can be significant dioxin sources. In the past, a substantial share of “dioxins” was also introduced via various products and chemicals (e.g. wood protecting agents, plant protection products, defoliants such as “Agent Orange”, chlorine-bleached pulp and paper, household detergents containing hypochlorite, etc.).

From an environmental protection perspective, waste co-incineration in household burners and unsuitable industrial facilities must be prohibited, since they create much higher emissions! The burning of residues from agriculture and forestry also creates a large amount of emissions and should be avoided to minimize the emission of air pollutants.

Example: Dioxin emissions in Germany per year measured [g TE]

	1990	1994	2000
Metal recovery and processing	740	220	40
Waste incineration	400	32	0.5
Power plants	5	3	3
Industrial furnaces	20	15	< 10
Domestic fuel burners	20	15	< 10
Vehicles	10	4	< 1
Crematories	4	2	< 2
Total emissions into the air	1,200	330	< 70

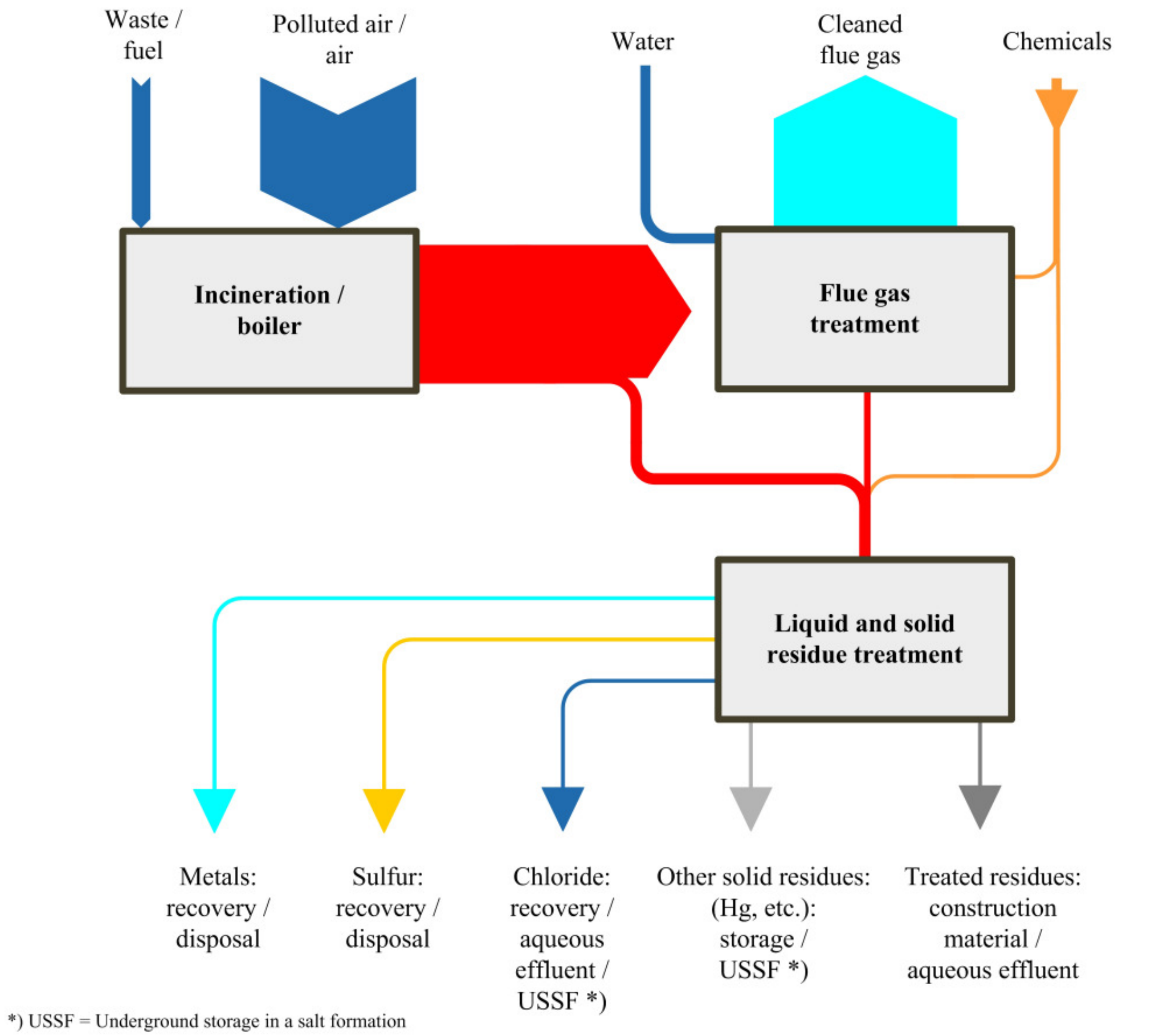
Source: BMU 2005

MEASUREMENTS OF ENVIRONMENTAL “DIOXINS” in recent years showed a remarkable reduction in Austria – an indirect confirmation of the success of the efforts undertaken to minimize "dioxin emissions". However, during winter months, higher air pollution figures suggest that domestic fuel burning is the main source of the remaining current dioxin burden in Austria.

WHAT ARE THE RESIDUES OF WASTE INCINERATION?

THE COMPOSITION OF THE WASTE AND FUELS USED, as well as that of the incineration gas and the required additives, engenders flows of inorganic substances, which are recoverable to a greater or lesser degree depending on the processes and type of technology used.

Main flows in waste incineration



Source: UV&P, 1996

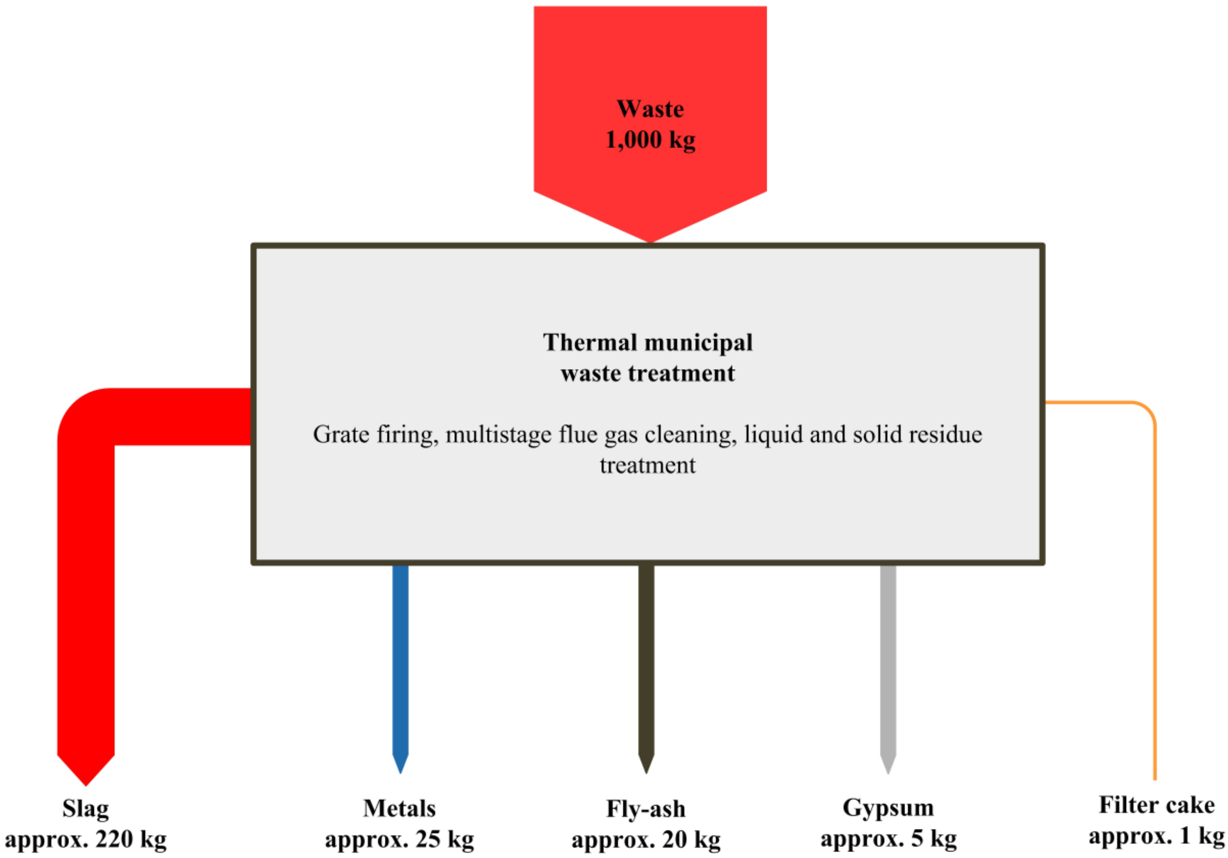
A SIGNIFICANT SHARE OF SOLID RESIDUES FROM INCINERATION can be recovered for recycling (e.g. metals or gypsum), and some are of sufficient quality to be used as construction material (e.g. stones and sand from the fluidized-bed, sintered slag, sintered ashes as a glasslike granulate).
By concentrating inorganic substances in certain residue streams (e.g. particulate matter or filter cake with an increased heavy metal content), they can be prepared for mechanical treatment for the sake of recovery, or at least for proper landfill disposal.

It is generally expedient to store certain residues separately for future use if the amounts involved and the prevailing economic conditions make such use economically viable. In the future, suitable processing technologies will make it possible to recycle all residues or deposit them in Austrian surface landfills as non-hazardous, immobilized waste.

1. EXAMPLE OF RESIDUES FROM WASTE INCINERATION

RESIDUAL WASTE CONSISTS OF HUMIDITY (water content of approximately 20% - 25% in Central as well as Western and Northern Europe), combustible components (approximately 45% - 50%) and ash (approximately 25% - 30%). The solid residues from residual waste incineration only make up 25% - 30% of the weight of the untreated residual waste. Owing to the relatively high density of these residues, the landfill volume required is only 10% of the original volume.

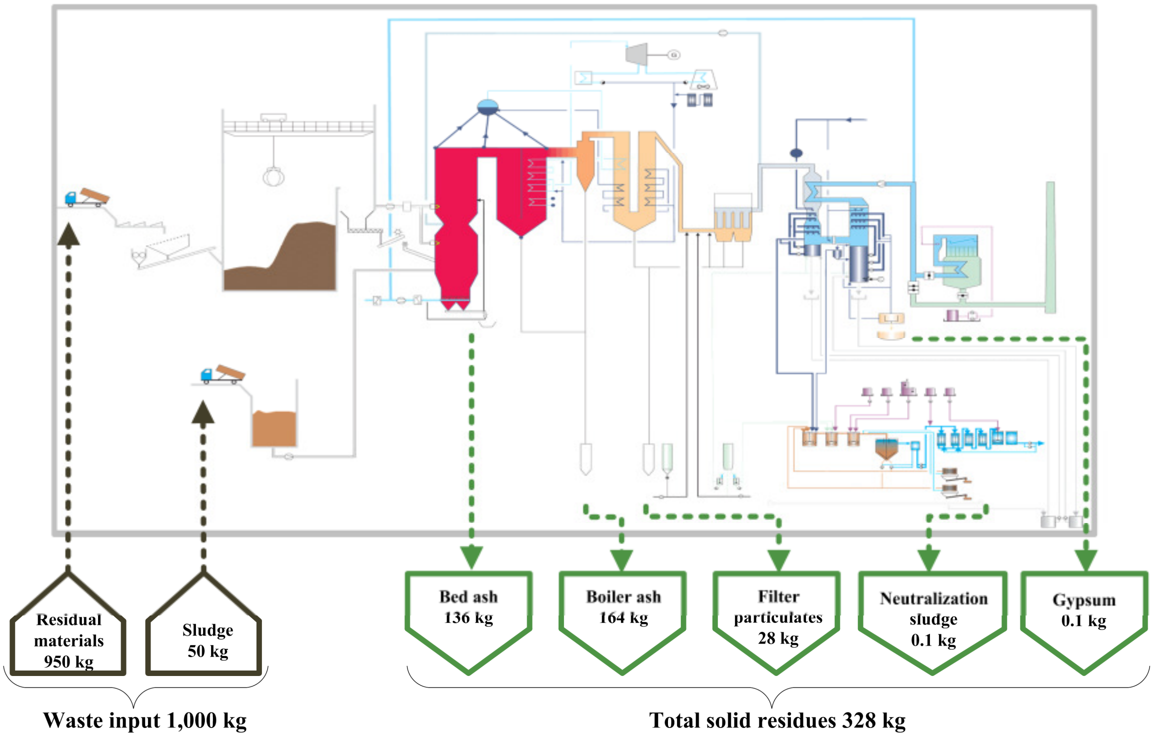
Solid residues from a grate incineration plant for incineration of municipal solid waste



Source: UV&P, 1999

Specific mass flows of a fluidized bed combustion / example WTP Niklasdorf

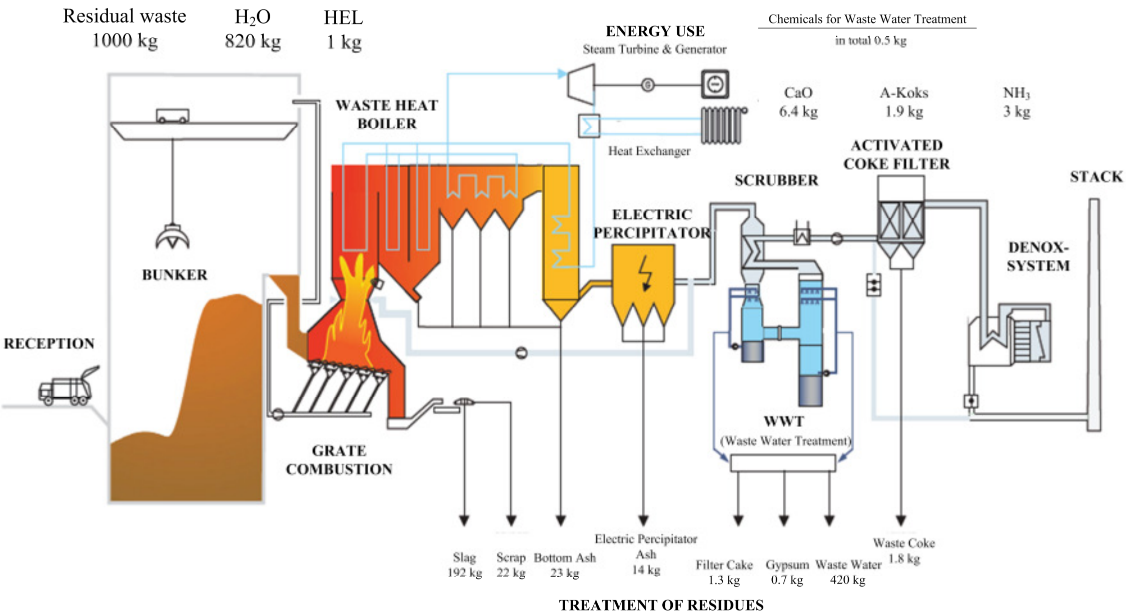
Average values of the year 2014 based on 1 t of waste fuel incl. sewage sludge; annual throughput: approx. 110,000 t



Source: Enages, Abfallbilanz 2014

Specific mass flows in a grate system / example WTP Pfaffenau, Vienna

Average values of the year 2014 based on 1 t of residual waste; annual throughput: 233,150 t residual waste



Source: WKU (Wiener Kommunal-Umweltschutzprojektgesellschaft mbH), Vienna, 2015

The type and amount of solid residues from fluidized-bed incineration depend on the waste used and on the process design of the plant.

2. TREATMENT OF RESIDUES CLASSIFIED AS HAZARDOUS WASTE

BY LAW, hazardous waste in Austria has to be landfilled underground as of 16 July 2001, unless special declassification is granted for landfill disposal in accordance with the Waste Management Act. In particular, this concerns residues from flue gas cleaning using waste-water-free processes, which have a higher concentration of water-soluble salts, and their permanent disposal in massive underground salt caverns that are naturally watertight (e.g. available in Baden-Württemberg, Germany).

Example for the backfill of underground caverns in massive salt formation with inorganic hazardous waste material packed in big bags. The space to the ceiling is backfilled with "waste rock" from mining by a belt slinger machine.

THEIR USE AS "BACKFILL" is both technically and legally separate from permanent underground disposal. In order to reduce the risk of rock burst and surface subsidence, the mining authority requires former mining sites to be backfilled.

The following technologies can be used for backfilling:

Hydraulic backfilling: Dusty, fluid and pasty components are processed into packing for paste backfilling. This packing is pumped through pipelines into prepared, underground mining caverns. Once the packing has hardened, it will support the overburden.

Backfilling using bulk material: Waste whose characteristics allow it to be used directly for backfilling without prior treatment is transported to the backfilling sites by way of a container system. The bulk material is filled directly into the caverns using loaders.

Mechanical backfilling using big bags: Certain types of waste are filled in big bags and conditioned by adding a binding agent or liquids, depending on mechanical strength requirements. The finished backfilling products are then used to backfill cavities with an official backfilling requirement.

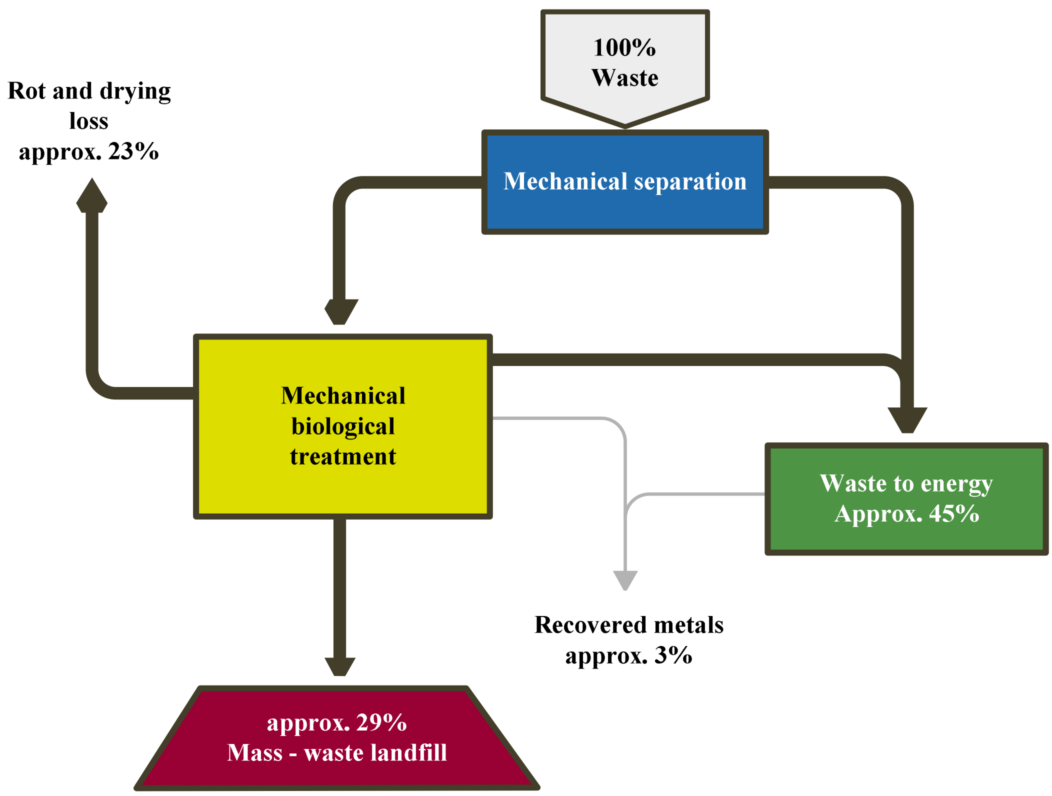
There is potential for innovation in more efficient integrated processes for further treatment and utilization of residues from waste treatment (even within Austria).

- Further development and application of processes for a more efficient treatment of hazardous residues from thermal and metalworking plants (usually sporadic heightened eluate values) through specific treatment with mineral additives. In this regard, long-term effective financial incentives should be considered, e.g. in landfill taxation, grants for innovative investments and demonstration plants. Any all-inclusive solution for the problem of thermal treatment and recycling of wastes must include integrated recovery and treatment of residues.
- The development of new processes for thermal treatment and recovery of low-calorific wastes (especially municipal solid waste), sewage sludge and residues from scrap processing. In scrap processing, solutions and technologies should be developed that include material stream-specific management with as complete a recovery of all metals as possible. This will facilitate the recovery of metals from slag and ashes generated by waste incineration, or separation from the other waste upstream of the incineration process.

IS MECHANICAL-BIOLOGICAL WASTE TREATMENT (MBT) AN ALTERNATIVE?

UNDER CERTAIN CONDITIONS AND WITH VARIOUS LIMITATIONS, the Austrian Landfill Ordinance 2008 also permits the incorporation of mechanical-biological waste treatment operations prior to landfilling of treated residues, thereby complementing the necessary thermal treatment. Suitably treated low-calorific and biologically stabilized residues can be deposited in separate cells of so-called "mass-waste" landfills even if the 5% TOC limit value is exceeded, provided the calorific value is less than 6,600 kJ per kg dry substance and other requirements (specifically bio-stability parameters) are observed.
A multitude of differing concepts for mechanical-biological waste treatment have been proposed throughout the years. In many cases, due to abundantly available cheap landfill capacity, the operators of MBTs aim to maximize the portion of waste being landfilled and to minimize the portion to be subjected to thermal treatment ("classical" MBT concept).

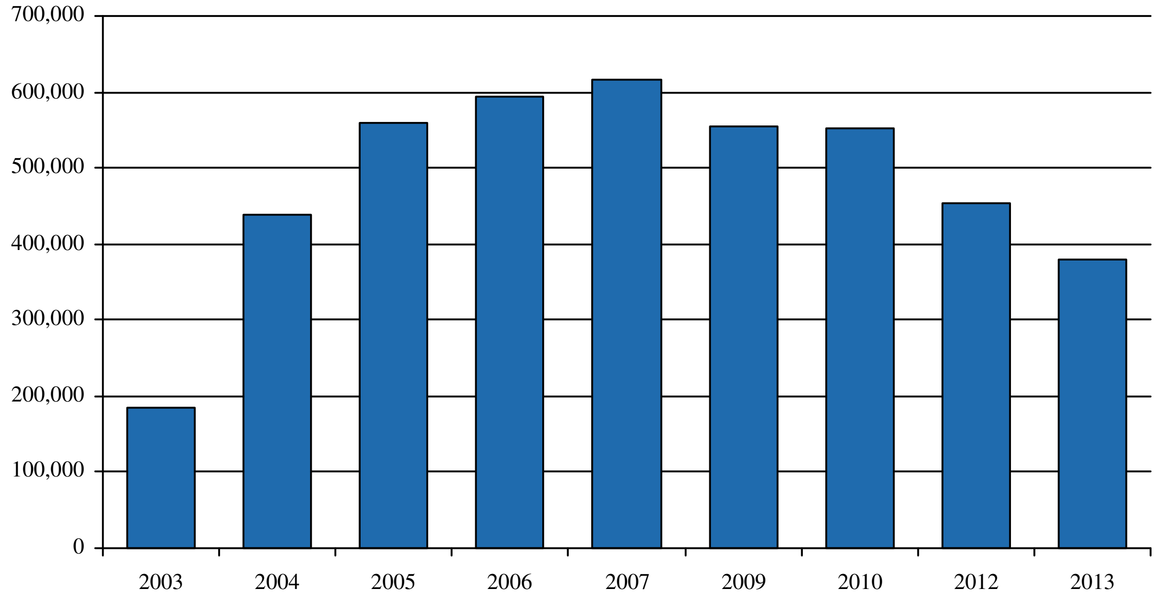
Distribution of mass flow in „classical" MBT plants in Austria



Source: Umweltbundesamt, 2006

Development of the total input in Austrian MBT plants in the reference period 2003 to 2014

Figures rounded to 1,000 t per year



Source: UV&P, 2015

BY MODIFYING THE "CLASSICAL" MBT CONCEPT, operations have been introduced with an integrated drying stage as a prerequisite for efficient separation of waste fractions for recycling, waste fuel and inert fractions. Plants utilized for these purposes were built especially in Germany (Herhof system). For mechanical and mechanical-biological procedures, fundamental distinctions can be drawn between:

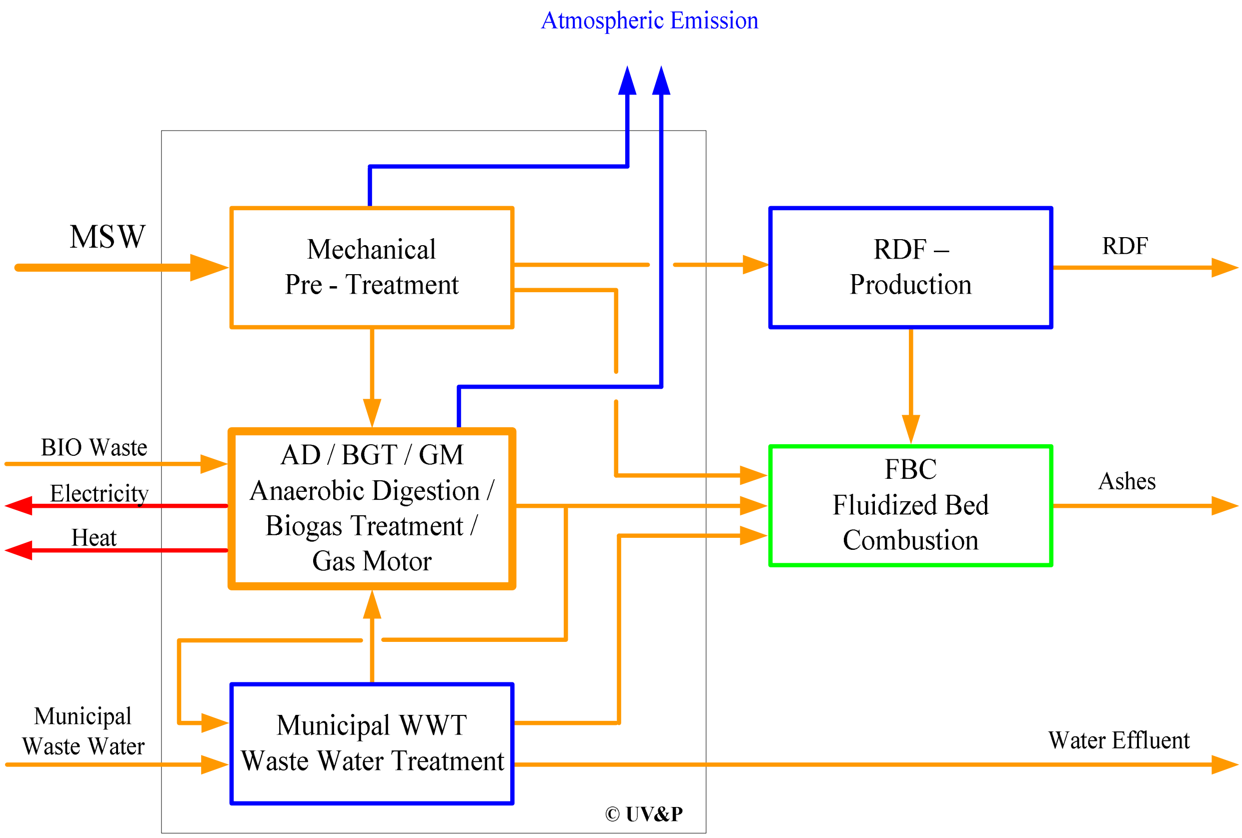
- procedures that are intended to produce a stabilized disposable fractions once the high-calorific waste fractions have been recovered (mechanical-biological waste treatment, MBT)
- procedures that are intended to produce high-calorific wastes for energy recovery through biological drying with subsequent dry mechanical processing, resulting in almost negligible residual mass for landfill (mechanical-biological stabilization, MBS)
- procedures in which high-calorific waste fractions are recovered from municipal waste and processed for energy recovery only through mechanical and physical operations (mechanical physical stabilization, MPS; mechanical waste treatment) (VDI, 2006).

THE MINIMUM REQUIREMENTS for mechanical-biological waste treatment have been defined in the Guideline for the Mechanical-Biological Treatment of Waste (Federal Ministry of Agriculture, Forestry, Environment and Water Management 2002). For IPPC plants (i.e. plants with a treatment capacity exceeding 17,500 tons p.a.) the BAT Reference Document Waste Treatment Industries of the European Commission must also be consulted.
The mechanical and biological treatment of residual waste requires suitable multistage exhaust air cleaning, and, therefore, a completely closed system with effective airflow management must be implemented with a cascade-like use: In the delivery area, fresh air is drawn into the system, passes through the mechanical processing area and will be used finally for the intensive rotting process. Exhaust air treatment comprising de-dusting in a filter, a wet scrubber to remove ammonia and a post-combustion of the organic pollutants (typically in a so-called thermal regenerative system). Alternatively to combustion, large bio-filters could be considered (if the necessary Environmental Impact Assessment will allow for the acceptance of residual odour emission). By recirculation and other measures such as using tightly closed rotting tunnels instead of rotting

halls, the total exhaust air volume is reduced as much as possible. In practice, a "classical" MBT – not including the exhaust air volume from the post-rotting process – can achieve a specific atmospheric emission volume of less than 8,000 m^3 per ton of waste (which is already significantly more in total than a state-of-the-art waste-to-energy plant based on grate or fluidized bed technology).

It must also be taken into account that persistent organic pollutants are generally not destroyed in a MBT process, thus the remaining (reduced) landfill gas formation potential, and some potentially hazardous emissions by leachate must be expected.
The generally poor overall energy balance from MBT can be somewhat improved (in addition to the recovery of RDF) by the treatment of the predominately organic wet fraction in an anaerobic process to produce biogas and to ultimately incinerate all solid residues for recovery of energy as indicated in the following process scheme.

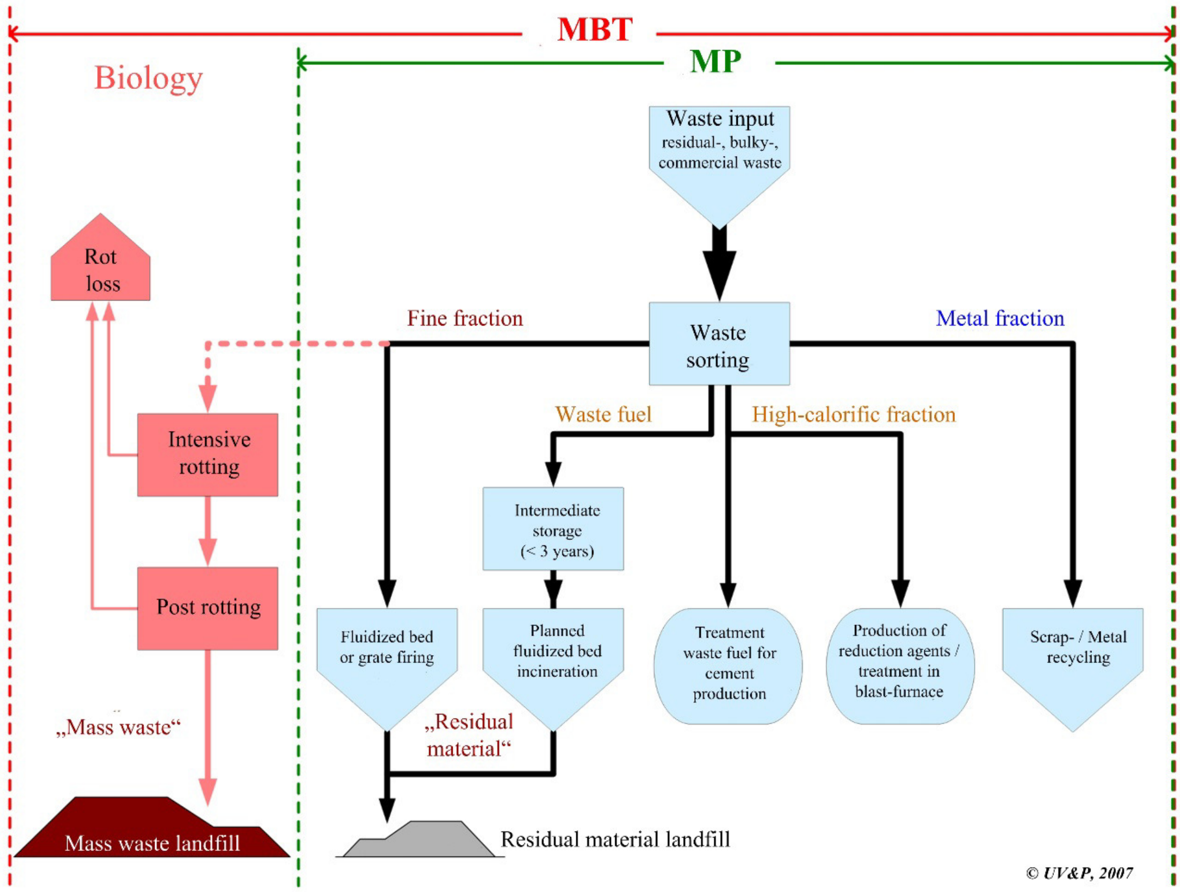
Technical scheme of a MBT plant with RDF production and incineration of digestate



Source: UV&P, 2014

According to advanced experience in Central Europe mechanical soild waste separation and processing – without biological treatment – can be advantageous in terms of energy efficiency and minimization of emissions as illustrated in the next scheme by comparison of MBT and MP (mechanical processing only for subsequent thermal processes).

Alternative concept for municipal waste treatment by mechanical - biological treatment (MBT) and mechanical processing (MP) only



Source: UV&P, 2007

PURELY AEROBIC PROCEDURES FOR RESIDUAL MUNICIPAL WASTE EXHIBIT BASIC SHORTCOMINGS in terms of the energy efficiency of the various MBT concepts, since the energy content of the organic substance is converted into something that cannot be used. The integration of a fermenting stage to make the energy content of biomass partly recoverable can help to improve the economic and ecological situation of these plants (SRU, 2008).

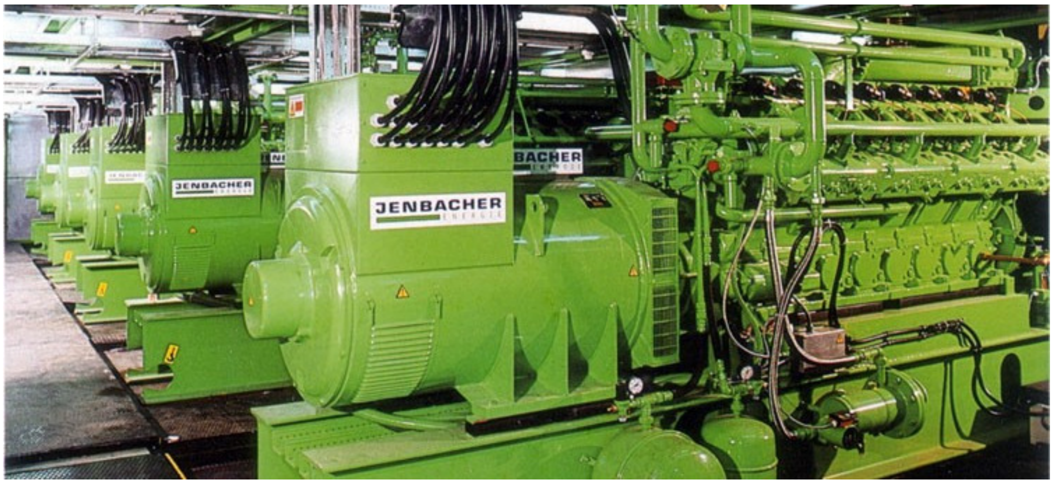
Against the implementation of the legal landfill prohibition in Austria from 2004 onwards, MBT initially became an important factor for residual waste disposal in those regions with excess landfill capacity and lack of demand for thermal energy utilization from waste incineration, or lack of political acceptance. However, the importance of classical MBT for residual municipal waste treatment in Austria will likely decrease further in the future compared to waste-to-energy with its higher resource and energy efficiency and minimization of greenhouse gas emissions.

COULD LANDFILLS WITH UTILIZATION OF BIOGAS BE A VIABLE ALTERNATIVE FOR WASTE DISPOSAL?

DUMPING AND LANDFILLING OF WASTE has become known as the most polluting and most "waste-full" option in the management of natural resources and end-of-life products. However, the disposal of solid waste to well-engineered landfills with bottom liners for collection and further treatment of leachate from disposed waste, the mechanical compaction of the disposed solid waste by a heavy compactor, the installation of a technical system for extraction of landfill gas and a closing cap of the landfill are seen as better options compared with open dumping and obvious, visible environmental pollution by the spreading of light waste materials by wind, visual smoke from random fires, and serious contamination of surrounding surface and underground aquifers.

1. RECOVERY OF BIOGAS FROM LANDFILLS WITH ORGANIC WASTES

ACCORDING TO PAST EXPERIENCE IN AUSTRIA about 200 m³ of biogas per ton of municipal waste can be expected from landfill operation within a maximum period of about 30 years. However, due to the necessary open area for waste disposal activity and incomplete sealing of the landfill only about 40% of the landfill gas can be recovered (composition of landfill gas see Appendix A4).



Recovery of landfill gas from the old municipal landfill in Vienna allows for production of 7.908 kWh electricity per hour, i.e. approx. 60 million kWh per year.

THE AVERAGE CALORIFIC VALUE OF LANDFILL GAS is approximately 6 kWh per m³, thus yielding approximately 480 kWh or 1,700 MJ per ton of waste. Therefore, the maximum energy recovery through such landfill operation is about a factor of 5 to 6 below the calorific value available for the waste-to-energy option by incineration according to state of the art.

2. RECOVERY AND TREATMENT OF LEACHATE FROM LANDFILLS

TREATMENT OF LEACHATE FROM LANDFILLS WITH MIXED WASTES (e.g. municipal solid wastes) is one of the most challenging tasks for purification of any waste water.

According to experience the most effective technology for treatment of leachate is based on reverse osmosis, which is a filtration process through a technical membrane. It allows for the removal of more than 99.9 % of organic and inorganic pollutants, as well as ammonia. The cleaned permeate can be discharged at requested quality standards directly into a river or used for irrigation purposes in agriculture. The concentrate (with the retained hazardous organic and inorganic pollutants) needs further treatment, which is special incineration according to state of the art (e.g. in kilns for hazardous waste incineration or cement clinker production).

Treatment of 60 m3/d leachate in reverse osmosis plant in Kusadasi, Turkey

The reverse osmosis process is a purely physical process which requires about 10 to 15 kWh electricity per m^3 of leachate for the necessary high pressure of about 60 bar (in special reverse osmosis plants with two stage systems up to 150 bar) in order to facilitate the filtration process through the technical membranes. Another significant adavantage of this process is that no chemicals are needed in the treatment process, which would cause emissions in their production as well as in final disposal.

The capacity of individual plants for fully automated treatment of leachate can vary between 0.4 and 50 m^3 per hour, based on pre-manufactured standard systems and built-in standard ISO-containers.

Example for cleaning efficiency for permeates compared to leachate

Parameter	Leachate inflow values	Discharge outflow values
COD (Chemical Oxygen Demand)	50,000 mg/l	< 50 mg/l
BOD_5 (Biological Oxygen Demand)	40,000 mg/l	< 15 mg/l
Total N (Total Nitrogen, incl. NH_3-)	3,000 mg/l	< 10 mg/l
SS (Suspended Solids)	1,500 mg/l	< 1 mg/l

Source: www.rotreat.at, 2010

3. ENVIRONMENTAL RISKS FROM LANDFILLS AND AFTER-CARE FOR BIOCHEMICALLY REACTIVE WASTES

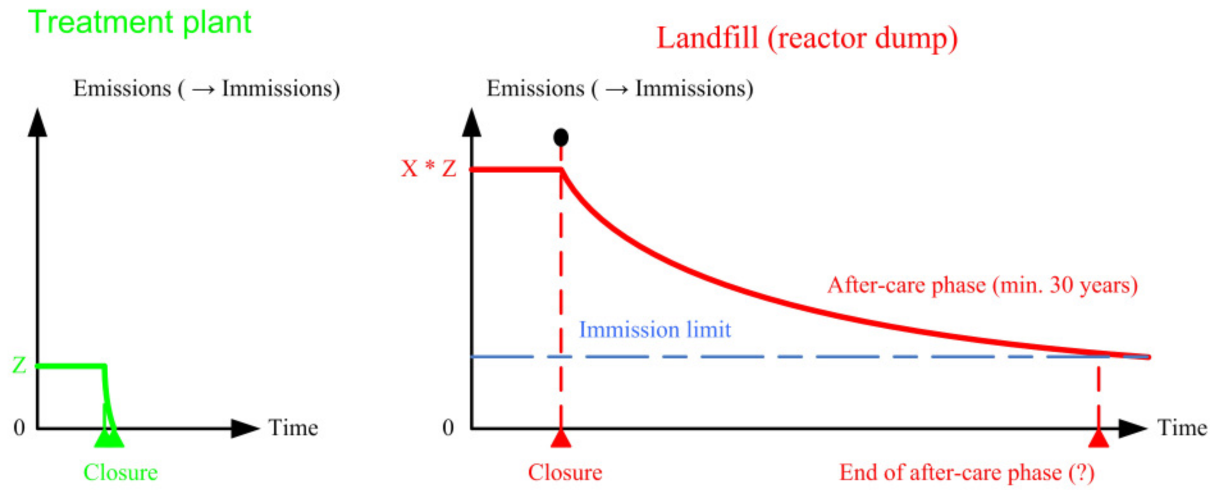
EMISSIONS FROM "WASTE DUMPS" AND LANDFILLS primarily occur in the form of contaminated leachate, bio-aerosols, odours, dust, and gaseous pollutants, which are difficult to control. Therefore, this type of landfill is a nuisance and requires placement far from nearby residential areas, including restrictions on land use in the proximity of such sites. Furthermore, over longer periods, there is also a latent risk of failure of the technical sealing systems both at the bottom and on the surface, as well as failure of collection and treatment of leachate and landfill gas (including emissions of gases with potential for damage to the ozone layer, for contribution to the development of ground-level ozone and to the greenhouse effect).

The Key-Messages according to ISWA International Solid Waste Association on "WASTED HEALTH – THE TRAGIC CASE OF DUMPSITES" include (ISWA 2015):

- Dumpsites are a global problem. They receive roughly 40 % of the world's waste and they serve about 3.5 – 4 billion people.
- Although there is a lack of systematic long-term epidemiological studies that fully document the health impacts from dumpsites, the existing scientific evidence demonstrates very important health risks.
- The health problems associated with dumpsites are related to their emissions, which usually involve POPs (persistent organic pollutants), heavy metals and VOC (volatile organic compounds). The actual health risk depend on the practices followed and on the type of the waste disposed in each dumpsite, as well as environmental and social conditions of the area.
- Open burning and animal feeding increase the health risks substantially, the first by direct emissions of dangerous pollutants and the second by transferring the pollutants to the food chain.
- Uncontrolled disposal of hazardous and healthcare wastes as well as manual on-site treatment and disposal of e-waste by informal workers result in important increases of all the health risks and the negative environmental impacts.
- ISWA calls upon international organizations, governments and local authorities to develop emergency programs that will identify the riskiest dumpsites and proceed with their closure. ISWA considers the closure of the dumpsites as a global health emergency and it will work closely with all the involved stakeholders to accelerate programs, initiatives and investments that will result in a world free of dumpsites.

THE FOLLOWING GRAPHS ILLUSTRATE THE DEVELOPMENT over time for emission of pollutants from state of the art waste treatment plants and from reactor dumps (landfill), including the after-care and post closure phase, until acceptable exposure limit values for pollution of water, ground and air have been achieved without further technical precautions or measures.

Emission concentrations and after-care for waste disposal plants



Parameter	Küpelbeck & Ehring (2000)	Heyer et al. (1997)	Kruse (1994)	Belevi & Baccini (1989)
C_{org}				500 - 1.700
CSB	65 - 320	80 - 360	280	
Cl	25 - 130	90 - 250	210	100 - 150
AO_X	40 - 100	30 - 120		

Source: Data from literature on after-care time for the landfill of mixed solid waste (numbers given in years)

4. SITE SELECTION OF NEW SITES FOR CONTROLLED LANDFILLS

SOME BASIC REQUIREMENTS OF LANDFILL SITES have been defined in appendix I of the EU Directive 1999/31/EC on the landfill of waste. In Austria, the requirements for landfill sites, as well as for design and operation of landfills are specified in the 2008 Landfill Ordinance (Federal Law Gazette II 2008/93). According to this ordinance, the following factors have to be taken into consideration when selecting the location of a landfill site:

- the distances from the outer limits of the landfill site to residential and recreational areas, surface waters and other agricultural or urban areas
- the presence of ground water or nature reserves in the area
- the geological, hydrological and geo-technical conditions in the area
- the risk of flooding, subsidence, landslides, mudflows or avalanches at the site
- the protection of the natural or cultural heritage of the area.

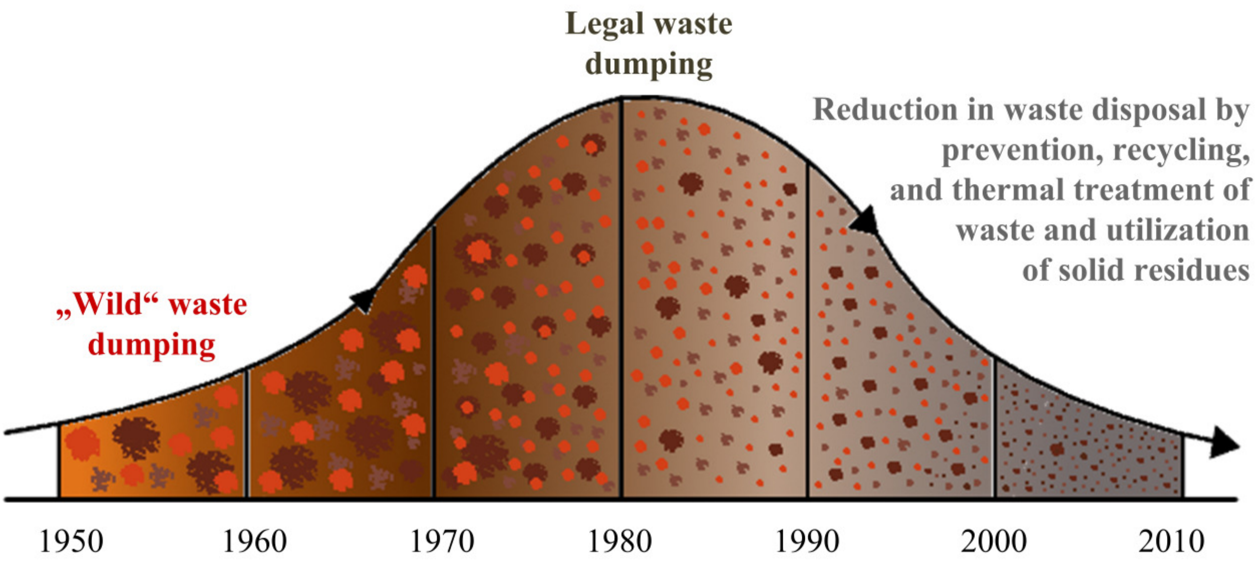
IN ADDITION to the above-mentioned factors, restrictive specific requirements for landfill sites according to the type of landfill defined in the 2008 Landfill Ordinance must be observed.
Based on many years of experience in Austria, the acceptance of a new landfill site in a region cannot be expected if already existing landfills are being perceived as environmental hazards and nuisance. For this reason, the securing and remediation of an existing landfill problem should be considered a priority. This could then also include the exploitation of additional landfill volume.

5. LEGAL RESTRICTIONS ON DISPOSAL OF ORGANIC WASTES IN LANDFILLS

FOR ECOLOGICAL AND WASTE MANAGEMENT REASONS, new landfills for waste exceeding 5% (TOC) have been banned by law since 1 January 1997 in Austria, similar to Switzerland and the Federal Republic of Germany. Waste of this kind was only allowed to be deposited in already existing landfills until 1 January 2004, or in exceptional cases, until 31 December 2008 at the latest by Decree of the regional State Governor. Some restricted exceptions from the landfill-ban for exceeding 5% TOC (by mass) are granted for mechanically-biologically pre-treated waste below a certain calorific value and specified biological stability criteria for disposal in a separate section with appropriate design and operational mode ("mass waste landfill").

THE FOLLOWING ILLUSTRATION INDICATES the reduction of waste disposal in landfills per year and change in quality of materials throughout the development of waste management in the last decades in Austria.

Waste disposal quantities in Austrian landfills



Source: UV&P

WHAT DOES WASTE INCINERATION IN A GRATE FIRING PLANT COST?

THE COSTS OF THERMAL WASTE TREATMENT depend essentially on the following specific site-related features: waste composition, already available technical infrastructure, competence in process and plant engineering, thermal output capacity of the incineration plant and, lastly, costs of residue disposal.

1. INVESTMENT AND OPERATING COSTS

ANALYSIS AND COMPARISON OF VARIOUS, already implemented residual waste incineration projects have shown that the financing costs and, hence, the investment costs combined with the chosen interest rates and depreciation period are the biggest factor in determining treatment costs per ton of residual waste.

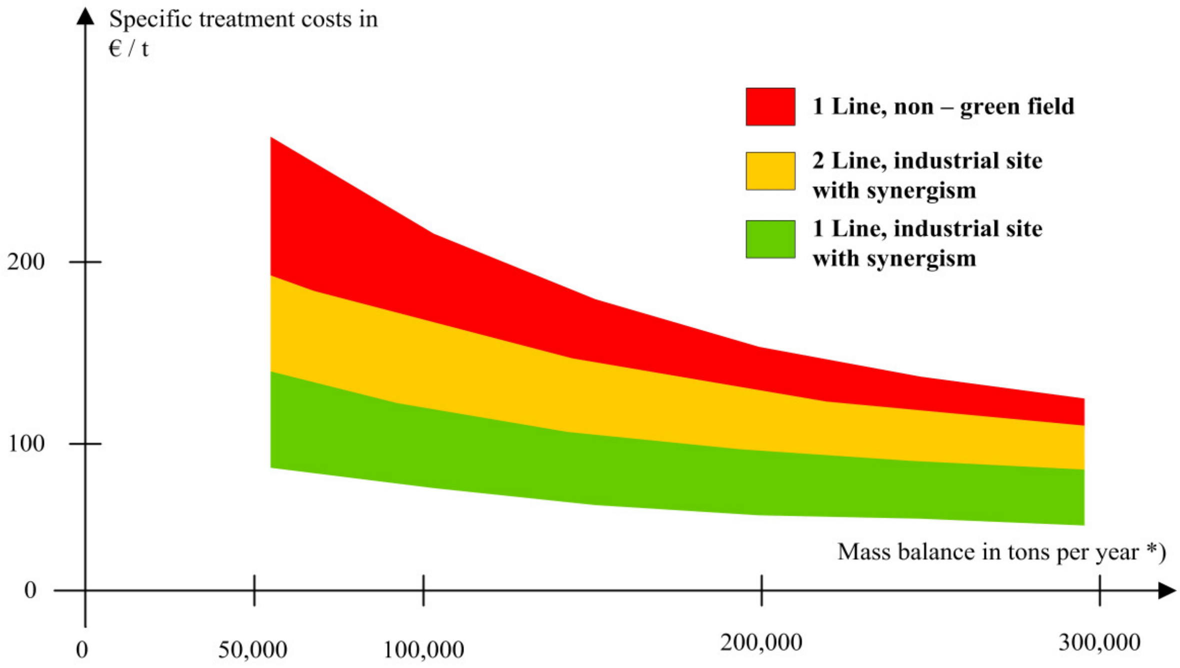
The choice and design of the process technology primarily affect treatment costs through the plant investments required and secondarily through the expected operating costs. The choice of a site - in addition to plant size - can also significantly influence investment costs. Considerable reductions can be achieved by using infrastructure already in place and ensuring economically efficient, year-round heat utilization.

2. TREATMENT COSTS

MODEL CALCULATIONS AND EXPERIENCE HAVE SHOWN that - compared to larger plants without such site-related advantages - treatment costs of under 100 Euros per ton of residual waste can be achieved even with small plants (approximately 80,000 to 100,000 tons per year) if the site can avail of an already existing infrastructure and year-round heat utilization is guaranteed.
As the plant is designed to produce heat from fuel, the throughput of a thermal waste treatment plant depends essentially on the mean calorific value of the waste-derived fuel used. In a plant running at full capacity, this means that an increase in the calorific value leads to a reduction in waste throughput. As a consequence, the higher calorific value causes the specific costs per ton of waste to rise as well.

A SIMPLE COMPARISON: compared to brown coal with a low calorific value, only half as much anthracite (double calorific value) is needed to heat a flat. In this way, the throughput is halved while the amount of heat stays the same.

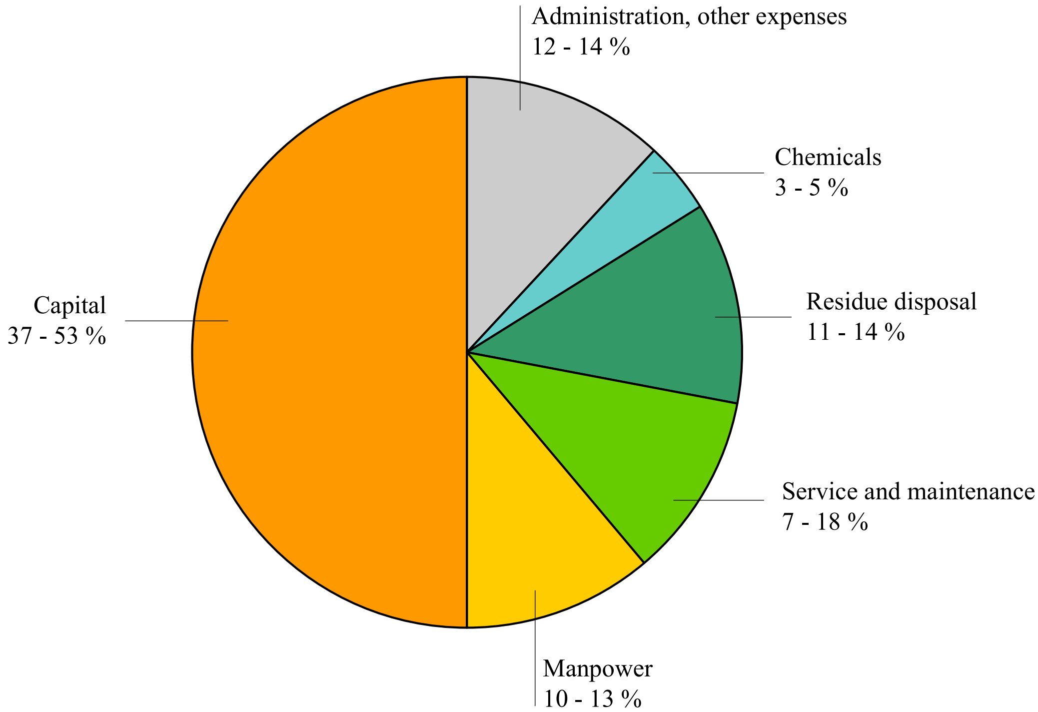
Specific treatment costs as a function of size and location



*) based on average calorific value of approx. 10 MJ / kg and annual operation of 8,000 h

Source: UV&P 1992

Composition of specific costs for incineration of municipal solid waste



Source: UV&P, Model calculation 2008

3. RUNNING THERMAL PLANTS CONTINUOUSLY AT FULL CAPACITY

THERMAL PLANTS have a different economic rationale than landfills. In the past, economic efficiency was achieved by completely filling the landfill over several years of operation. This was done irrespective of whether small or large amounts of waste were obtained on a specific day, month, or an individual year. The installed and, thus, available firing capacity of a thermal plant (MW) can only be used by continuously feeding it with waste-derived fuel (the consistent amount of fuel fed into the system in kg/s multiplied by the calorific value in MJ/kg yields MJ/s = MW).
The fact is, however, that fixed costs in thermal waste treatment (investment costs, including interest, staff, administration) make up some 80% of the total costs.

WHEN CAPACITY UTILIZATION IS REDUCED, the specific costs per ton of waste rise considerably. The situation becomes more serious when plants with energy supply commitments are compelled to procure fossil fuels - due to bottlenecks in waste supply. It is, therefore, highly expedient economically to maintain a certain minimum contingency stock of waste-derived fuel in appropriate form in order to bridge seasonal fluctuations in the supply of waste and have a (limited) fuel reservoir available. Contingency stocks have the positive ancillary effect of ensuring availability of storage capacities for deliveries made during operational downtime (e.g. during plant overhauls).

4. COSTS OF WASTE INCINERATION COMPARED TO COSTS FOR REMEDIATION OF CONTAMINATED SITES

EXPERIENCE IN AUSTRIA has shown thermal waste treatment costs less than ex-post measures taken to safeguard and remediate contaminated sites.

THE REMEDIATION OF THE SO-CALLED “FISCHER” LANDFILL in Lower Austria is an example thereof:
The inspection, removal and transport to other landfills as well as the incineration of small amounts of hazardous wastes subsequently cost EUR 130 million or some 140 Euros per ton of deposited and removed waste; overall 932,564 tons. These costs for the treatment of a contaminated site also include the excavation and disposal of some 700,000 tons of contaminated underlying material.

CAN WASTE FROM OTHER EU MEMBER STATES BE TREATED IN AUSTRIAN PLANTS?

ON ONE HAND, the technical possibilities in order to ship waste must be available, and on the other, an economic incentive to ship waste must be given. From an economic viewpoint, the comparably high environmental technology standards of thermal waste treatment in Austria tend to cause high prices. This is an indication that waste shipments from Austria (exports) - and not waste shipments to Austria (imports) - are to be expected. In order to ensure a high standard of protection for the environment and environmentally sound waste management, civilized societies need legal framework conditions, including detailed information for all stakeholders, monitoring and effective implementation measures. From the viewpoint of environmental protection, the shipment of waste for incineration in countries that landfill most of their own combustible wastes (particularly residual municipal waste) should be called into question and stopped.

Municipal waste quantities and type of treatment in selected European countries

	Waste quantity per person (kg/a)	Type of treatment (share in %)			
		Landfilling	Incineration	Recycling	Composting
EU	481	31	26	28	15
Belgium	439	1	44	34	21
Bulgaria	432	70	2	25	3
Czech Republic	307	56	20	21	3
Denmark	747	2	54	28	17
Germany*	617	0	35	47	17
Estonia	293	16	64	14	6
Ireland	586	42	18	34	6
Greece	506	81	0	16	4
Spain	449	60	10	20	10
France	530	28	34	21	17
Croatia	404	85	0	14	2
Italy	491	38	21	26	15
Cyprus	624	79	0	12	9
Latvia	312	83	0	11	6
Lithuania	433	64	7	21	8
Luxembourg	653	17	35	28	20
Hungary	378	65	9	21	5
Malta	570	88	0	6	5
Netherlands	526	1	49	24	26
Austria	578	4	37	24	35
Poland	297	63	8	16	13
Portugal	440	50	24	13	13
Romania	272	97	0	3	0
Slovenia	414	38	1	55	7
Slovakia	304	77	12	4	8

Finland	493	25	42	19	13
Sweden	458	1	50	33	16
United Kingdom	482	35	21	28	16
Iceland	345	49	6	37	8
Norway	496	2	58	2	16
Switzerland	702	0	49	34	17
Montenegro	507	99	0	1	0
FYR of Macedonia	384	100	0	0	0
Serbia	336	100	0	0	0
Turkey	406	99	0	0	1
Bosnia and Herzegovina	311	100	0	0	0

Source: EUROSTAT Press release of March 26th 2015

REGULATION (EC) NO. 1013/2006 of the European Parliament and of the Council of 14 June 2006 on shipments of waste presents detailed specifications for transboundary waste shipments between Member States within the EU and exhaustively lists the reasons for objections to shipments. This regulation has been in effect since 12 July 2007. The predominant objective and purpose of this regulation is the protection of the environment; its effect on trade is merely coincidental!

1. NOTIFICATION OF TRANSBOUNDARY WASTE SHIPMENT

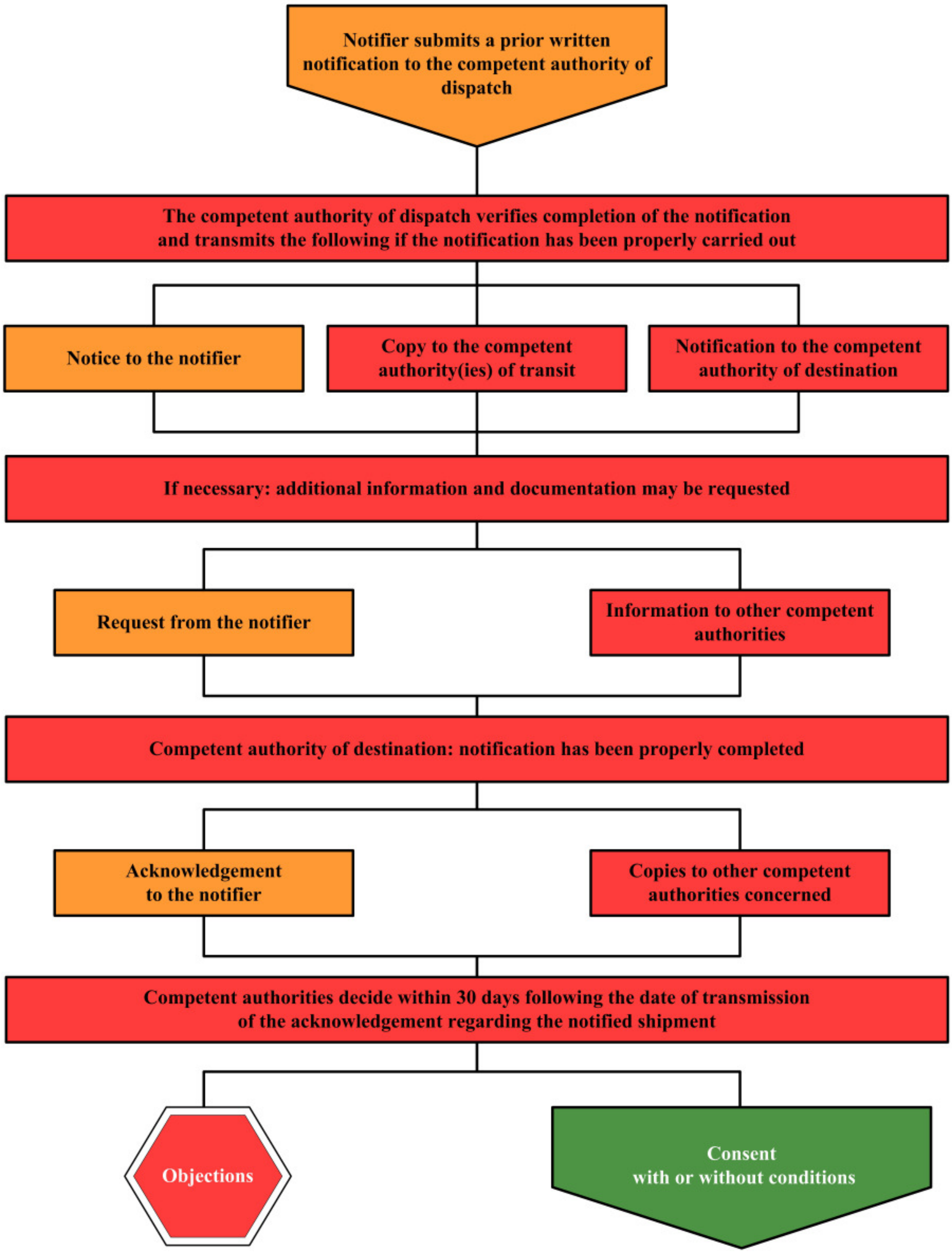
IN AUSTRIA, the Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) is responsible for the approval of transboundary waste shipments ("notification"). Chapter 8.2 of the Federal Waste Management Plan 2011 includes notes on applying the EC Waste Shipment Regulation. This Waste Management Plan will be amended in 2017.
An essential prerequisite for the approval of transboundary waste shipments is an adequate financial guarantee for the entire amount of waste to be notified. The guarantee is calculated as follows:

- shipment costs (e.g. for return shipment) of 0.1. Euro per ton of waste and km
- waste storage costs for a period of at least 90 days (e.g. 40 Euros per ton of non-hazardous waste, 150 Euros per ton of hazardous waste)
- waste treatment costs (dependant on type and composition of waste)

IN THE FIELD OF WASTE MANAGEMENT, EU legislation distinguishes between 15 different disposal operations (D1 - D 15) and 13 recovery operations (R1 – R 13) for waste. In case of transboundary shipments, the treatment of residual waste (municipal waste collected from private households, including where such collection also covers such waste from other sources) generally must be subject to the waste disposal regime (see Article 3 (5) and Article 11 (1) (i) of the Regulation). Stringent legal restrictions must be observed in case of transboundary shipments for the purpose of waste disposal and this includes obtaining the approval of the competent authorities both in the country of dispatch and the country of destination.
Pursuant to Regulation (EG) No. 1013/2006, Member States may take measures necessary to prevent the shipment of waste that is not in accordance with their waste management plans.
By way of derogation from the above-referenced regulation and pursuant to Directive 2008/98/EC on waste, Member States should be able to limit incoming shipments of waste destined for incinerators that are classified as recovery, where it has been demonstrably established that such shipments would result in national waste having to be disposed of as a result or having to be treated in a way that is inconsistent with their waste

management plans. This acknowledges that certain Member States may possibly not be in a position to provide a network in their territory offering the entire spectrum of plants for final recovery.
In the case of waste imports to Austria, the waste exporter (notifier) shall submit a prior written notification to the competent authority in the country in which the waste was produced. Subsequently, the BMLFUW becomes the competent authority of destination for waste treatment (see graph).

Procedure of prior written notification for the transboundery shipment of waste



Source: UV&P, 2009

Notification on transboundary waste shipments

Minimum 3 working days before the start of shipment: Notifier	Information regarding actual start of shipment using a movement document to the competent authorities, recipients
Transport	Annexation of movement document, copies, notification form and written approvals
Within 3 days of receipt of the waste: plant	Written confirmation to competent authorities, notifier
Within one calendar year from receipt of the waste, no later than 30 days after completion of the (non) intermediate recovery or disposal operation: plant	Certificate of (non) intermediate recovery or disposal operation to competent authorities, notifier

Source: UV&P, 2009

IT MUST BE NOTED THAT UNDER CERTAIN CIRCUMSTANCES the original waste producer may also be held liable for the costs of return of the illegal shipment, including its recovery or disposal, and for the payment of the contribution in accordance with the Act on Clean-Up of Contaminated Sites.

2. PRINCIPLE OF PROXIMITY – SELF-SUFFICIENCY IN WASTE DISPOSAL

THE FUNDAMENTALS OF THE EU WASTE POLICY are set forth in Directive 2008/98/EC of the European Parliament and of the Council of 19 April 2008 on waste. This Directive includes the "principle of proximity" (near-by plants should also be available to neighboring countries) and the principle of "self-sufficiency in waste disposal" (every Member State should establish the disposal installations it requires for itself).
If need be, Member States may take measures to prevent the shipment of waste that is not in accordance with their waste management plans.
Referring to the thermal treatment of waste, a distinction must be made between disposal operations (e.g. D10 - Incineration on land) and recovery operations (e.g. R1 - Use principally as a fuel or other means to generate energy), as different legal requirements and specifications apply to transboundary shipments.
R1 also includes incineration facilities dedicated to the processing of municipal solid waste only where their energy efficiency is equal to or above:

— 0.60 for installations in operation and permitted in accordance with applicable Community legislation before 1 January 2009,

— 0.65 for installations permitted after 31 December 2008.

In case of transboundary shipments of waste derived fuels the quality standards with regard to these fuels laid down in the Austrian Ordinance on Waste Incineration are to be met. Furthermore additional criteria and pollution limitations required by the facility of destination have to be met (e.g. limitation of sulphur or halogen contents or maximum content of POPs). The compliance with these (or other recognized adequate quality standards) must be documented (proof of assessment on the basis of sampling and analysis according to the state of the art).
Cross-border cooperation under the disposal regime should be sought - based on applicable EU regulations - in accordance with the principle of proximity. An example for this would be residual waste from the Reutte district in Tyrol, which is disposed of in a waste incineration plant in the neighboring Free State of Bavaria

(with free capacities). To do this, the requirements and specifications of the EC Waste Shipment Regulation must be met.
The approvals required for transboundary waste shipments (notification), however, may only be granted for a maximum period of 1 year each time. They depend on the consent of the Federal Ministry of Agriculture, Forestry, Environment and Water Management in Vienna and the corresponding competent authority in the country of destination.
It must be noted in this regard, the planning, the approval procedure and the installation of a new thermal waste treatment plant requires at least 5 to 8 years, which is why regional cooperation for transboundary waste shipment should be suitably ensured not only by reaching long-term agreements, but also by making these agreements part of the respective waste management plans of the countries concerned.

3. PRE-AUTHORIZATION OF SPECIFIC RECOVERY FACILITIES

PURSUANT TO ARTICLE 14 OF THE REGULATION ON THE SHIPMENT OF WASTE, the competent authority of destination may authorize recovery facilities for a specified period of no longer than 3 years by issuing a pre-consent. This consent should take into account any possible objections against the shipment of waste destined for recovery pursuant to Article 12.

THE COMPETENT AUTHORITY shall then issue its consent to the transboundary waste shipment subject to a time limit of seven working days, but no longer than 30 days, following the date of transmission of the acknowledgement of receipt of the notification by the competent authority of destination.

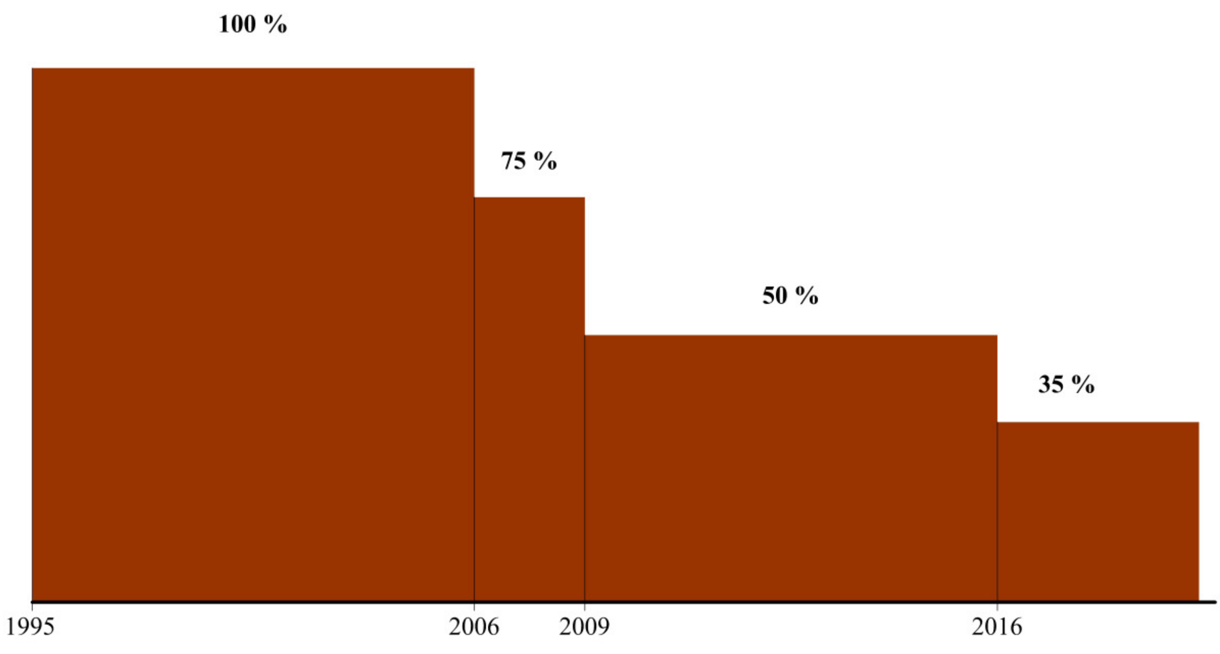
FOR SPECIAL WASTE RECOVERY FACILITIES to obtain pre-consent or pre-authorization, proof must be provided that these facilities meet very high environmental standards both in terms of equipment and operation. A thermal waste recovery plant must also meet technical requirements. Among these, is the requirement that it has been successfully operating for at least one whole year (this corresponds to the cycle leading to the next facility overhaul or the typical period between maintenance outages of a steam boiler installation). It must provide proof that it has kept below all emission limit values and submit evidence that it has met the minimum operational requirements with sufficient certainty - particularly the parameters for whole-year energy efficiency.

WILL CENTRAL WASTE INCINERATION PLANTS PROMOTE “WASTE TOURISM“ IN THE EU?

THE TERM "WASTE TOURISM" became a watchword against "undesirable" shipments when globalization of the economy increased and brought with it transboundary goods shipments.
For the individual EU Member States, however, self-sufficiency in waste disposal is prescribed by law. According to applicable EU regulations, regional independence in terms of municipal solid waste management and residual waste disposal has been maintained. The shipment of municipal solid waste across borders is permissible only in special justified cases and only upon consent by the competent Federal Minister of Agriculture, Forestry, Environment and Water Management in Austria and the respective body in the corresponding country.
The European Union facilitates the development of a common single market. Numerous directives aiming to implement a high level of waste recovery have been adopted in the field of waste management. The Landfill Directive prescribes a gradual reduction of the maximum volume of biodegradable waste that may be landfilled (this EU Landfill Directive stipulates compliance by 2016, but Austria has been in compliance with the requirements since the end of 2003).

Limitations for disposal to landfills

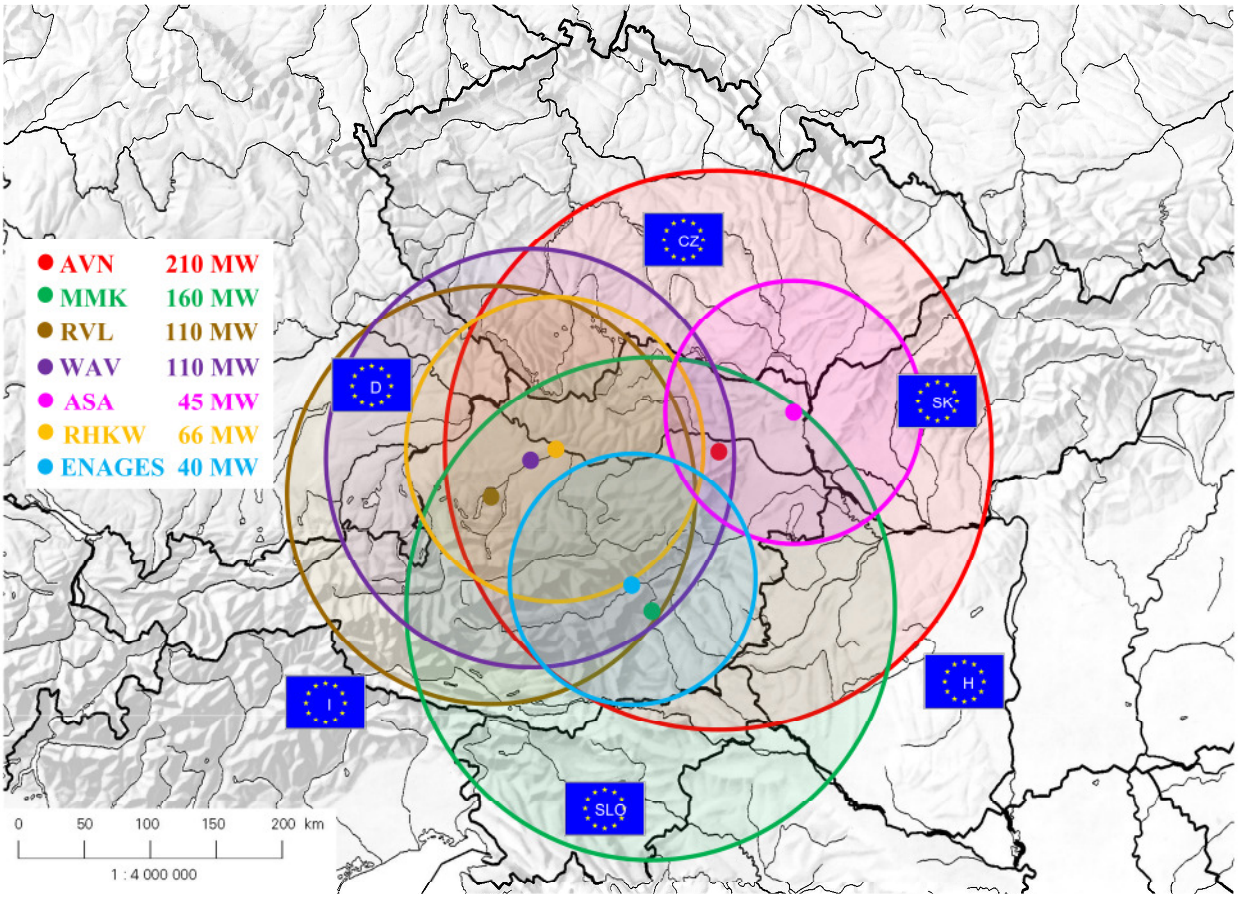
Reduction of biodegradable waste according to Council Directive 1999/31/EC Art. 5 on the Landfill of Waste



Source: Directive 1999/31/EC on the Landfill of Waste

Capacity of individual waste incineration plants with interregional supply *) of waste

Epicenter = location of plant, area of circle corresponds to plant capacity



*) therefore without FWW and KRV

Source: Neubacher F., 2009

4. ECONOMIC SIZE OF THE CATCHMENT AREA

IN THE PAST, some landfills in Austria have accepted waste deliveries coming from distances of several hundred kilometers with annual supplies of approximately 300,000 tons of waste. This volume corresponds to that of a medium-sized waste incineration plant with supplies coming from neighboring regions. Environmentally sound shipment by railway plays a significant role in this respect. The option of delivery by railway should be taken into account when planning new waste incineration plants with a trans-regional catchment area.

OVERLAPPING CATCHMENT AREAS for individual thermal waste treatment plants (yet without eco-dumping as a result of different environmental standards) make for low tariffs and competitive prices.

The cost differences between small (e.g. thermal capacity of 30 MW) and large plants (e.g. thermal capacity greater than 80 MW) and between installations "in the prairie" or "greenfield" installations and plants with

whole-year heat utilization that have been integrated into an industrial infrastructure already in place may actually amount to more than 50 Euros per ton of waste.
This difference in cost, however, allows for a shipping distance that is approximately 1,000 km farther (assumption: € 0.05/t * km for railway transport over a large distance; main costs are for loading and unloading, irrespective of the distance). As a consequence, economic considerations make it expedient for plants to be situated at appropriate sites with a correspondingly high heat requirement and an industrial infrastructure that is already in operation or in the planning stage (e.g. in Lenzing, Niklasdorf, Frohnleiten, Heiligenkreuz, Pitten, etc.).
Note: Unlike these ecologically and economically reasonable concepts for efficient waste recovery, "waste tourism" in the sense of "eco-dumping" must be seen in a critical light, particularly with regard to transboundary shipment to countries having insufficient capacities for thermal waste treatment and were their dominant practice is landfilling of waste.

5. COMPARING THE SIZE OF SHIPMENTS IN GOODS PRODUCTION WITH SHIPMENTS FOR THE SAKE OF WASTE RECOVERY

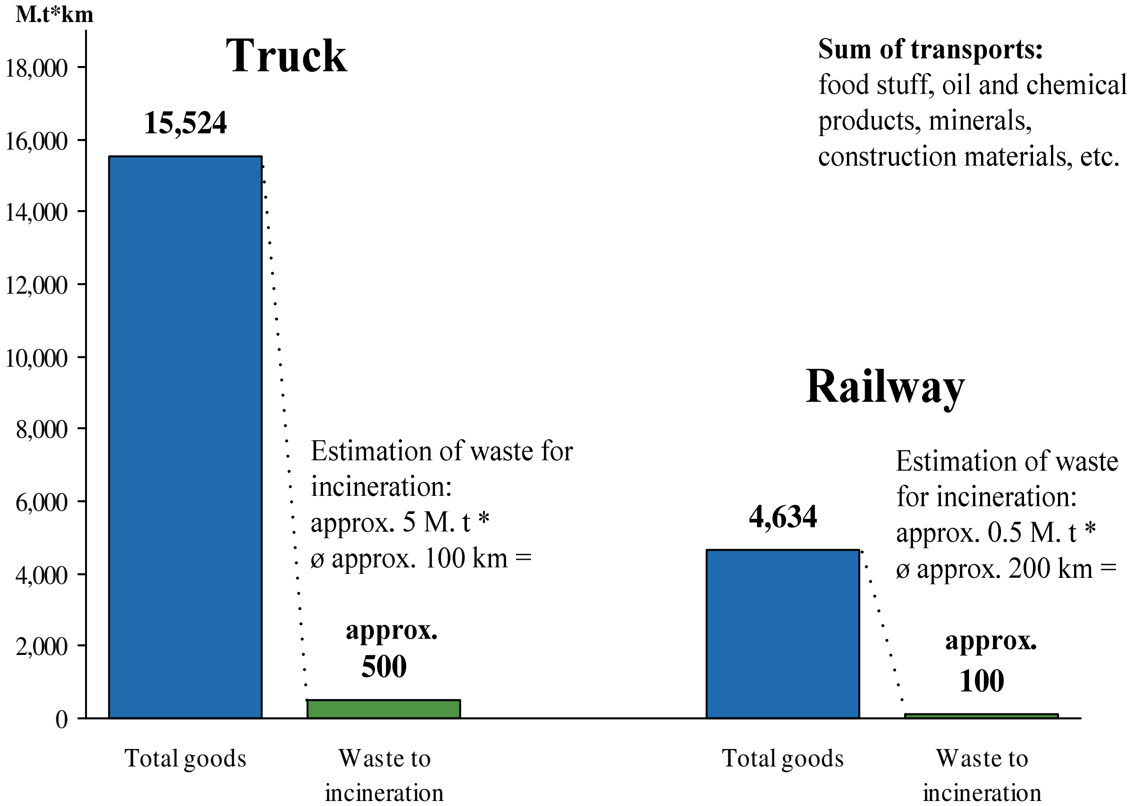
AS THE FOLLOWING SAMPLE CALCULATIONS SHOW, a comparison between necessary waste disposal and the supply of goods is indeed helpful to put the scope of shipments into proper perspective. These days, it is taken for granted that every citizen can freely choose and buy a car that has been "Made in Japan" or "Made in Mexico". As a result, the new car with an assumed total weight of 1,000 kg that is shipped across half the globe requires a shipment efficiency of 20,000 km * 1 t or 20,000 t*km.
By way of comparison, the shipment of shredder waste recovered from old cars (approximately 0.25 tons per old car) for necessary thermal treatment - even with a distance of 800 km (0.25 t * 800 km = 200 t*km) - represents a performance that is lower by a factor of 100. The same applies for the shipment of treated metals for recycling plants.
It is taken for granted that a modern refinery has a throughput of at least 10 million tons of crude oil per year and regional supplies cover a radius of approx. 500 to 1,000 km. (Austria's requirement is covered by a total of four refineries, one in southern Germany, one in northern Italy, one in Slovakia, and one in Schwechat, the latter being Austria's only refinery). Compared to a refinery, the throughput of a larger waste incineration plant with some 500,000 tons is smaller by a factor of twenty. Even with the highest concentration of waste incineration furnaces in Europe, Rotterdam has a throughput (approximately 1 million tons per year) that is still smaller than that of one refinery by a factor of 10.

Another comparison to illustrate the above is the requisite use of anthracite in Austrian power plants, which is preferably imported from Poland and South Africa. Some 1,000,000 tons of anthracite are necessary to ensure the permanent operation of a medium-sized power plant.

Recycling material, too, (e.g. waste metals, waste paper) must be shipped to appropriate production facilities of economic size for recycling or material recovery. An example for this would be the Mayer-Melnhof cardboard factory in Frohnleiten: Approximately 500,000 t/a waste cardboard and waste paper are employed, and the future will see the use of some 300,000 t/a high-calorific residues to generate energy for cardboard production based on a thermal capacity of 160 MW. By way of comparison, building a small decentralized facility for thermal waste treatment would come with disproportionately high costs. To optimize costs, low-cost shipment logistics must be developed in the field of waste collection, including necessary intermediate storage capacities for full utilization of plant capacities.

Comparison of shipment of total goods to shipment of waste for incineration

Domestic transport volumes in million (M) tons (t)*km



Source: Statistik Austria, 2013, assessment by UV&P, 2014

WHAT ARE THE REQUIREMENTS FOR INTERMEDIATE STORAGE OF WASTE WITH HIGH CALORIFIC VALUE?

THE INTERMEDIATE STORAGE OF WASTE WITH HIGH CALORIFIC VALUE is liable to entail considerable risks in terms of environmental pollution (carrying by the wind, smell, pollution of bodies of water and soil) and the danger of self-ignition and arson. For this reason, a team of experts conducted the study "Requirements of Intermediate Storage of Waste with High Calorific Value" (Anforderungen an die Zwischenlagerung von heizwertreichen Abfällen, BMLFUW b, 2007) on behalf of the Federal Ministry of Agriculture, Forestry, Environment and Water Management. The following picture depicts one of many typical fires in "open landfills" and waste storages not in compliance with the technical requirements defined by this study.

Fire at the waste disposal site in Stockerau in May 2006

THE TRANSITION FROM LANDFILL TO WASTE RECOVERY also requires fundamental changes in waste logistics. While it may be irrelevant to the landfill operator whether double the amount of waste or no waste is supplied in a given week, a thermal plant definitely requires a consistent supply (thermal performance in MW for every second is calculated by multiplying the calorific value of the waste in MJ/kg by the amount of waste fed to the system in kg/s). Thermal waste recovery, therefore, requires the development and application of systems to store treated waste in an environmentally sound manner. In particular, this is an effort to bridge seasonal fluctuations and plant downtime and also to bridge the time period during which additional facilities are under construction (BMLFUW a, 2007).

Example of state of the art temporary storage of waste in plastic wrapped bales in Wels (1 bale equals to 2 or 3 barrels of crude oil)

LOGISTICAL INTERMEDIATE STORAGE FACILITIES are also necessary for material recovery procedures, e.g. for glass and metal smelting plants as well as for paper and cardboard machines. To ensure the continuous supply for a cardboard factory, for example, it is standard procedure to keep recycling material for 3 to 4 production months in intermediate storage and distribute these stocks across several locations.

For ongoing operation, thermal waste treatment facilities have a storage capacity (low-level or flat bunkers) of only some 3 (to maximum 10) days in order to bridge short-term supply fluctuations (e.g. weekends and holidays). The largest waste bunker in Austria has a gross volume of 40,000 m^3 and is located in an AVN waste incineration plant in Dürnrohr.

In order to achieve a high storage density (tons of waste per hectare), high-calorific waste must be suitably compacted. This can be done by using either heavy-duty channel balers or through the machine production of densely compacted, cylindrical bales. The individual compacted bales are tied together by nets, wires, or ropes. For the sake of thermal treatment, however, only residue-free combustible plastics (e.g. polyethylene) should be used, and not metal wires.

To avoid organic and/or chemical transformation processes, the compacted bales must be covered by several layers of stretch foil in order to prevent gas exchange and preserve the content and also to forestall any negative impact on the environment.

The production of square bales has proven of value over decades in various applications, such as waste paper, waste cardboard and plastics.

Comparison of alternative intermediate storage at the same point in time at the disposal site Rautenweg, Vienna: The plastic wrapping suppresses heat development – thus layers of snow are only on the plastic wrapped waste (Dez. 2002)

THE REQUIREMENTS UNDER WASTE LAW can be met by ensuring orderly stocking and destocking operations and keeping ongoing records. The targeted selection of standardized colors and color combinations for the stretch foil used helps visually designate the various categories of the packed waste-derived fuel without running the risk of confusion for downstream storage and transport logistics up to the time when the waste is fed to the incinerator. The most important categories in waste-derived fuel are quality-assured waste fuels for cement production, treated solid municipal waste, or shredder light fractions (rich in pollutants) for fluidized-bed incineration with multi-stage off-gas cleaning as well as untreated municipal solid waste.

The highest possible storage density is achieved in practice by simply using round bales and storing them in a compact form. With compacted, cylindrical bales in the standard size of 1.2 meters in diameter and height, up to 60,000 tons of waste per hectare of storage space can be placed in clean intermediate storage that is safe in terms of fire risk.

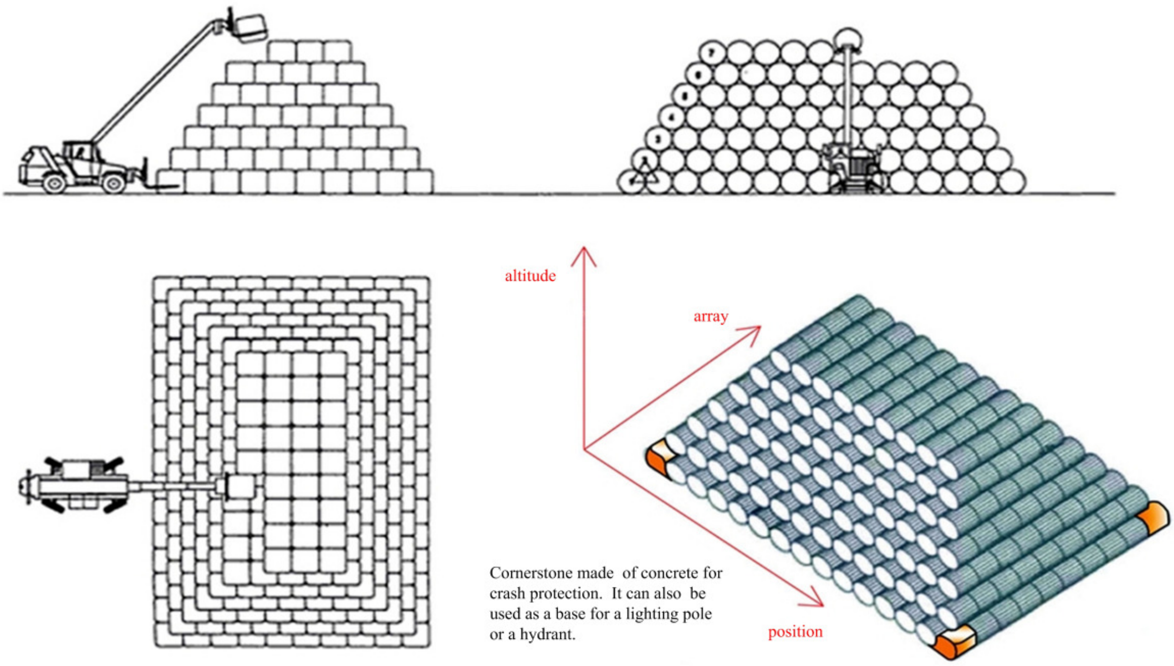
By means of a suitable compaction and packing machine, 30 bales can be produced hourly and approximately 60,000 to 120,000 tons of waste can be packed per year.

Example:

To operate trans-regional thermal waste recovery systems with a total of 800 MW and 2 to 3 million tons of waste per year - with an assumed 3-month storage capacity - an intermediate storage capacity of 500,000 to 750,000 tons is required. These should be kept in stock and distributed across 4 to 7 regional intermediate storage facilities with railway sidings.

IN TERMS OF FIRE PREVENTION ENGINEERING, requirements should be defined specifically for each project and location in a fire protection plan.

System for safe and clean storage of waste-derived fuel



Source: Patentanmeldungen PCT/EP2009/050238 und PCT/EP2009/058150

Example for intermediate storage of mechanically processed MSW in Vienna in order to manage seasonal variations in waste generation and temporary shutdown of an incinerator

Depending on the kind of material to be shredded, there is a considerable risk that hazardous or easily inflammable parts implied in the waste may ignite a fire during the shredding process. In case of a fire, the burning material may be transferred via the discharge conveying system through the plant within a short time and can cause substantial damage to the plant equipment and the building if not extinguished shortly.

In order to protect both the machines as well as the building of the process plant, automatic, quick-reacting extinguishing system – installed within the shredder – now represent a state-of-the-art add-on to a waste processing facility. Automatic UV detectors monitoring both the feeding hopper as well as the cutting chamber of the shredder will detect any fire ignition within a short time. In case of a fire, a magnetic valve will open and water for immediate extinguishing of the fire will be transferred to spray nozzles installed above the discharge conveying belt within a few seconds in order to ensure that the fire will be extinguished before it can spread through the plant. Such a system can reduce the risk of a fire in a processing plant considerably and therefore, fire insurance fees for the building will drop significantly.

Besides self ignition during storage of waste the most critical cause for fire hazards are the mechanical processes such as shredding of waste. Therefore automated fire detection and fighting systems have become state-of-the-art as illustrated in the photo below.

Example of state of the art automatic, quick-reacting extinguishing system

WHAT IMPACTS DO WASTE MANAGEMENT MEASURES HAVE ON THE GREENHOUSE EFFECT?

THE REDUCTION OF GREENHOUSE GAS (GHG) EMISSIONS has been intensively debated internationally for many years, since, based on various model calculations, there are fears that a general warming of the earth may cause disastrous climate change. This is why international memorandums of understanding and agreements have been drawn up (conferences of Toronto 1988, Rio 1992, Kyoto 1997, Buenos Aires 1998, etc.). According to the Convention, greenhouse gases include carbon dioxide (CO_2), methane (CH_4), laughing gas (N_2O) and (HCFCs, PFCs, SF_6), which are added up based on their individual greenhouse potential to give CO_2 equivalents.

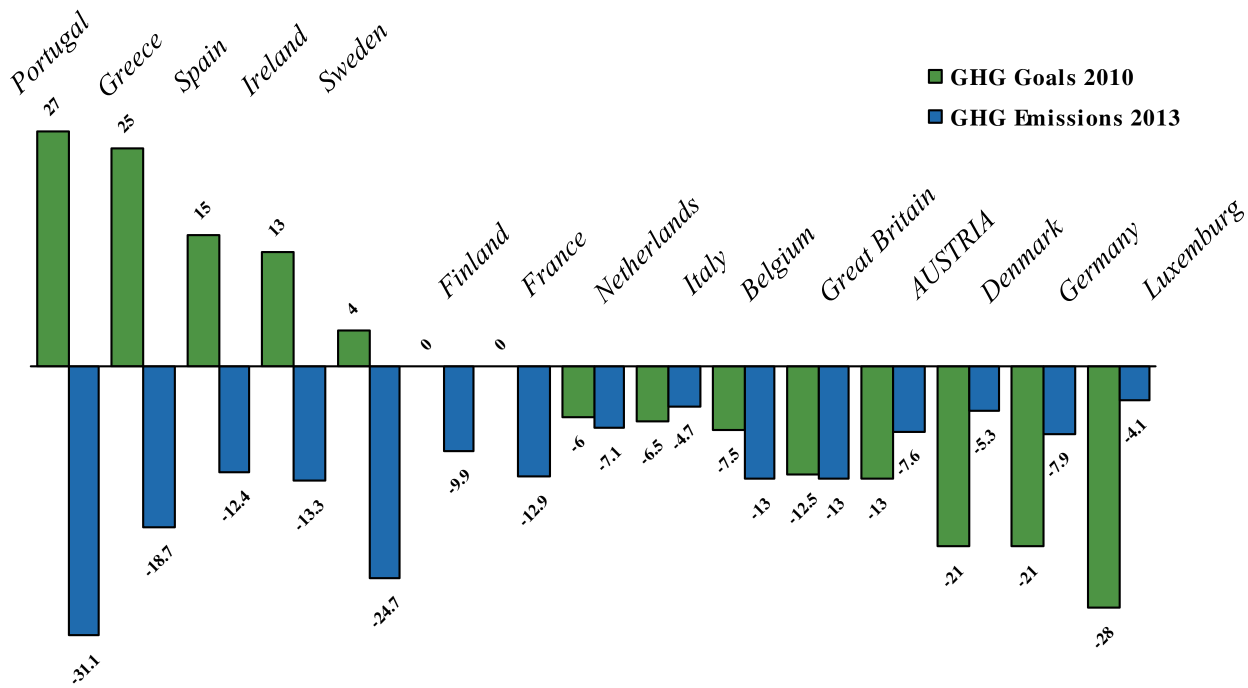
In the EU, a binding agreement was concluded between the Member States to reduce greenhouse gas emissions by 2010 in average by a total of 8%, with Austria committing itself to a 13% cutback. To achieve these reductions, the Federal Government adopted the "Austrian Climate Strategy", which defined target values and measures for a total of eight different sectors. Waste management was one of them.

The national energy and climate goals for 2020 comprise a 34% share of renewable energy sources, a cutback of the final energy consumption to 1,100 Petajoule and a 16% reduction of greenhouse gases in the effort-sharing sector (compared to 2005), which also includes waste management.

At the end of 2014 the EU leaders agreed to a 2030 greenhouse gas reduction of at least 40% (compared to 1990), increasing the share of renewable energy to at least 27% and increasing energy efficiency by at least 27%. For 2050 the European Commission suggests a roadmap with the even more ambitious goal to cut back the emissions by 80% as compared to 1990.

EU climate goals till 2010 – obligation of EU Member States for reduction of GHG – emissions

Proposed development of GHG emissions by the EU-council on 17 June 1998 (based on 1990) and GHG emissions for 2008 - 2012



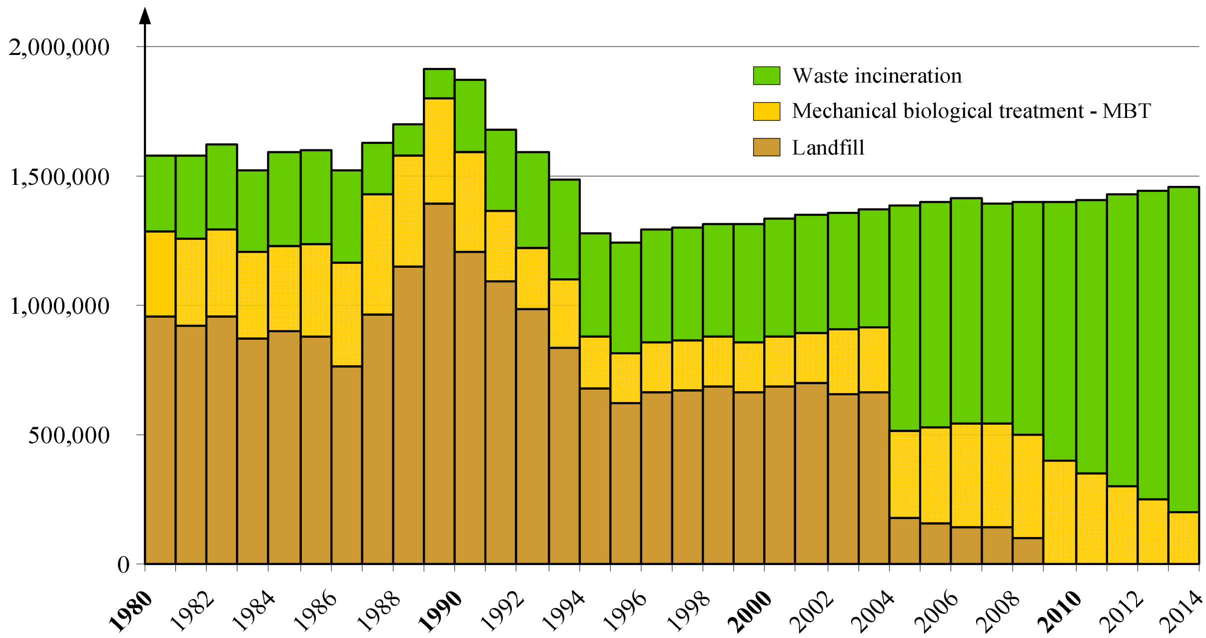
Source: UV&P, 2015

1. GREENHOUSE GAS EMISSIONS OF VARIOUS RESIDUAL WASTE TREATMENT PROCESSES

THE WASTE SECTOR'S CONTRIBUTION to climate protection was extensively examined as early as 1998 ("Klimarelevanz der Abfallwirtschaft" study by A. Hackl and G. Mauschitz: Schriftenreihe des Bundesministeriums für Umwelt, Jugend und Familie, volume 11/1998). The study determined that waste landfills cause a significant share of greenhouse gas emissions due to the landfill gases they release (methane and carbon dioxide, but also traces of chlorofluorocarbon compounds (CFCs) and laughing gas). In terms of mass, methane in particular- which is formed during the rotting processes of biologically degradable carbon compounds - has a greenhouse effect that is stronger by a factor of 21 compared to CO_2! The potential release of greenhouse gases needs to be taken into account in all waste treatment operations, with indirect emissions from the use of fossil fuels for waste treatment requiring consideration as well.

Generation and treatment of residual municipal solid waste from 1980 to 2013

Figures expressed in tons per year



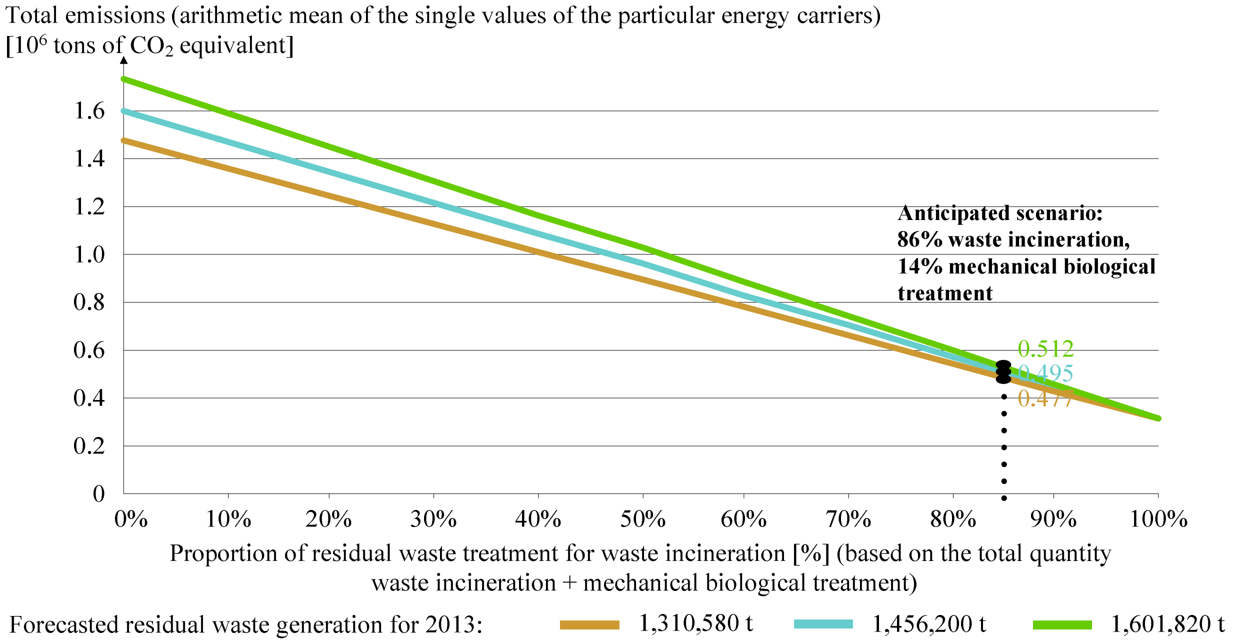
Source: Gerd Mauschitz, Klimarelevanz der Abfallwirtschaft IV, Studie im Auftrag des Bundesministeriums für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, TU Wien, 2009

A RECENT STUDY (Mauschitz, 2009) provided detailed calculations of the GHG emissions from residual waste treatment for the years 1996 to 2006 and 2013 (commissioning of the envisaged thermal waste treatment plants), taking 1990 as reference year (currently the most recent available data assessment). Some sixty parameters were taken into account in the comprehensive calculations, including various parameters for residual waste, reaction products from treatment and CO_2 and CH_4 emission values, efficiency of technical facilities and their energy consumption.

The key results of the model calculation for GHG emissions in Austria are:

- According to the emission scorecard, GHG emissions from residual waste treatment (approximately 1.25 million tons) made up a share of some 1.5% of total GHG emissions in 2006 (CO_2 and CH_4).
- In comparison, the emission scorecards for the years 1990, 1996 and 2006 show a steady decline in GHG emissions from residual waste treatment (approximately 1.03 million tons in 1990 to approximately 1.25 million tons in 2006). This equals a reduction of more than 38% over a period of 16 years.
- The calculations for 2013 show that, given the forecast amounts and 100% thermal treatment of the residual waste accumulated (waste incineration plant), a GHG emission reduction on 1990 levels of more than 84% will be achieved.
- As shown in the graph below, mechanical-biological residual waste treatment would achieve only a considerably smaller decline compared to 100% incineration (compared to 1990 only by approximately 15%).

Forecasted GHG – emissions for the treatment of residual waste for the year 2013



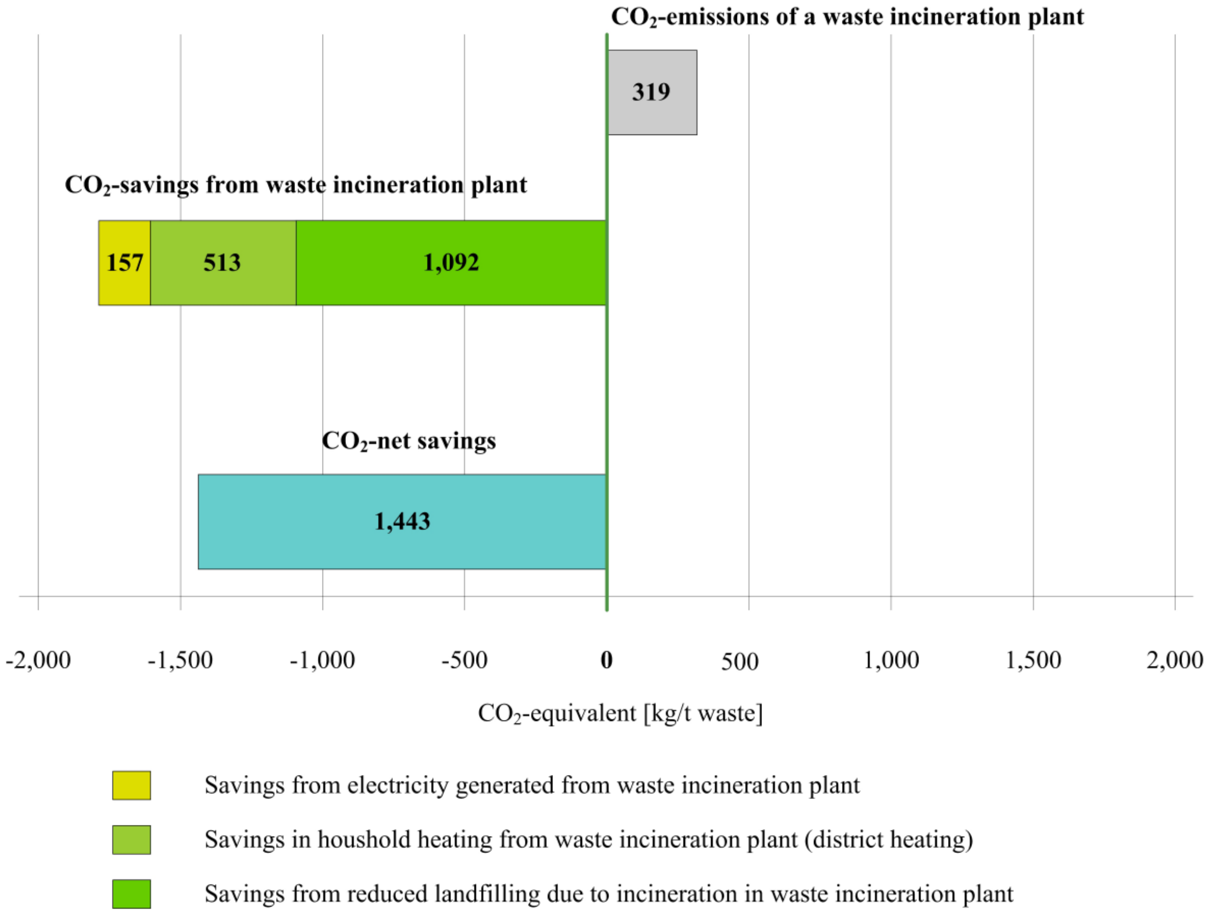
Source: Gerd Mauschitz, Klimarelevanz der Abfallwirtschaft IV, Studie im Auftrag des Bundesministeriums für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, TU Wien, 2009

2. EXAMPLE: DISTRICT HEATING IN VIENNA POSITIVE SIGNIFICANCE OF THERMAL TREATMENT FOR CO2 EMISSIONS

IT IS ONLY NATURAL for the incineration of carbon in residual waste to simultaneously emit CO_2. As the share of renewable raw materials is climate neutral by definition, it is not to be taken into account because the same amount of CO_2 is absorbed and converted by plants in nature.
The CO_2 emission from waste incineration that needs to be taken into account therefore corresponds to the share of fossil and non-renewable carbon (e.g. plastics made of crude oil and natural gas).

Thermal residual waste treatment is an effective and low-cost contribution to the reduction of greenhouse gas emissions in Austria as proven by the detailed calculations for thermal waste treatment in combination with district heating for the city region of Vienna.

Reduction of GHG - emissions by waste incineration plants



Source: Kirchner, Effiziente thermische Abfallverwertung Hand in Hand mit optimaler städtischer Energieversorgung am Beispiel Wien; IIR Konferenz: Effiziente Abfallbehandlungsmethoden der Zukunft, August 2008

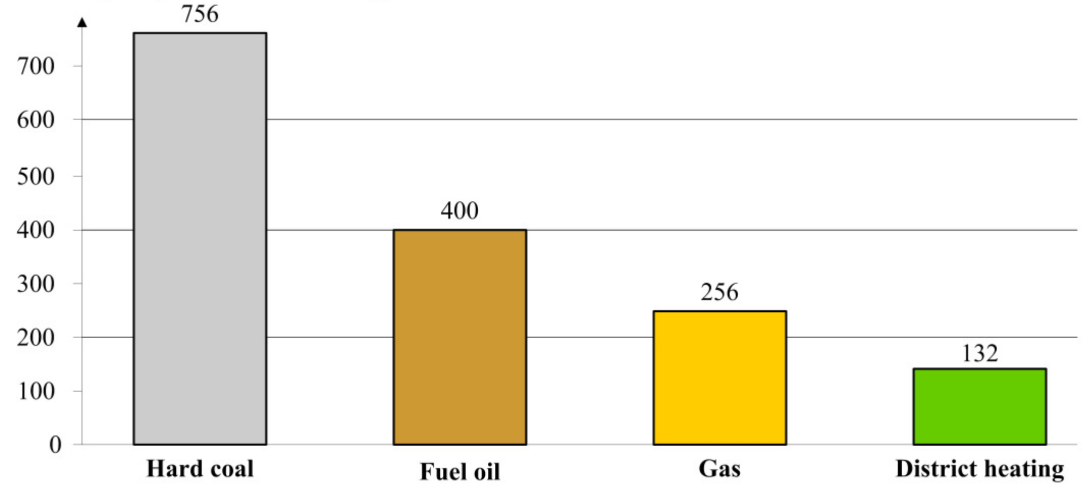
THE AMOUNT OF GHG EMISSION SAVINGS achieved through waste incineration results from the following:

- Emission savings achieved by preventing waste from being landfilled (avoiding the formation and release of landfill gases, particularly CH_4 whose greenhouse gas potential is 21 times greater than the same mass of CO_2)
- Avoidance of GHG emissions from household heaters for heat generation (e.g. using natural gas, heating oil) by using district heating from waste incineration
- Avoidance of GHG emissions from power generation by integrating cogeneration in the waste incineration plant

THE VARYING GHG EMISSIONS for alternative heating systems are depicted in the following graph. It must be noted that a major share of district heating in Vienna uses fossil fuel-fired cogeneration, entailing the corresponding GHG emissions in winter time (e.g. natural-gas-fired gas turbine and steam boiler systems in Donaustadt and Simmering).
In the meantime there is also a significant increase in district cooling supply in Austria based on thermal power from waste incineration (BMLFUW, 2014).

CO_2-emission comparison for heating systems, example Vienna

Figures in kg CO_2 / MWh net energy effective



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On the occasion of the 2006 United Nations Climate Change Conference in Nairobi, it was determined that 110 million tons of CO_2 equivalents could be saved every year by prohibiting landfills for municipal solid waste across Europe; this would correspond to 10% of Europe's targets!

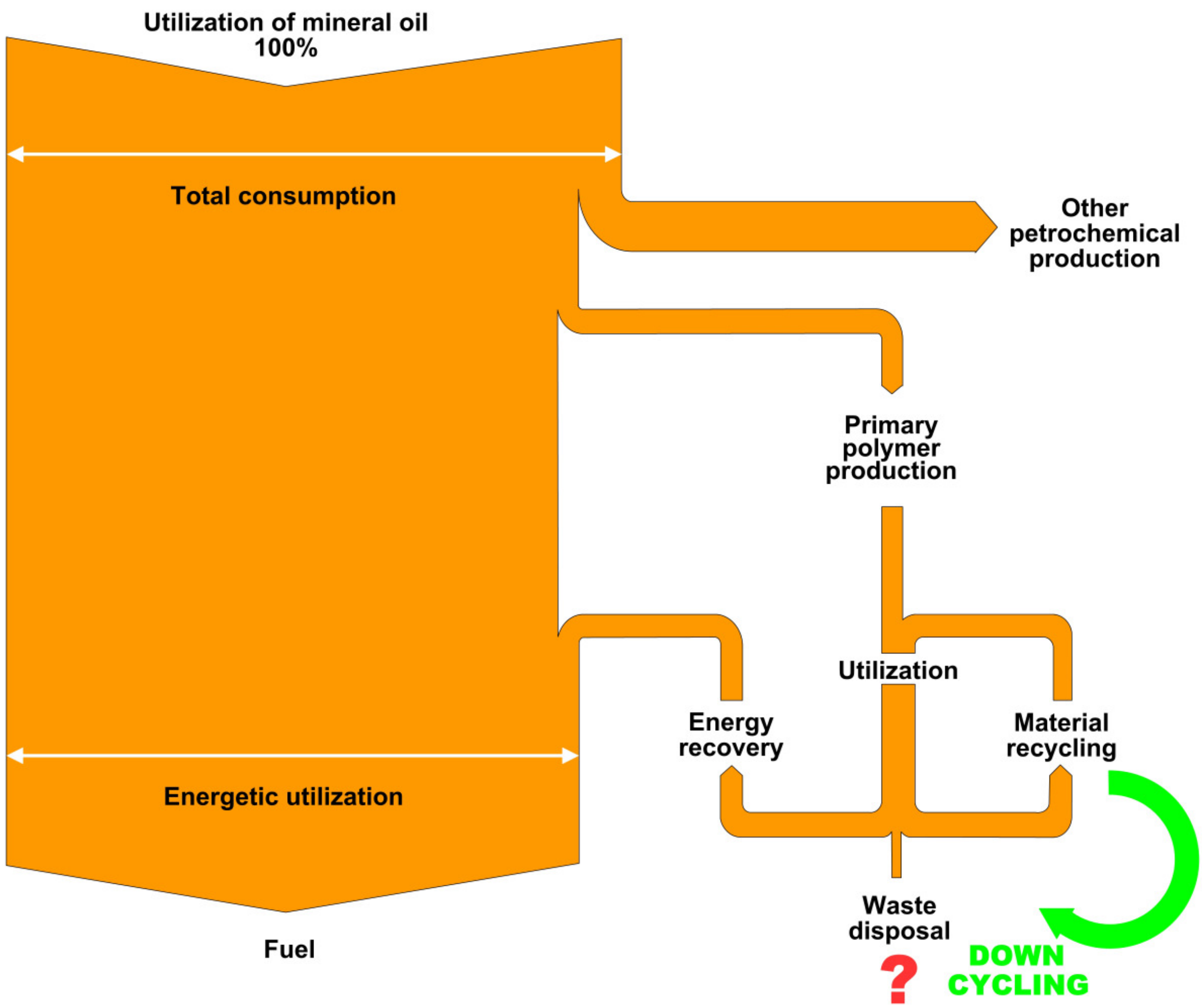
CAN WASTE INCINERATION BE PART OF SUSTAINABLE WASTE MANAGEMENT?

IN AN ECOLOGICALLY AND ECONOMICALLY THOUGHT out and sustainable closed loop economy, recycling pure production waste as well as separately collected and sorted paper, cardboard and fiber products is just as important as the thermal recovery of waste (waste-to-energy). Sustainability requires thermal waste recovery.

1. EFFICIENT USE OF RESOURCES

THE EFFICIENT USE OF LIMITED FOSSIL RESOURCES (e.g. crude oil, natural gas, coal) is indispensable in any sustainable economy and waste management system.

Efficient use of non-renewable resources – example mineral oil



Source: UVP 2015

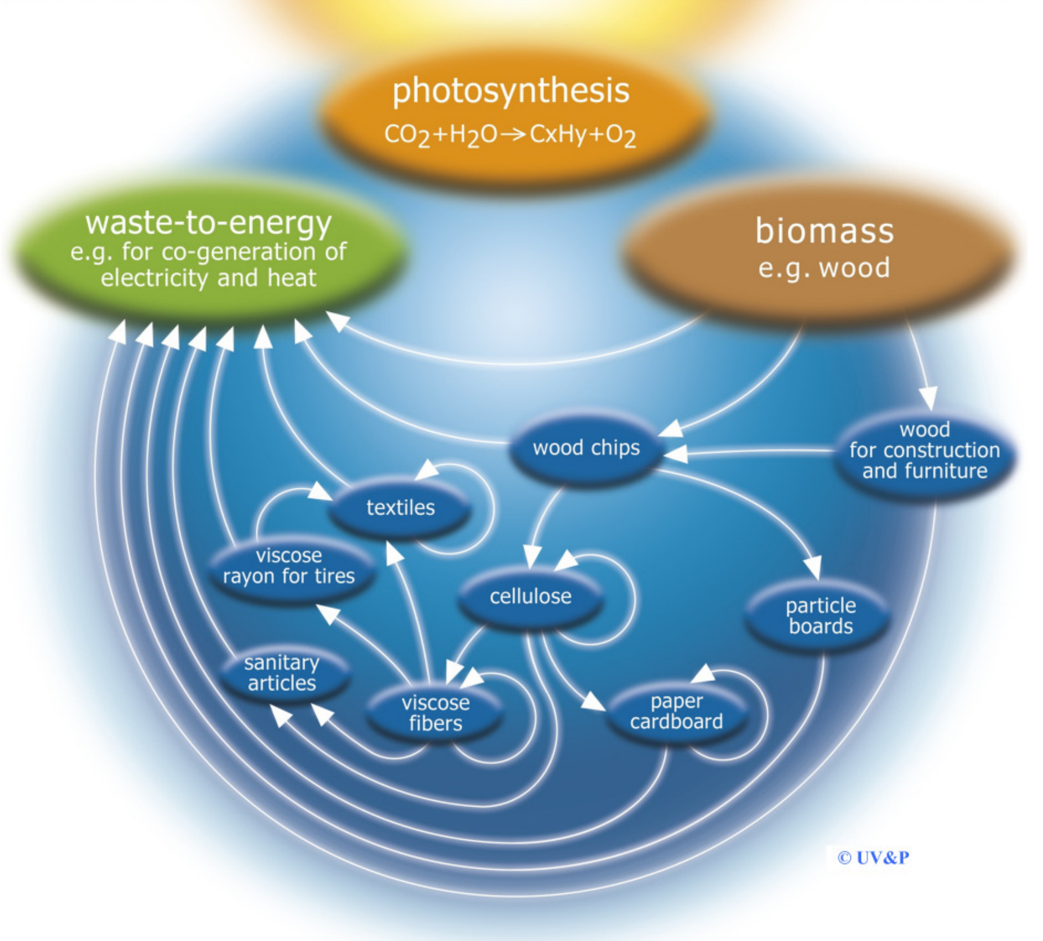
TO DATE, more than 90% of the world's extracted crude oil has gone directly into incineration in the form of fuels, aviation fuel, heating oils, and petroleum coke. Considerably more efficient use could be

achieved by ensuring cascade-like multi-purpose utilization of crude oil products (e.g. use in weight-saving plastics in automotive engineering) with final energy recovery from the residual waste with high calorific value (e.g. shredder light fraction).
Due to the (absolute) validity of the 2nd Law of Thermodynamics also for waste management "re-cycling" is from an engineering view, naturally "down-cycling". Materials can be "re-used" only in a cascade approach, e.g. high quality bleached paper with its bright white appearance, recycled paper with good quality in a less white appearance, further fibre reuse for newsprint or paperboard products, and in a next level of the cascade in production of tissue toilet paper, followed by energy recovery from waste in an appropriate incineration process for the mechanically dewatered residues from sewage treatment. The same is true for plastic "re-cycling" – either the "down-cycling" or – thermodynamically speaking – the "up-cycling" by using mineral oil first for production of polymer materials, possibly in a cascade use of further "down-cycling" and finally for recovery of energy from (plastic) waste in an appropriate incineration facility

2. RENEWABLE RAW MATERIALS AND ENERGY

PHOTOSYNTHESIS CLOSES THE NATURAL CYCLE from thermal waste recovery to renewable biomass. Biomass is a renewable type of fuel. In addition to biomass made of wood and waste from the wood-processing industry, this type of fuel also includes energy crops (e.g. rapeseed), agricultural waste, dung, waste water from the food industry, organic components from solid or liquid municipal waste, sorted household refuse, and sewage sludge.

Sustainable development based on renewable resources and recycling



Source: UV&P, 1999

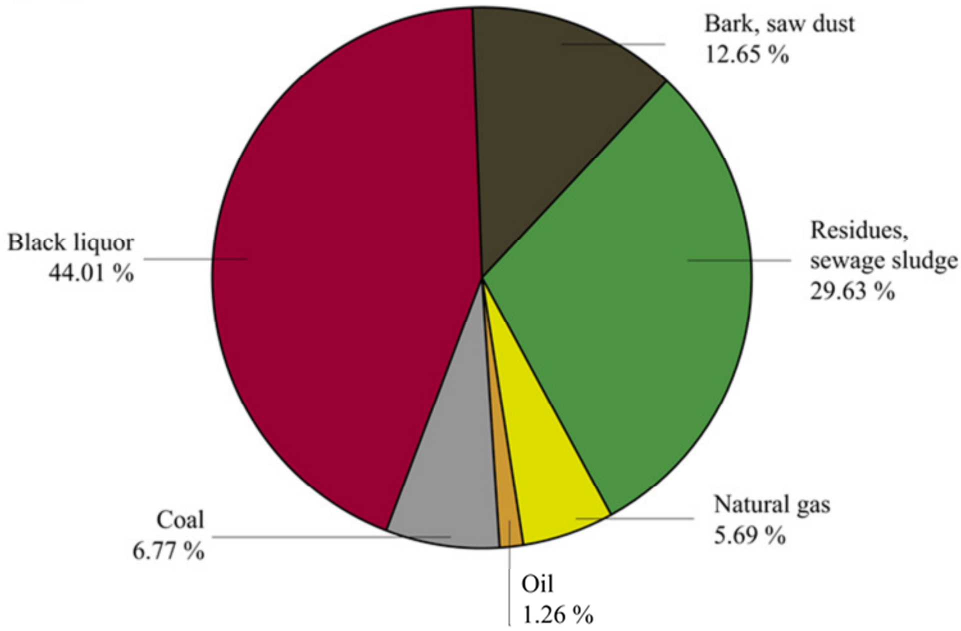
3. USE OF FUELS IN INDUSTRY - EXAMPLE OF INDUSTRIAL SITE LENZING

LENZING AG operates the world's largest integrated production plant for viscose fibre and by-products in Upper Austria. The overall thermal capacity of the boiler systems on site is some 400 MW and approximately 420,000 tons of coal equivalents per year.

Waste-to-energy plant integrated into the Industrial site Lenzing in the tourist region around Lake Attersee, Upper Austria.

Fuel mix in 2007 at Lenzing AG:

Fuel input: 12,600,863 GJ



Due to thermal waste incineration, 86% of the used fuels can be classified as CO_2 neutral

Source: Rosenauer, 2008

DO WASTE INCINERATION PLANTS REPRESENT A STEP BACKWARD IN TERMS OF WASTE PREVENTION?

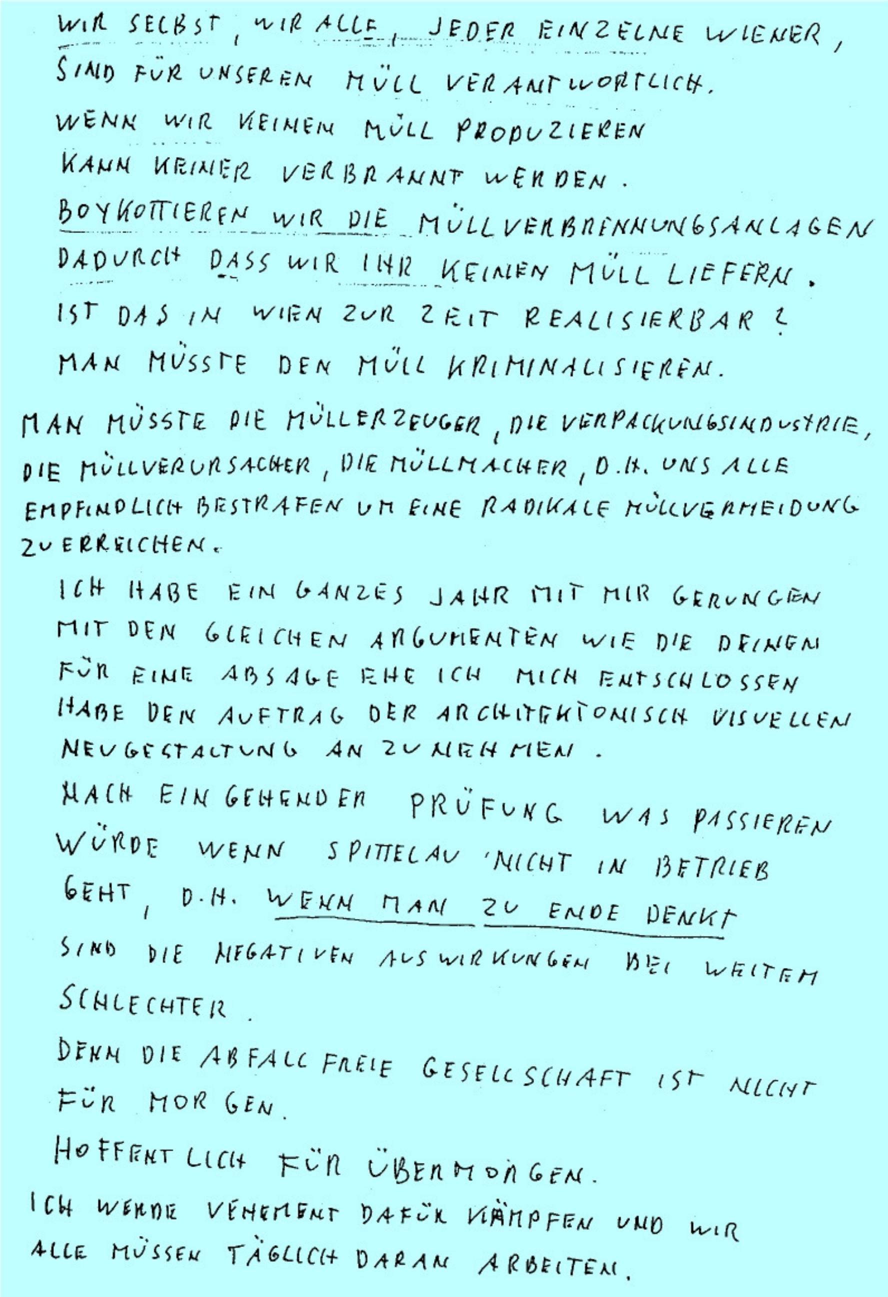
NO! Prevention and treatment are not contradictory, but rather complement each other. (Simple comparison: dental treatment is complementary to preventive dental care).

Cheap waste landfills are the biggest obstacle, both for waste prevention and for environmentally sound waste treatment. Conventional waste landfills (e.g. like those formerly in Austria and those currently encountered in numerous EU countries in Eastern, Western and Southern Europe) have purchase prices or directly allocable costs lower than those of state of the art thermal waste treatment plants by a factor of 4 (up to a factor of approximately 10!).Prevention of waste is, thus, being undermined, not by targeted and cost-intensive treatment, but by cheap waste disposal which was common in the past - unfortunately not taking into account the long-term effects in the form of soil, air and water pollution, as well as contaminated sites. Therefore, the targeted use of incineration technologies is necessary for thermal recovery of combustible waste on the one hand, and treatment of specific waste and residual waste on the other. In so doing, the requirements for largely aftercare-free landfill should be met using conditioned residual waste that is as non-reactive as possible. In the meantime, there has been the realization that true aftercare-free landfill of reactive waste like residual waste is practically impossible so that pertinent requirements for the quality of waste left for landfill have been stipulated by way of the Landfill Ordinance. The legal restriction on the landfill of waste gives preference to all alternatives, i.e. prevention as well as material and thermal recovery and any other necessary treatment of waste.

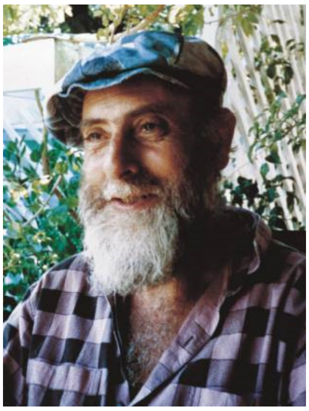
Giving high priority to waste prevention is not inconsistent with compulsory participation in a regional residual waste treatment system - just as an obligatory sewage connection is no impediment to the prevention and reduction of the waste water load of a household connected to the sewage system. On the contrary, a fair pay-as-you-throw fee provides a continuous economic incentive to further prevent and reduce waste. An example would be payment of the actual waste volume generated based on container volume and the actual drained off waste water amount based on water consumption.

By providing comprehensive information and undertaking additional efforts to prevent waste, even critical citizens will come to understand that prevention and treatment are not contradictory, but are actually measures that complement one another, need to be implemented at the same time and represent a directive to take on the responsibility for our environment.

The designer of the external façade of the Spittelau incineration plant, Friedensreich Hundertwasser, wrote the following statement in this regard (in excerpts):



WIR SELBST, WIR ALLE, JEDER EINZELNE WIENER,
SIND FÜR UNSEREN MÜLL VERANTWORTLICH.
WENN WIR KEINEN MÜLL PRODUZIEREN
KANN KEINER VERBRANNT WERDEN.
BOYKOTTIEREN WIR DIE MÜLLVERBRENNUNGSANLAGEN
DADURCH DASS WIR IHR KEINEN MÜLL LIEFERN.
IST DAS IN WIEN ZUR ZEIT REALISIERBAR?
MAN MÜSSTE DEN MÜLL KRIMINALISIEREN.
MAN MÜSSTE DIE MÜLLERZEUGER, DIE VERPACKUNGSINDUSTRIE,
DIE MÜLLVERURSACHER, DIE MÜLLMACHER, D.H. UNS ALLE
EMPFINDLICH BESTRAFEN UM EINE RADIKALE MÜLLVERMEIDUNG
ZU ERREICHEN.
ICH HABE EIN GANZES JAHR MIT MIR GERUNGEN
MIT DEN GLEICHEN ARGUMENTEN WIE DIE DEINEN
FÜR EINE ABSAGE EHE ICH MICH ENTSCHLOSSEN
HABE DEN AUFTRAG DER ARCHITEKTONISCH VISUELLEN
NEUGESTALTUNG ANZUNEHMEN.
NACH EINGEHENDER PRÜFUNG WAS PASSIEREN
WÜRDE WENN SPITTELAU NICHT IN BETRIEB
GEHT, D.H. WENN MAN ZU ENDE DENKT
SIND DIE NEGATIVEN AUSWIRKUNGEN BEI WEITEM
SCHLECHTER.
DENN DIE ABFALLFREIE GESELLSCHAFT IST NICHT
FÜR MORGEN.
HOFFENTLICH FÜR ÜBERMORGEN.
ICH WERDE VEHEMENT DAFÜR KÄMPFEN UND WIR
ALLE MÜSSEN TÄGLICH DARAN ARBEITEN.



Translation of the original text from Friedensreich Hundertwasser:

… We ourselves, all of us, every single Viennese, are responsible for our waste. Were we to produce no waste none could be incinerated. Let us boycott the waste incinerators by not supplying any waste. Is that doable in Vienna today? You would have to criminalize waste. You would have to severely punish those who produce waste, the packaging industry, those who cause waste, the waste makers, I.e. all of us in order to accomplish a radical prevention of waste.I have struggled with myself for a whole year using the same arguments you give to refuse the job before I decided to accept the commission for the architectural-visual redesign. After looking closely at what would happen if Spittelau were not put into operation, i.e. if you think it through to the end, the negative impact would be far worse because a waste free society is not for tomorrow. Hopefully, for the day after tomorrow. I will fight fiercely for this and all of us must work on it daily…

WHAT SIGNIFICANCE DOES WASTE INCINERATION HAVE IN ENERGY SUPPLY?

A CLOSE EXAMINATION OF SPECIFIC EXAMPLES clearly shows that thermal treatment of residual waste and other comparable wastes entails economic benefits as it reduces the use of conventional fuels on site (thanks to the energy recovery of waste heat); this makes "reactor landfills" and waste landfills unnecessary and also precludes any long-term costs for aftercare measures and restrictions on use for future generations.
All in all, the thermal treatment of residual waste and other comparable waste with high calorific value has benefits in store for the national economy which far exceed the business advantages of seemingly "cheap waste landfills".

IN TERMS OF THE NATIONAL ECONOMY, a further economizing factor is given by the pre-emptive credit thereby earned in terms of the reduction in greenhouse gas emissions Austria will be required to implement in the future.
Energy efficiency is indispensable for sustainable resource management and is decidedly determined by the site choice and the plant design. In planning thermal waste treatment plants, the requirements of the EU IPPC Directive must be observed (IPPC = Integrated Prevention Pollution Control). According to this Directive, the best available techniques must be used (BATs).

A SCIENTIFICALLY PLAUSIBLE CALCULATION can determine energy efficiency using various methods. Energy efficiency is derived in a simplified manner from the proportion of energy used (e.g. electricity, process and thermal heat and coolness for cooling processes), put into relation to the thermal performance provided (calorific value of waste and auxiliary fuels), and expressed in percent.

THE FOLLOWING SAMPLE CALCULATIONS (options 1 through 6) for use of 100% waste-derived fuel illustrate the typical differences in efficiency, given the customary loss factors in Austria for waste heat (discharged flue gas, etc.), flue gas cleaning and residues, in relation to plant design and choice of the site. The actual utilization rates in the operation will be somewhat lower due to the start-ups and run-downs and the required auxiliary fuels.

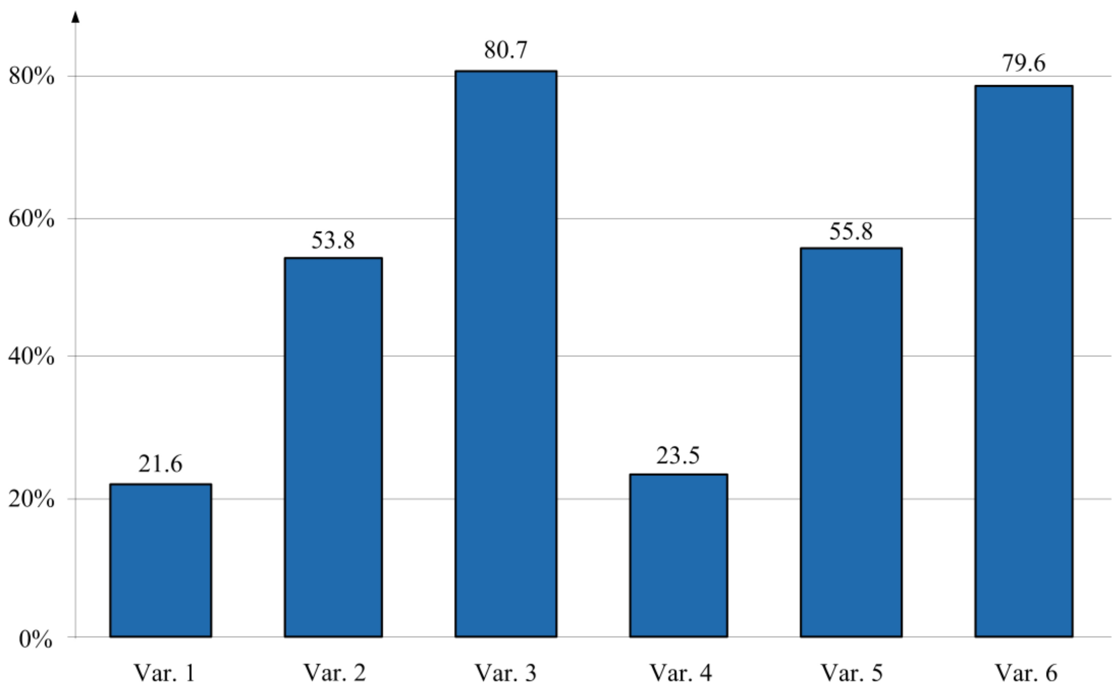
Assumptions for sample efficiency calculations of waste incineration

	Unit	Variant 1	Variant 2	Variant 3	Variant 4	Variant 5	Variant 6
Energy utilization		Electricity	CHP	CHP	Electricity	CHP	CHP
Steam parameter	bar °C	40 400	40 400	40 400	65 460	65 460	65 460
Low-pressure steam parameter	bar °C	- -	5.5 185	5.5 185	- -	5.5 185	5.5 185
Net electricity	%	21.6	13.8	8.7	23.5	15.8	10.8
Heat extraction	%	0	40	72	0	40	68
Sum total electricity and heat	%	21.6	53.8	80.7	23.5	55.8	79.6

Source: Zechner F., 2009

Options 1 to 3 are based on the standard steam parameter of 40 bar and 400°C for waste incineration. Options 4 through 6 have higher steam parameters with 65 bar and 460°C due to the generation of larger amounts of electricity. (Note: Higher steam parameters mean higher wall temperatures on the flue gas side of the boiler pipes and therefore a higher risk of corrosion, which may lead to higher costs and reduced plant availability.) An increase in heat extraction has been assumed for both options 1 to 3 and 4 to 6, i.e. 0% to 40% and the maximum steam extraction of approximately 70% (in relation to the added thermal performance of the waste-derived fuel).

Comparison of results for examples of calculated energy efficiency



Source: Zechner F., 2009

THE HIGHEST ENERGY EFFICIENCY is achieved with maximum heat extraction and lowest steam parameters (lower consumption of electrical energy for cooling and condensation). Thermal waste recovery plants can attain energy efficiency of some 80% if the plant design is optimized and the chosen site is appropriate. Maximum efficiency can be achieved by taking the following factors into account:

- Site with complete, year - round heat utilization
- High steam parameter (pressure, temperature)
- Low flue gas temperature at boiler outlet
- Low off-gas amount achieved by suitably devised and controlled firing and partial flue gas recirculation (i.e. low level of residual oxygen in off gas)
- Complete incineration of solid materials and incineration gases
- Heat recovery systems within the plant (possibly also from ash cooling) and therefore low off-gas temperature at chimney outlet
- Low energy consumption, both in waste pre-treatment and plant operation
- No energy-intensive treatment processes for residues of plant operation
- Reducing consumption of chemical additives and auxiliary fuels to a minimum and avoiding

frequent start-ups and shut-downs as well as downtimes
- Optimal plant size: smaller plants have higher losses and greater energy consumption per ton of throughput.

In Annex II of the Waste Framework Directive of the EU, a simplified formula is stipulated for the calculation of energy efficiency.

Minimum requirement energy efficiency:
Installations in operation and permitted before 1 January 2009 > 0.60,
Installations permitted after 31 December 2008 > 0.65

$$\textbf{Energy efficiency} = \frac{(Ep-(Ef+Ei))}{0.97\times(Ew+Ef)}$$

Legend:

Ep Annual energy produced as heat or electricity (GJ/year)

Ef Annual energy input to the system from fuels contributing to the production of steam (GJ/year)

Ei Annual energy imported excluding Ew and Ef (GJ/year)

Ew Annual energy contained in the treated waste (GJ/year)

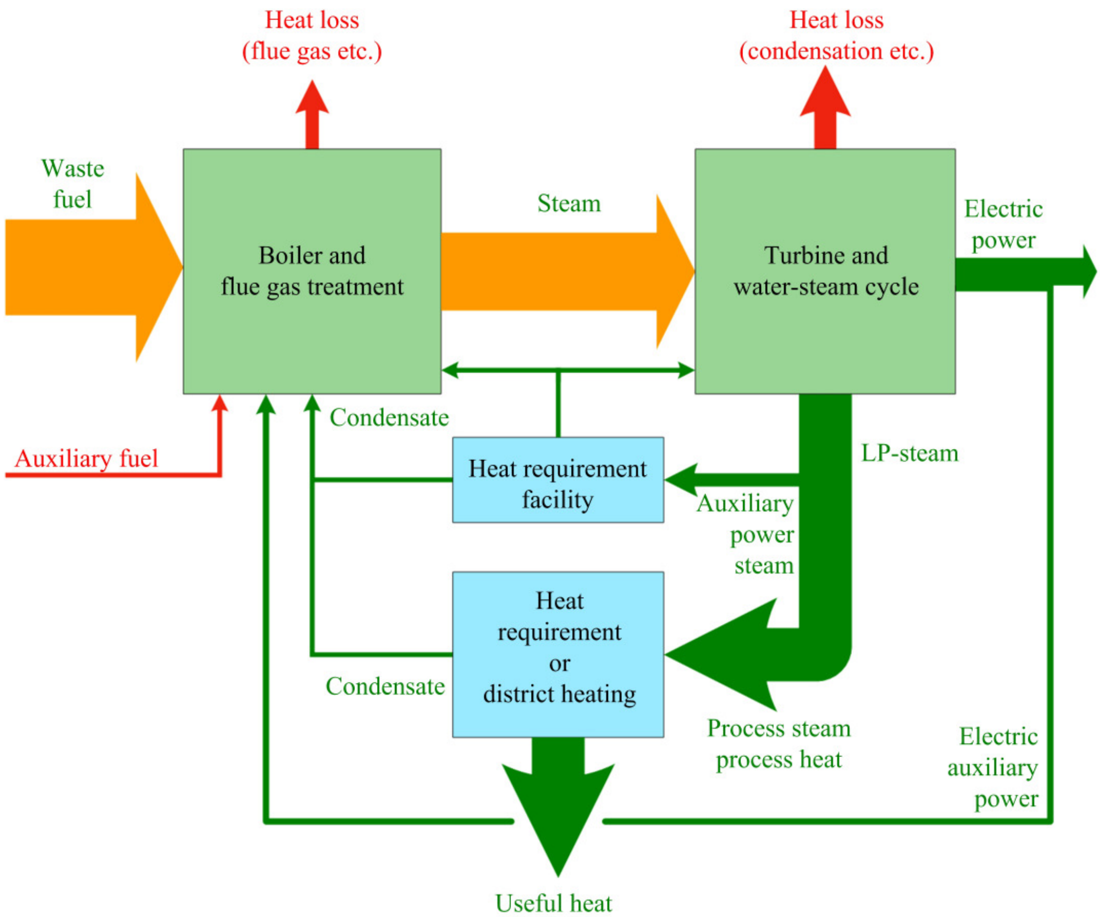
0,97 It is a factor accounting for energy losses due to bottom ash and radiation

The following equivalents shall be used for all figures in the formula:

- Electricity: 1 MWh abs = 2.6 MWh equivalent (comparable to electricity production in a coal-fired power plant)
- Process heat: 1 MWh abs = 1.1 MWh equivalent (comparable to a boiler for heat production)

It should be noted from an expert view that the appropriate choice of sites for new facilities and competent process design will allow for R1 values exceeding 0.9 or even 1.0, as proven by Best Practice examples in Austria. Even in countries with warmer climate conditions (and therefore no district heating demand) the competent choice of sites and process design will allow for R1 values well above 0.65, which should also be a “must” in terms of resource and energy efficiency as well as greenhouse gas emission reduction as requested by several EU Directives.

Energy flux for the calculation of energy efficiency



Source: Zechner, F., 2009

In a broader perspective of energy management, the option of reducing the use of additives to a minimum (whose production requires high energy input) should also be taken into consideration.

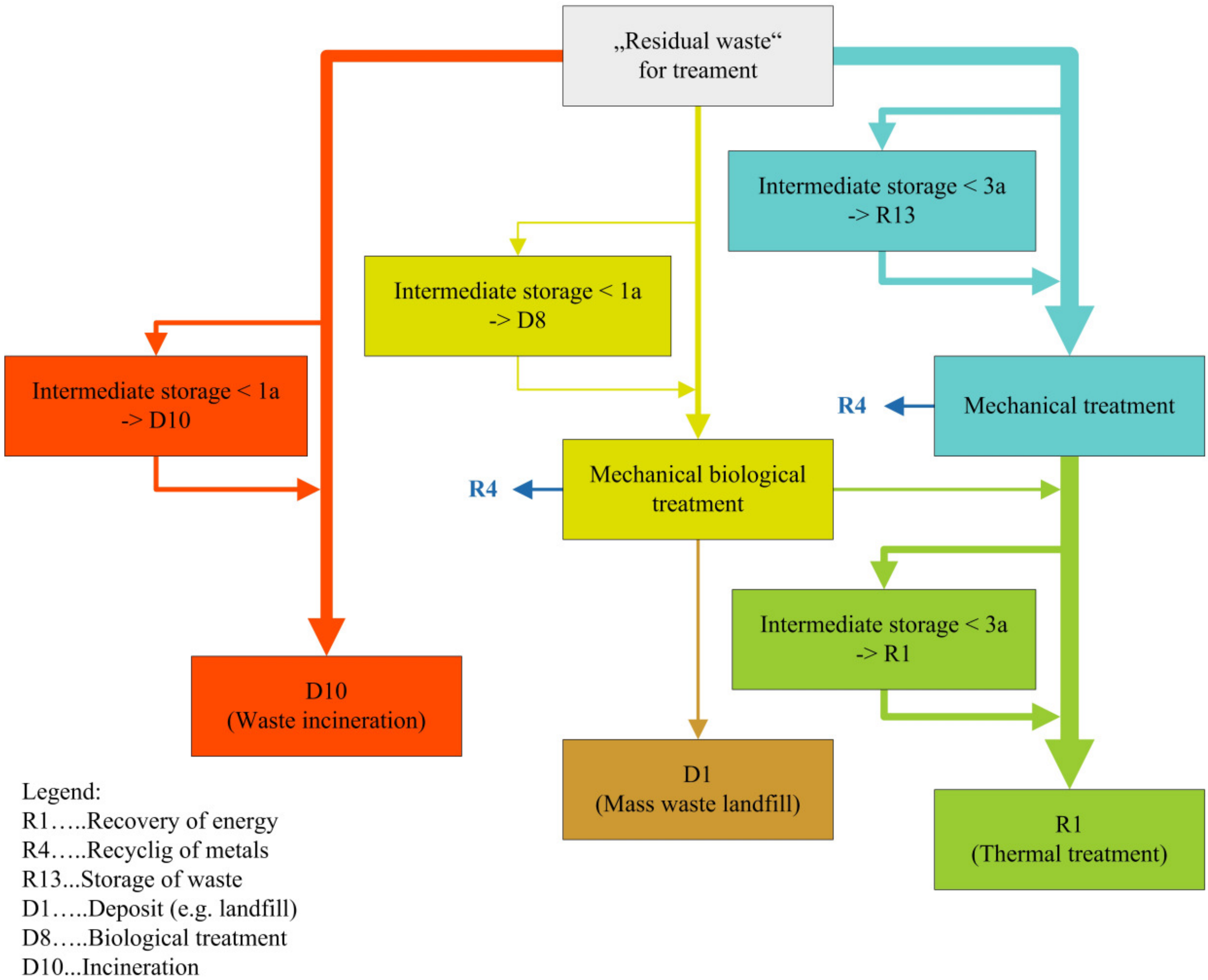
Examples are:

- Use of limestone instead of sodium hydroxide solution or sodium hydrogen carbonate
- Use of silt from gravel washing instead of cement to immobilize ashes

WHAT WASTE INCINERATION CAPACITY IS REQUIRED FOR DIVERSION OF MUNICIPAL SOLID WASTE FROM LANDFILL?

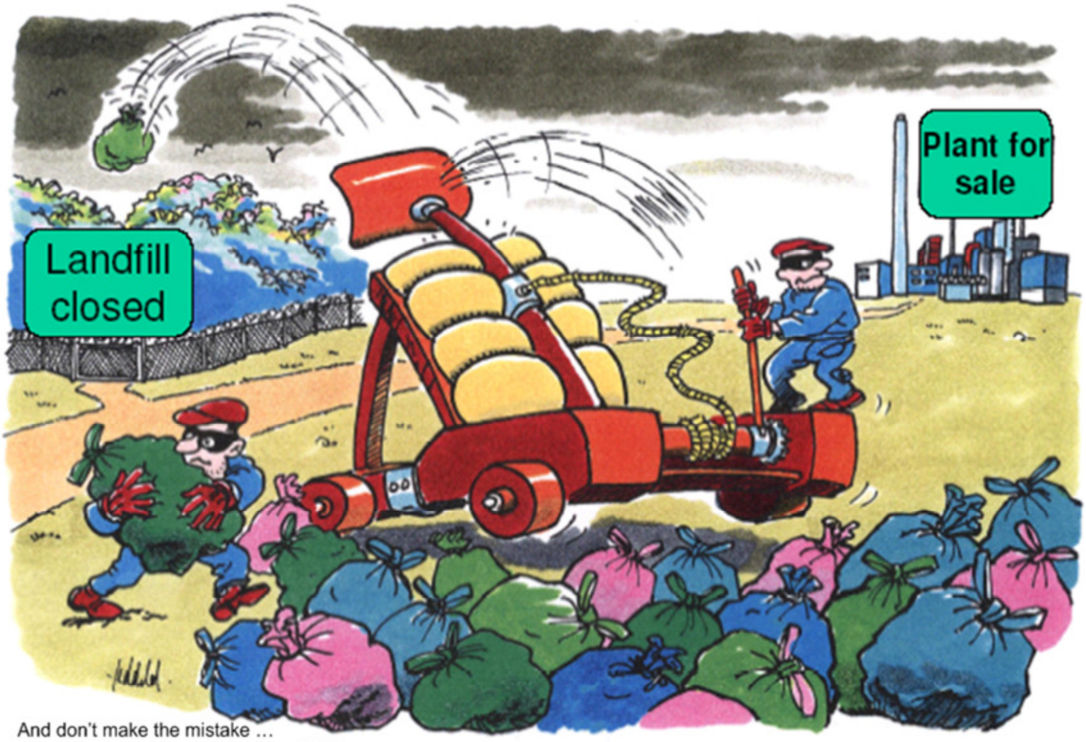
IN LIGHT OF THE STATUTORY REQUIREMENTS for the necessary treatment of various wastes in Austria, appropriate plant capacities for "waste disposal" are needed to ensure the sought self-sufficiency in waste disposal.

Technical alternatives for the proper treatment of residual waste in Austria



Source: Neubacher F., 2009

FOR THE SAKE OF SELF-SUFFICIENCY of a State in terms of the disposal of waste, which is historically called "Müll" or “Kehrricht” in German language, which could be translated as “trash” (and is designated to be “beseitigt” which translates to something like "done away with" or “disposed of”) the need for additional and new capacities for waste-to-energy was determined in the past by the legally requested exact notifications of the specific wastes (by exact recording of the Waste Codes and kg per year) being landfilled in the respective calendar years (disposal operation D1) and by taking into account the volumes exported (and also imports if applicable) for incineration (disposal operation D10 or recovery operation R1), but only in hindsight (with a delay of some 1 to 2 years for entry and statistical analysis). Furthermore, all additional capacity under construction or in the permitting or planning stage have been carefully considered as well as the closure dates of already operational facilities. These careful analyses suffered a significant setback: Undeclared "storage" of waste and large shipments of waste across the (technically open) borders, often even with misleading or wrong declarations (e.g, "Green" listed materials on top of another waste). In a market economy the waste always flows towards the destinations with lower cost. In reality the price level of (old, often even financially subsidized) landfills (particularly in Eastern and Southeastern Europe) and thus options for co-combustion in old coal-fired plants and cement kilns at that very same price level in those regions caused major material flows through profit-oriented waste management firms towards those cheaper destinations. The result can be economically destructive for new investments in waste-to-energy plants (as illustrated by the "plant for sale" in the picture "And don't make the mistake..." presented by German experience illustrated by Hamburg-2008).

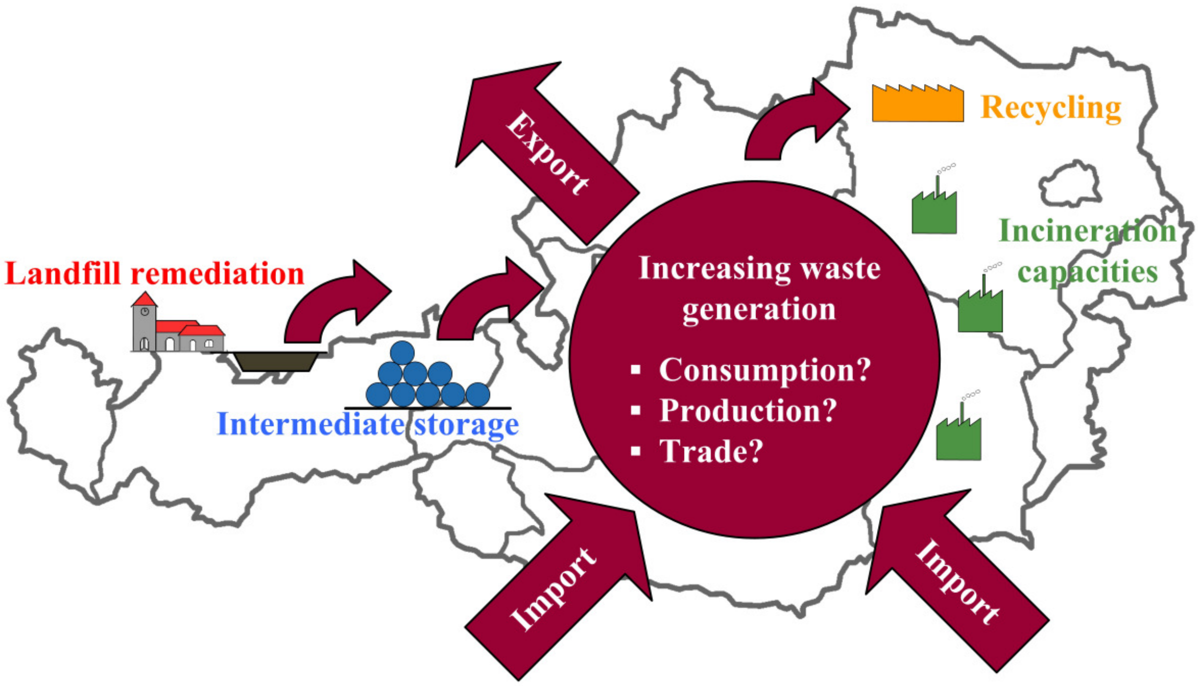


And don't make the mistake ...
Source: Stadtreinigung Hamburg-2008

WASTE MANAGEMENT IS A DYNAMIC SYSTEM that involves changes difficult to forecast, particularly in terms of prevention and the development of waste volumes, new establishments, or closures of production, additional requirements for decommissioning and remediation of contaminated landfill sites, but also in terms of changes in the temporary stored waste volumes and in the framework of transboundary cooperation.

Another factor to be considered is the fact that population growth accompanied by an increase in material wealth leads to the generation of a specific higher waste volume (smaller households, changing fashions, etc.) and, as a consequence of economic growth, the waste volumes produced increase by approximately 2% annually. The rise in the average calorific value disproportionately augments the need for additional incineration capacities.

Development of waste generation and incineration capacity in Austria



Source: Neubacher F., 2009

1. THERMAL TREATMENT FOR REMEDIATION OF CONTAMINATED SITES

THERMAL TREATMENT is also required when clearing and remedying a contaminated landfill site. If proper splitting is ensured, the costs for contaminated site remediation can be reduced – compared to complete clearing and incineration of the contaminated material – by reintegrating the separated and treated fine fractions in a sealed section of the landfill at the given contaminated site.

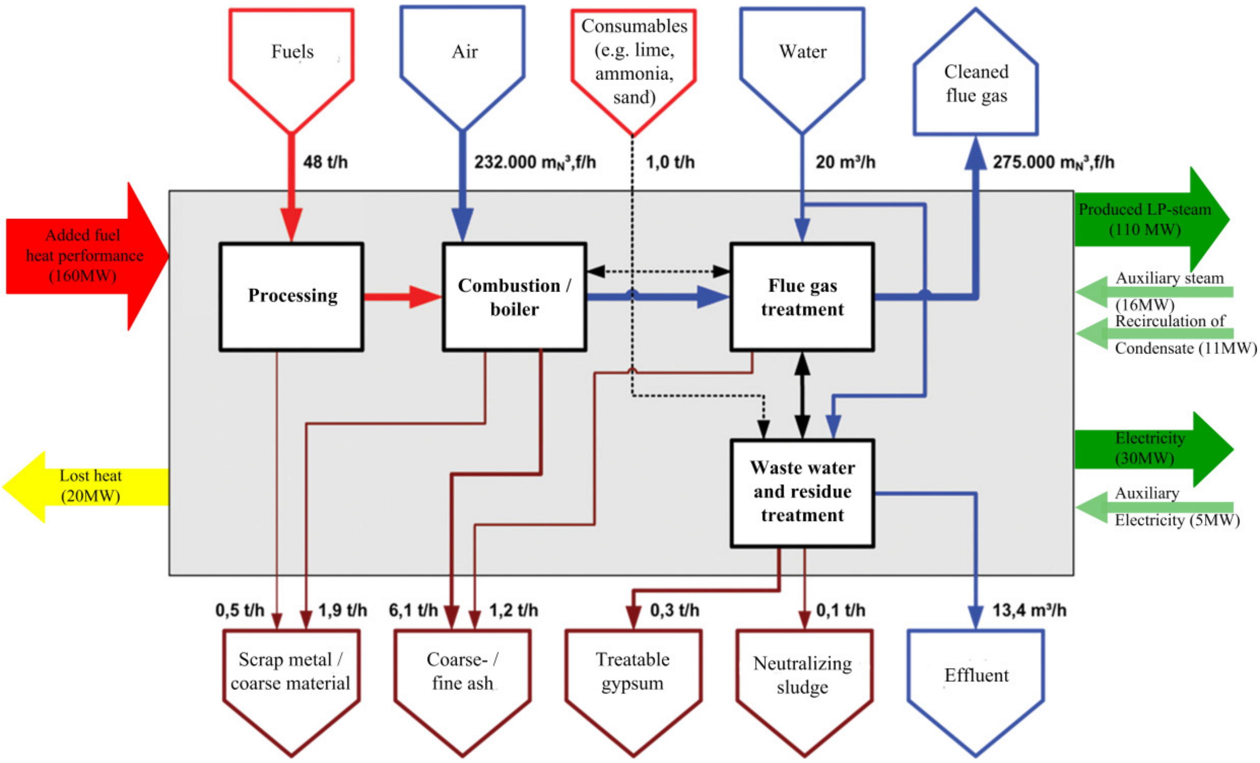
2. RECYCLING AND ENERGY RECOVERY FROM WASTE IN THE INDUSTRY

THE INTEGRATION OF THERMAL WASTE RECOVERY at industrial sites with continuous whole-year heat requirement (cogeneration) is an important factor of any sustainable economy.
The combination of Austria's high expertise in environmental technology with suitable industrial sites requiring whole-year heat utilization allows for a further expansion of thermal waste recovery in the interest of the business location. This is a contribution to reducing the volumes of high-calorific waste still being disposed of in neighboring countries of the EU. In addition, this will make imports of fossil fuels unnecessary and reduce CO_2 emissions. (Note: It is preferable to have waste fuels supplied by rail from neighboring EU countries than to have expensive crude oil coming from distant countries like Nigeria, Libya, Venezuela or from the Middle East).

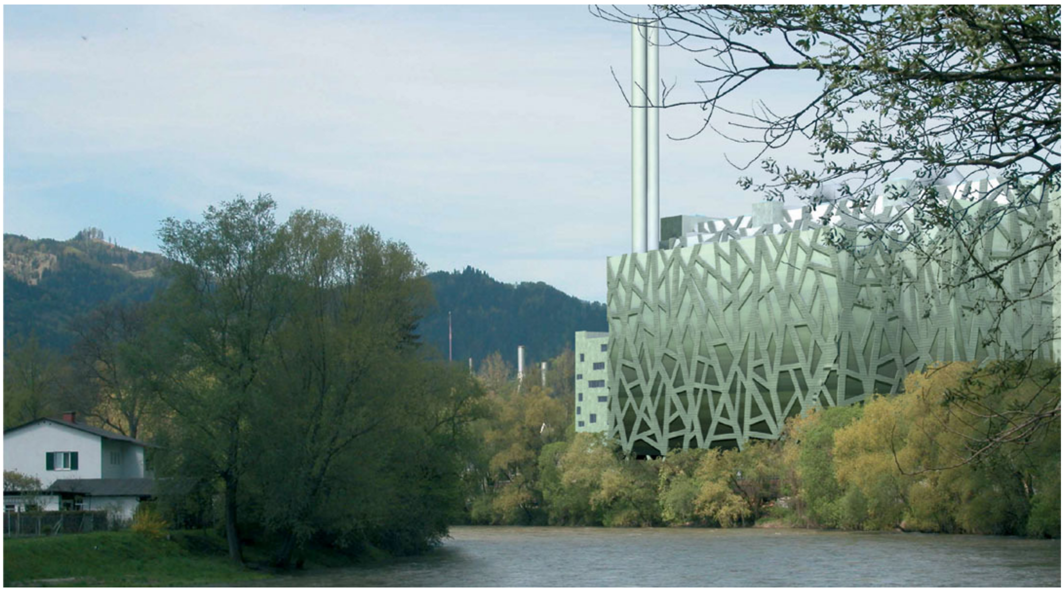
The following example which cites the new energy hub planned for the location of the Mayr-Melnhof cardboard factory in Frohnleiten with a thermal capacity of 160 MW (which corresponds to 19.2 t of anthracite per hour or 19.2 t of coal equivalents/h) presents the energy and waste management concept in a project of this magnitude.

Thanks to careful architectural planning, such facilities can be integrated into the surrounding town and landscape as shown by the following photo composition for the new energy hub of the Frohnleiten cardboard factory.

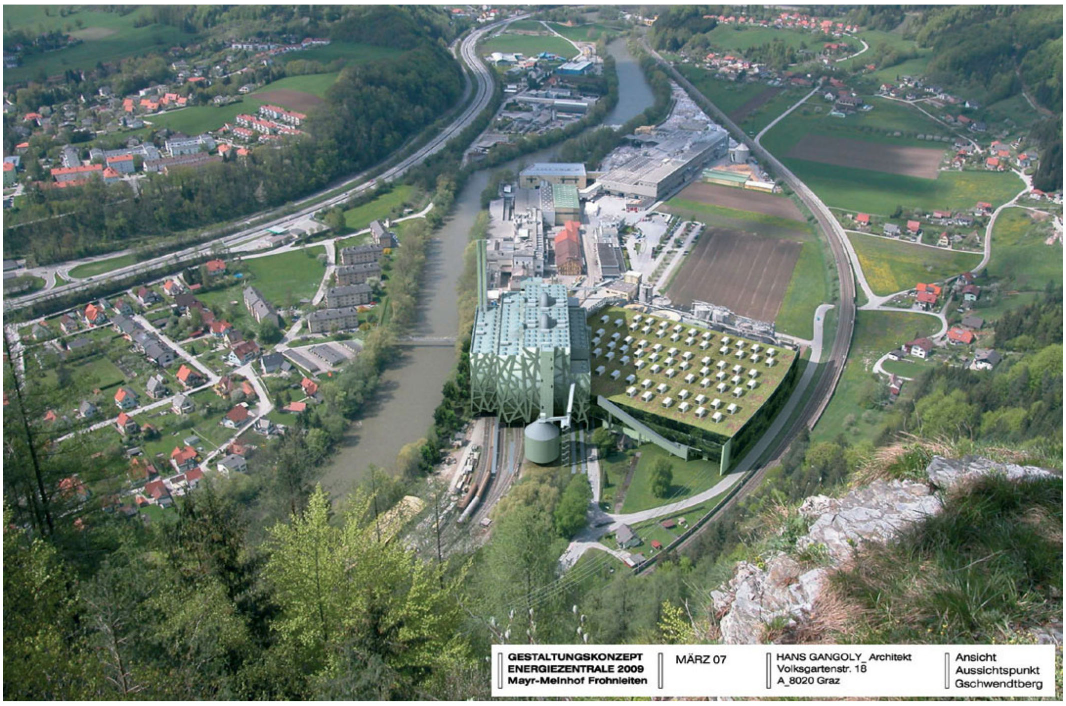
Planned energy center for MMK Frohnleiten – input – output balance for 2 lines with an average fuel mix (calorific value approx. 12 MJ/kg)



Source: UV&P, 2007



Photomontage of the planned Energy Centre Mayr-Melnhof Frohnleiten



View of Gschwendtberg with the photomontage of the planned Energy Centre Mayr-Melnhof Frohnleiten

WHAT ARE THE CITIZENS’ RIGHTS IN THE APPROVAL PROCEDURE FOR A WASTE INCINERATION PLANT?

IN AUSTRIA, the approval of new waste incineration plants is subject to strict statutory provisions. Binding directives are also already effective within the EU. Citizens enjoy the right to information, participation, and, in the event that a citizen is party to proceedings, legal recourse against the granting of an approval.
Starting with a plant size of 100 tons non-hazardous waste per day, the specifications of the Council Directive of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment (the initial Directive 85/337/EEC and its three amendedments have been codified and amended in 2014 by Directive 2014/52/EU) must be observed. In Austria, the Council Directive is implemented through the Environmental Assessment Law (Umweltverträglichkeitsprüfungsgesetz 2000). This comprehensive procedure has the significant advantage of concentrating all the differing legal requirements given in various regulations into only one (although rather complex) permitting process.

THIS ENVIRONMENTAL IMPACT DIRECTIVE requires the developer submitting a project to draw up an environmental impact statement including the following information:

- Description of the project including site, type of project and scope.
- Overview of the most important solutions looked into by the project applicants and indication of the main reasons for the selection.
- Description of the environment (status quo) which may be considerably impaired by the project; these include the population, flora, fauna, soil, water, air, climate, material and cultural goods, the landscape and correlations between these factors.
- Description of any major effects the project could have on the environment.
- Description of the measures to be taken to avoid, reduce and off-set to the greatest extent possible any major harmful effects.
- Overview of the most important other solutions looked into by the project developer and indication of the main selection reasons in terms of their environmental impact.
- Non-technical summary of the data referenced above.
- Short description of any difficulties encountered while compiling the required information.

ALL MEMBER STATES must ensure that the general public is given access to the approval applications and the required information within a reasonable deadline. In this way, the public is given an opportunity to express its opinion on the granting of an approval.

1. THE APPROVAL PROCEDURE

THE FIRST AND MOST IMPORTANT INFORMATION for interested parties is the public announcement of the project by the authority "in an appropriate form" (e.g. regional newspaper, official publication of the Federal Province, etc.). At the same time, the public must also be informed of the application by having the information posted at the municipal office of the plant site and in the adjacent municipalities and, if applicable, through other appropriate means. In addition, the project documents must be made available for personal inspection by interested parties at the district administrative authority and the municipality of the plant site.

OPINIONS MAY BE SUBMITTED WITHIN THE DEADLINE PRESCRIBED BY LAW. These must then be taken into consideration when deciding on the approval application.

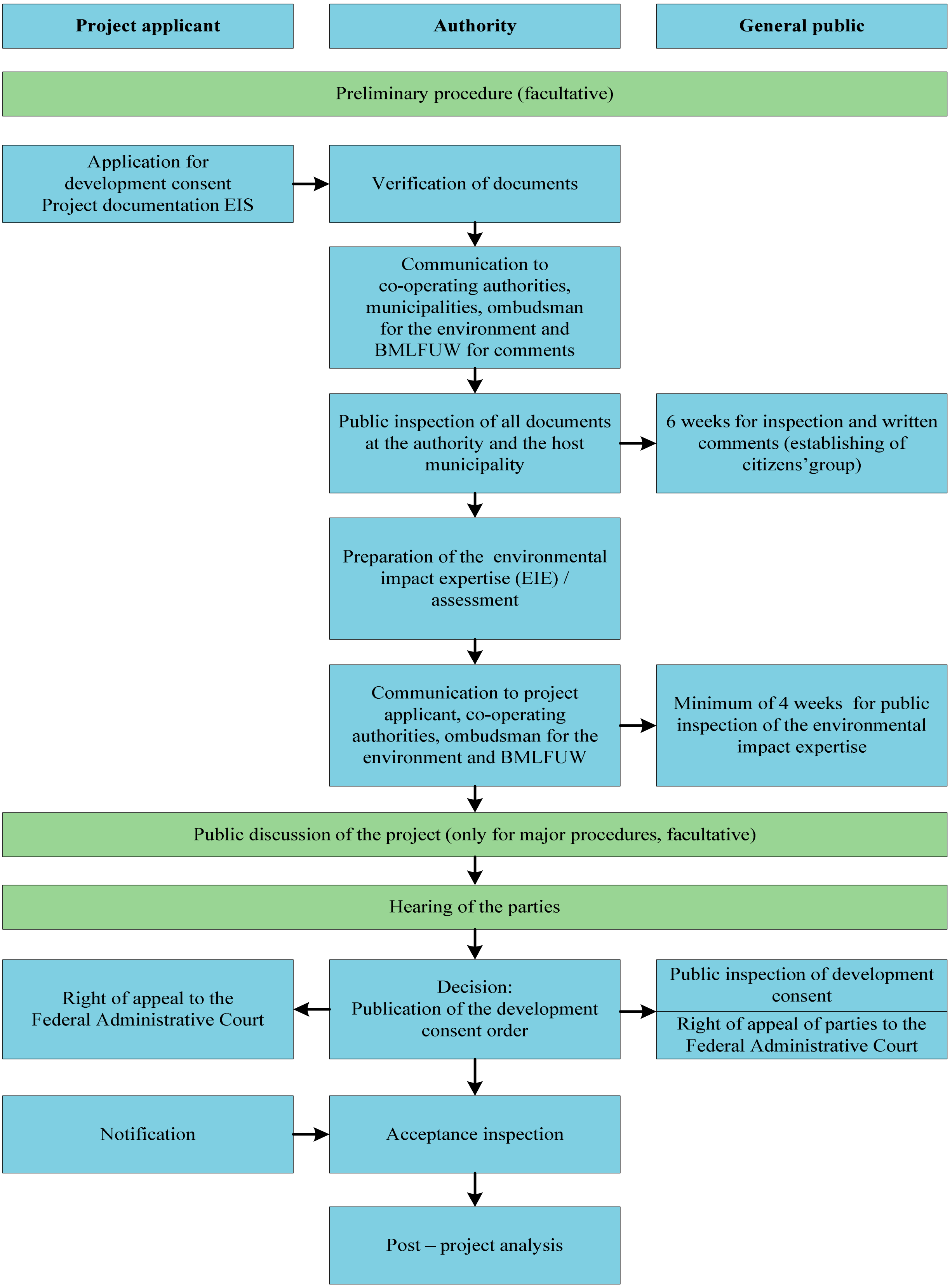
The parties enjoying locus standi are:

- Neighbors
- Municipalities of the site
- Adjacent municipalities
- Parties pursuant to the substantive law stipulated by the applicable administrative provisions
- Environmental ombudsperson and water management planning body
- Citizens groups (at least 200 people who are eligible to vote in the municipality of the site or the adjacent municipalities)
- Environmental organizations

THESE PARTIES ARE GIVEN AN OPPORTUNITY to participate in the procedure and, if needed, take legal recourse against a decision (including right of complaint before the Constitutional Court [VfGH] and the Administrative Court [VwGH]).

THE FOLLOWING ILLUSTRATION shows the numerous steps to be taken in the course of an Environmental Impact Assessment and highlights everyone's right to inspection and right to submit an opinion, providing reference to the pertinent provision in the Environmental Impact Assessment Act.

Development consent procedure according to the Austrian Federal Act on Environmental Impact Assessment (EIA)



Source: Umweltverträglichkeitsprüfungsgesetz, 2000

WHAT INFORMATION MUST THE PLANT OPERATOR PROVIDE?

IN JUNE 1990, the Council of the European Union adopted Directive 90/31/EC on the freedom of access to information on the environment. This Directive warrants public access to all environmental data available at state bodies. Upon Austria's accession to the European Economic Area (EEA), the right to free access to information on the environment had to be transposed into Austrian law by 1 January 1994. In Austria this was ensured at federal level by enacting the Environmental Information Act (UIG, Federal Law Gazette No. 495/1993 last amended by Federal Law Gazette No. 97/2013) on 1 July 1993.
Detailed documents with the following structure, including a waste management plan, must be provided as early as when submitting the application for approval of a waste incineration plant:

- General information
- Description of processes
  - Description of the operations relevant to the operational waste management, processes and plant parts with an indication of the capacities and, to the extent possible, an allocation of the amounts of waste and production residues
  - Description of the reliance of waste and production residue amounts on the volume, type and quality of the materials used
  - Description of the qualitative and quantitative measures taken to ensure waste prevention and recovery
- Description required under waste law
  - Description of the waste to be generated (classified according to hazardous waste, non-hazardous waste, waste materials, and waste oils) with an indication of the type, key number, volume, special characteristics, whereabouts and recipient (external/internal)
  - Waste logistics (if possible, schematic presentation, overview plan, short description of technical precautions)
  - Assessment of future developments

The documents accompanying the application for the approval of a plant must be made accessible to interested parties in a consent procedure.

1. INDIVIDUAL REQUEST FOR INFORMATION ON THE ENVIRONMENT

A REQUEST FOR THE DISCLOSURE OF INFORMATION on the environment in accordance with the Environmental Information Act (UIG) may be submitted to the authority in various forms. Generally, any request should be submitted in a writing, i.e. by letter or fax, for evidentiary purposes.
When requesting the disclosure of information on the environment, formulating the request as clearly as possible is decisive. If the formulation is too general, the party requesting the information may be asked to make the request more precise:

- Information on the state of the environment and its individual elements such as air, water, soil, noise nuisance, fauna and flora
- Information, “aggregated in time or in statistical form”, on the consumption of natural resources
- Information, “aggregated in time or in statistical form”, on emissions of substances or waste from a plant into the environment
- Information when emission limit values are exceeded

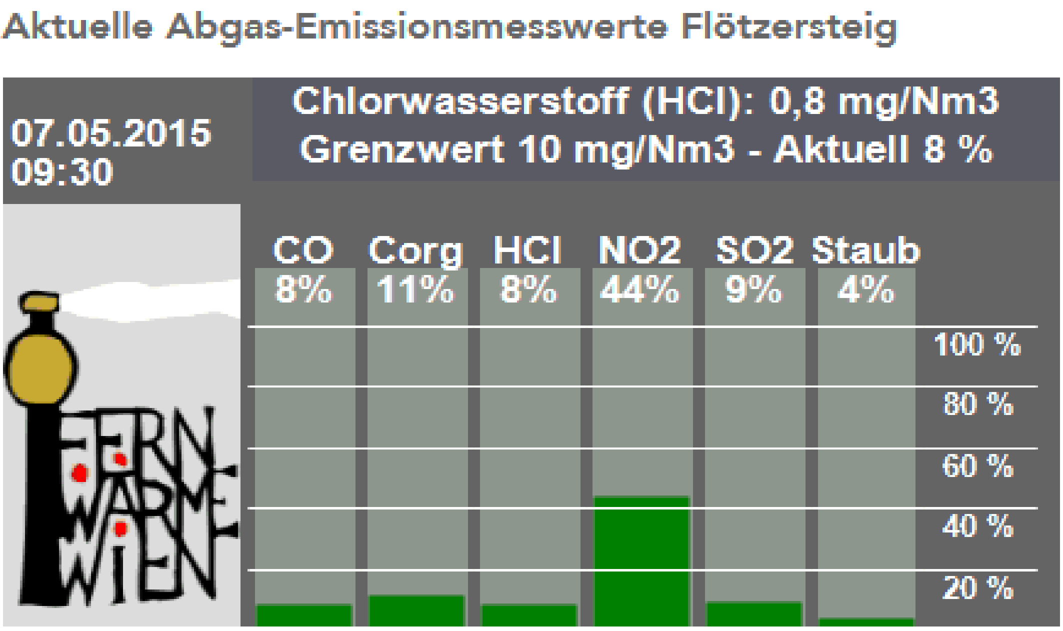
2. PUBLIC ACCESS OF EMISSIONS

FOR PEOPLE LIVING IN THE NEIGHBORHOOD of a thermal waste treatment plant, it is the quality of the atmospheric emissions cleaning and its ongoing monitoring in particular that are of interest. The Environmental Information Act (UIG) provides for the active responsibility on the part of enterprises to inform. They are obligated under law to measure emissions and keep records on emissions in their own operation. Pursuant to Sec. 13 (1) Waste Incineration Ordinance (AVV), owners of an incineration or co-incineration plant with a nominal capacity of two tons per hour or more are obligated to submit an emission declaration for the index via the EDM portal.

USING THE ELECTRONICALLY TRANSMITTED DATA by the individual plant owners, the information is made available to the public via the EDM portal (see http://www.edm.gv.at).
This emission declaration also forms the basis for the duty to submit an annual report to the European Commission. The data provided by all Member States is then publicly available (http://eionet.europa.eu/).

THE SPITTELAU WASTE INCINERATION PLANT IN VIENNA is an example of a plant that had publicly disclosed its essential, continuously measured parameters for many years on a clearly visible posting board. Furthermore, the competent monitoring authority is able to query current data via the online connection on a continuous basis. Interested parties can also query key data via the internet (http://wienenergie.at).

Public display panel with the current emission data of the waste incineration plant Spittelau in Vienna



Online emission data Waste-to-Energy plant Flötzersteig, published on Wien Energie portal, Vienna, 2015 (http://www.wienenergie.at/eportal2/ep/channelView.do?channelId=-49103)

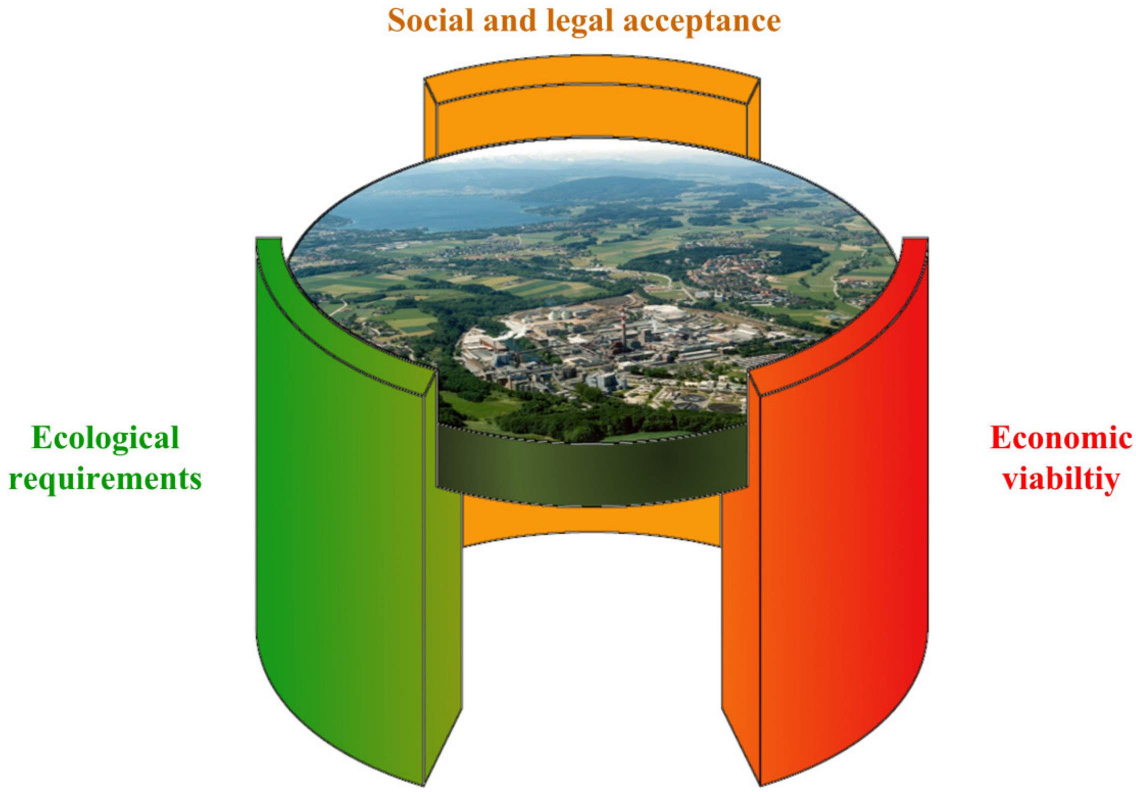
WHAT ARE THE RECOMMENDATIONS FOR KNOW-HOW TRANSFER IN WASTE-TO-ENERGY?

WASTE IS A COMPLEX ISSUE. Integrated waste management became known about 30 years ago in Austria, Germany and Switzerland. Thus, much experience is available from those senior experts, also with respect to suboptimal projects and costly failures as well as successful experience and economically valuable know-how.

The successful development and implementation of a waste-to-energy project in a region must consider ecological conditions for protection of the environment, social and legal acceptance as well as economic viability, which require an interdisciplinary approach in the competent engineering of such projects. The following illustration indicates the need of "3 supportive legs" for a stable foundation in a successful integration of a large waste-to-energy plant in a region.

Illustration of the interdisciplinary approach for the successful implementation of a waste-to-energy project

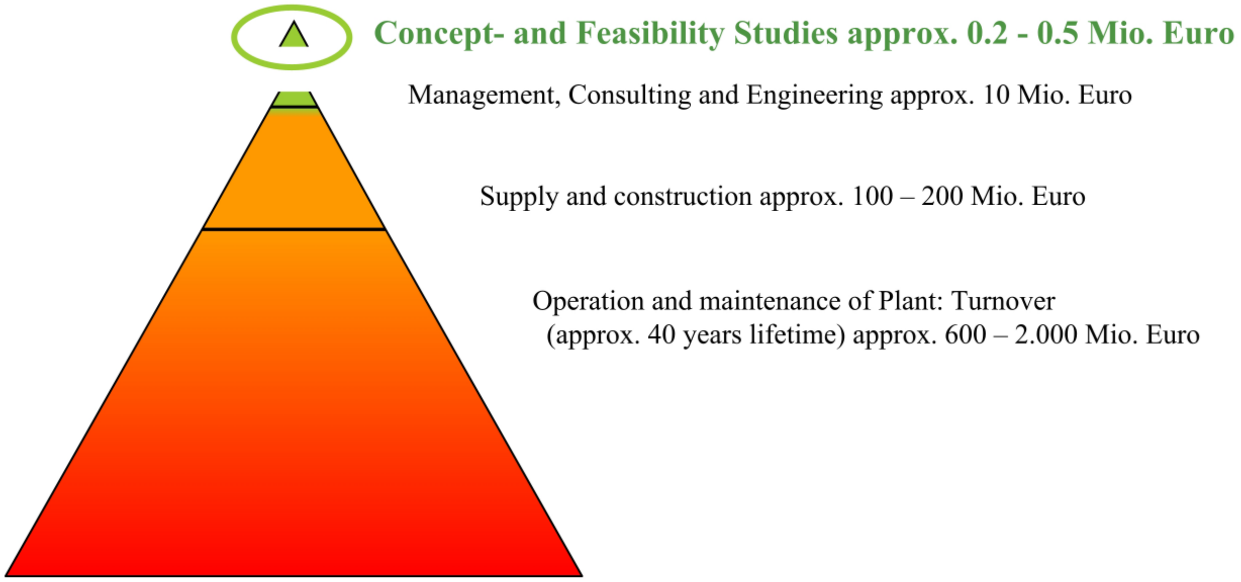
Photo indicates location of the industrial site Lenzing in the tourist region of Lake Attersee in Austria



Source: UV&P, 2009

THE ECONOMIC SIGNIFICANCE of a medium size or large waste-to-energy plant can be realized by significant investment costs in the range of 100 to 200 million Euros. The initial costs of about 0.2 to 0.5 million Euros for a competent concept study with systems analyses of regional waste and energy management, technical alternatives, preliminary evaluation of potential sites and a pre-feasibility study will largely determine the overall, long-term success (or suboptimal performance or even disastrous economic failure) of a project, which may accumulate costs and revenues of about one billion Euros over a useful life time of about 40 years, as indicated in the following illustration.

Overall costs of a thermal waste treatment plant over a time period of 40 years



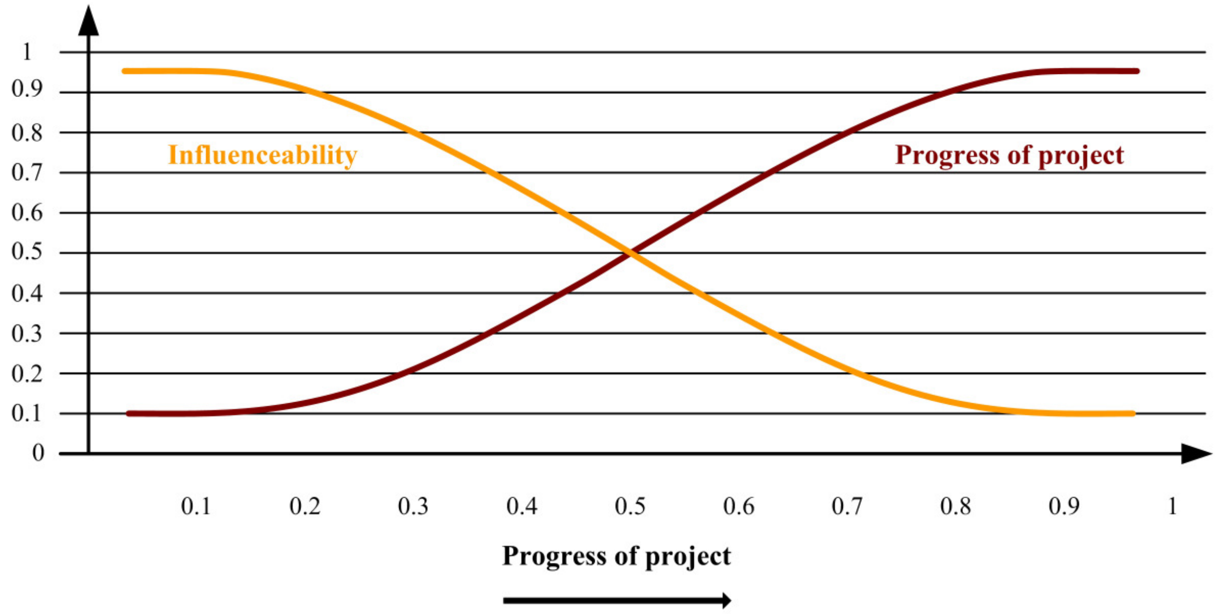
Source: UV&P, 2015

IT SHOULD BE NOTED that the optimum treatment of mixed municipal waste (as a necessary part of an integrated overall system for prevention of waste and management of resources) may at the present time in some regions only comprise mechanical separation including recovery of metal scrap, sieving, controlled disposal of the fine fraction in a landfill with extraction and utilization of biogas and the technically safe intermediate storage of the high calorific light fraction in compressed bales with multilayer protective wrapping and coverage for future use in a new waste-to-energy plant in the region.

THE INFLUENCE on the overall design and profitability of a project is largest at the beginning and will be dramatically reduced during the subsequent professional execution.

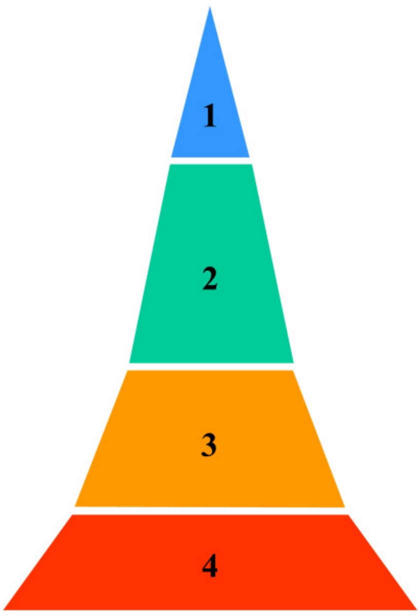
KNOW-HOW TRANSFER to regions with lack of experience may include various specific engineering tasks, as indicated in the following illustration. It will always be vital to cooperate with competent local people to ensure adaptation to local conditions and sustainability.

Influenceability and investment of project during its progress



Source: Pelloni, 2010

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
- Pre-Feasibility study

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

Source: UV&P, 1991

WHERE DOES ONE FIND FURTHER INFORMATION ON WASTE INCINERATION?

EU authorities and general information

European Commission – DG ENVIRONMENT 200, Rue de la Loi, 1049 Brussels, Belgium http://ec.europa.eu/dgs/environment	+32(0)2 / 29-91573
CEWEP – Confederation of European Waste-to-Energy Plants e.V. Avenue de Tervuren 113, 1040 Brussels, Belgium http://www.cewep.com	+32 (0)2 / 7706311
ITAD – Interessensgemeinschaft der thermischen Abfallbehandlungsanlagen in Deutschland e.V. Peter-Müller-Straße 16a, 40468 Düsseldorf, Germany http://www.itad.de	+49(0)211 / 9367609-0
ISWA International Solid Waste Association Auerspergstraße 15, 1080 Vienna, Austria http://www.iswa.org	+43(0)1 / 2536001

Plant operators in Austria

Wien Energie GmbH Spittelauer Länder 45, 1090 Vienna, Austria http://www.wienenergie.at	+43(0)1 / 58200
.A.S.A. Abfall Service AG Hans-Hruschka-Gasse 9, 2325 Himberg, Austria http://www.fcc-group.eu/de/Osterreich/Home.html	+43(0)2235 / 855-0
EVN Abfallverwertung Niederösterreich GmbH AVN Straße 1, 3435 Zwentendorf, Austria http://www.evn-abfallverwertung.at	+43(0)2277 / 26121-0
Energie AG Oberösterreich Umwelt Service GmbH Flughafenstraße 8, 4063 Hörsching, Austria http://www.umweltservice.energieag.at	+43(0)50 / 823-0
ABRG Asamer-Becker Recycling GmbH Industriestraße 17, 9601 Arnoldstein, Austria http://www.abrg.at	+43(0)4255 / 3990-0
KRV Kärntner Restmüllverwertungs GmbH Industriestraße 25, 9601 Arnoldstein, Austria http://www.krv.co.at	+43(0)4255 / 22366
ENAGES Energie- und Abfallverwertungsges.m.b.H. Proleber Straße 10, 8712 Niklasdorf, Austria http://www.enages.at	+43(0)3842 / 83481-100

Technical consulting and project planning

R + M – Ressourcen + Management GmbH Marktgasse 34, 7434 Bernstein, Austria http://www.re-ma.at	+43(0)3354 / 23937
UVP Environmental Managment and Engineering GmbH Lassallestraße 42, 1020 Vienna, Austria http://www.uvp.at	+43(0)1 / 2149520

Detailed planning and plant construction

ANDRITZ Energy & Environment GmbH Waagner-Biro-Platz 1; 8074 Raaba / Graz, Austria; Eibesbrunnergasse 20, 1120 Vienna, Austria http://www.andritz.com/de/pp-andritz-energy-environment-gmbh	+43(0)316 / 501-0 +43(0)1 / 50805-0
BERTSCH Holding GmbH Herrengasse 23, 6700 Bludenz, Austria http://www.bertsch.at	+43(0)5552 / 6135-0
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APPENDIX

A1 EU DIRECTIVE 2008/98/EC ON WASTE

A2 ATMOSPHERIC EMISSION LIMIT FOR WASTE INCINERATION PLANTS

A3 CHEMICAL COMPOSITION OF LANDFILL GAS

A1 EU - DIRECTIVE 2008/98/EC ON WASTE (EXCERPTS)

Article 4
Waste hierarchy

1. The following waste hierarchy shall apply as a priority order in waste prevention and management legislation and policy:
(a) prevention;
(b) preparing for re-use;
(c) recycling;
(d) other recovery, e.g. energy recovery; and
(e) disposal.

2. When applying the waste hierarchy referred to in paragraph 1, Member States shall take measures to encourage the options that deliver the best overall environmental outcome. This may require specific waste streams departing from the hierarchy where this is justified by life-cycle thinking on the overall impacts of the generation and management of such waste.

Member States shall ensure that the development of waste legislation and policy is a fully transparent process, observing existing national rules about the consultation and involvement of citizens and stakeholders.

Member States shall take into account the general environmental protection principles of precaution and sustainability, technical feasibility and economic viability, protection of resources as well as the overall environmental, human health, economic and social impacts, in accordance with Articles 1 and 13.

Article 15
Responsibility for waste management

1. Member States shall take the necessary measures to ensure that any original waste producer or other holder carries out the treatment of waste himself or has the treatment handled by a dealer or an establishment or undertaking which carries out waste treatment operations or arranged by a private or public waste collector in accordance with Articles 4 and 13.

2. When the waste is transferred from the original producer or holder to one of the natural or legal persons referred to in paragraph 1 for preliminary treatment, the responsibility for carrying out a complete recovery or disposal operation shall not be discharged as a general rule.

Without prejudice to Regulation (EC) No 1013/2006, Member States may specify the conditions of responsibility and decide in which cases the original producer is to retain responsibility for the whole treatment chain or in which cases theresponsibility of the producer and the holder can be shared or delegated among the actors of the treatment chain.

3. Member States may decide, in accordance with Article 8, that the responsibility for arranging waste management is to be borne partly or wholly by the producer of the product from which the waste came and that distributors of such product may share this responsibility.

4. Member States shall take the necessary measures to ensure that, within their territory, the establishments or undertakings which collect or transport waste on a professional basis deliver the waste collected and transported to appropriate treatment installations respecting the provisions of Article 13.

Article 16
Principles of self-sufficiency and proximity

1. Member States shall take appropriate measures, in cooperation with other Member States where this is necessary or advisable, to establish an integrated and adequate network of waste disposal installations and of installations for the recovery of mixed municipal waste collected from private households, including where such collection also covers such waste from other producers, taking into account best available techniques.

By way of derogation from Regulation (EC) No 1013/2006, Member States may, in order to protect their network, limit incoming shipments of waste destined to incinerators that are classified as recovery, where it has been established that such shipments would result in national waste having to be disposed of or waste having to be treated in a way that is not consistent with their waste management plans. Member States shall notify the Commission of any such decision. Member States may also limit outgoing shipments of waste on environmental grounds as set out in Regulation (EC) No 1013/2006.

2. The network shall be designed to enable the Community as a whole to become self-sufficient in waste disposal as well as in the recovery of waste referred to in paragraph 1, and to enable Member States to move towards that aim individually, taking into account geographical circumstances or the need for specialised installations for certain types of waste.

3. The network shall enable waste to be disposed of or waste referred to in paragraph 1 to be recovered in one of the nearest appropriate installations, by means of the most appropriate methods and technologies, in order to ensure a high level of protection for the environment and public health.

4. The principles of proximity and self-sufficiency shall not mean that each Member State has to possess the full range of final recovery facilities within that Member State.

Article 17
Control of hazardous waste

Member States shall take the necessary action to ensure that the production, collection and transportation of hazardous waste, as well as its storage and treatment, are carried out in conditions providing protection for the environment and human health in order to meet the provisions of Article 13, including action to ensure traceability from production to final destination and control of hazardous waste in order to meet the requirements of Articles 35 and 36.

Article 18
Ban on the mixing of hazardous waste

1. Member States shall take the necessary measures to ensure that hazardous waste is not mixed, either with other categories of hazardous waste or with other waste, substances or materials. Mixing shall include the dilution of hazardous substances.

2. By way of derogation from paragraph 1, Member States may allow mixing provided that:
(a) the mixing operation is carried out by an establishment or undertaking which has obtained a permit in accordance with Article 23;
(b) the provisions of Article 13 are complied with and the adverse impact of the waste management on human health and the environment is not increased; and
(c) the mixing operation conforms to best available techniques.

3. Subject to technical and economic feasibility criteria, where hazardous waste has been mixed in a manner contrary to paragraph 1, separation shall be carried out where possible and necessary in order to comply with Article 13.

Article 19
Labelling of hazardous waste

1. Member States shall take the necessary measures to ensure that, in the course of collection, transport and temporary storage, hazardous waste is packaged and labelled in accordance with the international and Community standards in force.

2. Whenever hazardous waste is transferred within a Member State, it shall be accompanied by an identification document, which may be in electronic format, containing the appropriate data specified in Annex IB to Regulation (EC) No 1013/2006.

Article 20
Hazardous waste produced by households

Articles 17, 18, 19 and 35 shall not apply to mixed waste produced by households.

Articles 19 and 35 shall not apply to separate fractions of hazardous waste produced by households until they are accepted for collection, disposal or recovery by an establishment or an undertaking which has obtained a permit or has been registered in accordance with Articles 23 or 26.

Article 21
Waste oils

1. Without prejudice to the obligations related to the management of hazardous waste laid down in Articles 18 and 19, Member States shall take the necessary measures to ensure that:
(a) waste oils are collected separately, where this is technically feasible;
(b) waste oils are treated in accordance with Articles 4 and 13;
(c) where this is technically feasible and economically viable, waste oils of different characteristics are not mixed and waste oils are not mixed with other kinds of waste or substances, if such mixing impedes their treatment.

2. For the purposes of separate collection of waste oils and their proper treatment, Member States may, according to their national conditions, apply additional measures such as technical requirements, producer responsibility, economic instruments or voluntary agreements.

3. If waste oils, according to national legislation, are subject to requirements of regeneration, Member States may prescribe that such waste oils shall be regenerated if technically feasible and, where Articles 11 or 12 of Regulation (EC) No 1013/2006 apply, restrict the transboundary shipment of waste oils from their territory to incineration or co-incineration facilities in order to give priority to the regeneration of waste oils.

Article 22
Bio-waste

Member States shall take measures, as appropriate, and in accordance with Articles 4 and 13, to encourage:
(a) the separate collection of bio-waste with a view to the composting and digestion of bio-waste;
(b) the treatment of bio-waste in a way that fulfills a high level of environmental protection;
(c) the use of environmentally safe materials produced from bio-waste.

The Commission shall carry out an assessment on the management of bio-waste with a view to submitting a proposal, if appropriate. The assessment shall examine the opportunity of setting minimum requirements for bio-waste management and quality criteria for compost and digestate from bio-waste, in order to guarantee a high level of protection for human health and the environment.

A2 ATMOSPHERIC EMISSION LIMITS FOR WASTE INCINERATION PLANTS

Air emission limit values for waste incineration plants pursuant to Annex 1 AVV

Parameter	Emission limit value (in mg/m^3, normal conditions and 11% oxygen)	
	Half-hourly average values	Daily average values
Total dust	10	10
Total organic carbon	10	10
Hydrogen chloride	10	10
Hydrogen fluoride	0.7	0.5
Sulfur dioxide	50	50
Nitrogen oxides with a nominal capacity of		
• up to 2 t_{waste}/h	300	200
• 2 to 6 t_{waste}/h	200	150
• more than 6 t_{waste}/h		
- for new incineration plants	100	70
- for existing incineration plants		100
Carbon monoxide	100	50
Mercury	0.05	0.03
	Average value over 0,5 to 8 hours	
Cadmium and Thallium		0.05
Sum of the elements antimony, arsenic, lead, chromium, cobalt, copper, manganese, nickel, vanadium, zinc		0.5
Ammonia		5
	Average value over 6 to 8 hours (in ng TE/m^3)	
Dioxins and furans		0.1

Comparison of selected emission limits for waste incineration: Daily average maximum in mg/Nm^3 based on 11% O_2, dry gas

	EU Directive 2010/75 on industrial emissions	Swiss LRV Luftreinhalte-Verordnung	Austrian AVV Abfallverbrennungs-Verordnung
CO	100	50	50
Particulates	10	10	10
NO_x	200	80	70*
SO_2	50	50	50
Hg	0.05	0.10	0.03

*) for new plants > 6 t/h of waste

Source: Directive 2010/75/EU on industrial emissions; Luftreinhalte-Verordnung (LRV); Waste Incineration Ordinance - Abfallverbrennungsverordnung (AVV)

A3 CHEMICAL COMPOSITION OF LANDFILL GAS

Composition of landfill gas

Component	Concentration range	Dimension
Methane	40.0 to 55.5	Vol.-%
Carbon dioxide	30.0 to 45.0	Vol.-%
Oxygen	0.1 to 5.0	Vol.-%
Nitrogen	5.0 to 24.0	Vol.-%
Hydrogen	0.1 to 1.0	Vol.-%
Ethane	6 to 44	mg/m^3
Ethene	10 to 17	mg/m^3
Propane	3 to 18	mg/m^3
Propene	4 to 6	mg/m^3
Butane	12 to 26	mg/m^3
Pentane	< 5 to 10	mg/m^3
Hexane	< 5 to 24	mg/m^3
Heptane	< 5 to 18	mg/m^3
Octane	10 to 32	mg/m^3
Nonane	15 to 37	mg/m^3
Decane	35 to 112	mg/m^3
Benzene	4 to 34	mg/m^3
Toluene	62 to 130	mg/m^3
Xylene	92 to 116	mg/m^3
Ethylbenzene	42 to 135	mg/m^3
Ammonia	1 to 30	mg/m^3
Hygrogen sulfide	3 to 200	mg/m^3
Mercaptans	1 to 78	mg/m^3
Total sulfur	30 to 54	mg/m^3
Vinyl chloride	3 to 9	mg/m^3
Dichlorofluoromethane	8 to 47	mg/m^3
Trichlorofluoromethane	< 1 to 8	mg/m^3
1,1,2-Trichlorotrifluoroethane	< 1	mg/m^3
Chloromethane	< 0.5	mg/m^3
Dichloromethane	< 0.5 to 12	mg/m^3
Trichloromethane	< 0,5	mg/m^3
Tetrachloromethane	< 0.1	mg/m^3
1,1-Dichloroethane	< 0.05	mg/m^3
1,1-Dichloroethene	< 0.5 to 0.7	mg/m^3
cis-1,2-Dichloroethene	0.8 to 18	mg/m^3
trans-1,2-Dichloroethene	0.2 to 0.7	mg/m^3
1,1,1-Trichloroethane	< 0.5 to 4	mg/m^3
Trichloroethene	3 to 19	mg/m^3
Tetrachloroethene	4 to 20	mg/m^3
Total chlorine	19 to 85	mg/m^3
Total fluorine	2.7 to 15.2	mg/m^3

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ABBREVIATIONS

AlSAG .... Altlastensanierungsgesetz - Act on the Remediation of Contaminated Sites
AVV............ Abfallverbrennungsverordnung - Waste Incineration Ordinance
BAT .... Best Available Technique
BMLFUW.... Bundesministerium für Land- und Forstwirtschaft, Umwelt- und Wasserwirtschaft - Federal Ministry of Agriculture, Forestry, Environment and Water Management
BOD............ Biological Oxygen Demand
CHP............. Combined heat and power
CHPC.......... Combined Heat, Power and Cooling
CO............... Carbon monoxide
COD............ Chemical Oxygen Demand
D.S. .... Dry substance
EDM............ Electronic Data Management
e-waste .... Electronic waste
GHG............ Greenhouse gas
HCB .... Hexachlorobenzine
IPPC............ Integrated Pollution Prevention and Control
ISWA .... International Solid Waste Association
MBT............ Mechanical-biological treatment
NO_x .... Nitrogen oxides
ÖBIG........... Österreichisches Bundesinstitut für Gesundheitswesen (Austrian Department for Health Care System)
PAH .... Polycyclic aromatic hydrocarbons
PCB............. Polychlorinated biphenyls
PCDD.......... Polychloric dibenzodioxins
PCDF .... Polychloric dibenzofurans
PET .... Polyethylene – Terephthalate
POP............. Persistant organic pollutants
PVC............. Polyvinyl chloride
RVL .... (Reststoffverwertung Lenzing) Waste utilization plant Lenzing
SCR............. Selective catalytic reduction
SNCR.......... Selective non-catalytic reduction
SO_x.............. Sulfur oxides
SRF .... Solid recovered fuels
SS................ Suspended Solids
TE .... Toxicity equivalent
TOC .... Total Organic Carbon
UAE .... United Arab Emirates
UIG .... Umweltinformationsgesetz - Environmental Information Act
UVP .... Umweltverträglichkeitsprüfung - Environmental Impact Assessment
UVP-G .... Umweltverträglichkeitsprüfungsgesetz - Environmental Impact Assessment Act
WEEE .... Waste Electrical and Electronic Equipment
WTP............ Waste treatment plant

SUBJECT INDEX

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