The most efficient waste management system in Europe

Waste-to-energy in Denmark

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RAMBØLL

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Summary

Owing to visionary environmental and energy policies combined with coherent public planning, Denmark has developed the most efficient waste management system in Europe.

In Denmark the municipalities are responsible for the management of all waste. They have the responsibility and decision-making authority for the collection and treatment of household waste and control the flow of commercial and industrial waste to assigned treatment and disposal facilities.

In order to recover the resources of the waste the first priority is to reuse or recycle it. The residual waste is either incinerated at waste-to-energy facilities or, as the last resort, landfilled. Denmark was the first country in Europe to introduce a ban on landfilling of waste suitable for incineration. This has proven to be a major benefit to the Danish economy and the environment.

At the end of 2005 Denmark had 29 waste-to-energy facilities that treated a total of 3.5 million tonnes of waste, which corresponds to roughly 26 per cent of the total waste generated in Denmark. Environmentally friendly electricity and district heating are produced from this waste, corresponding to the energy consumption of approx. 400,000 households. The existing legislation on environmental protection, heat and electricity supply ensures favourable framework conditions for waste incineration in Denmark. This has made Denmark the country in Europe that incinerates the greatest amount of waste per capita – under very strict environmental regulations.

By far the majority of the facilities are owned by municipalities or inter-municipal companies. The municipal cooperation secures the establishment of the necessary incineration capacity. Moreover, it ensures that the waste is managed according to the principles of proximity and self-sufficiency. The waste-to-energy facilities are operated by non-profit companies, based on a cost coverage principle. This is why households, commerce and industry can have their waste treated in a safe and environmentally friendly manner at low cost.

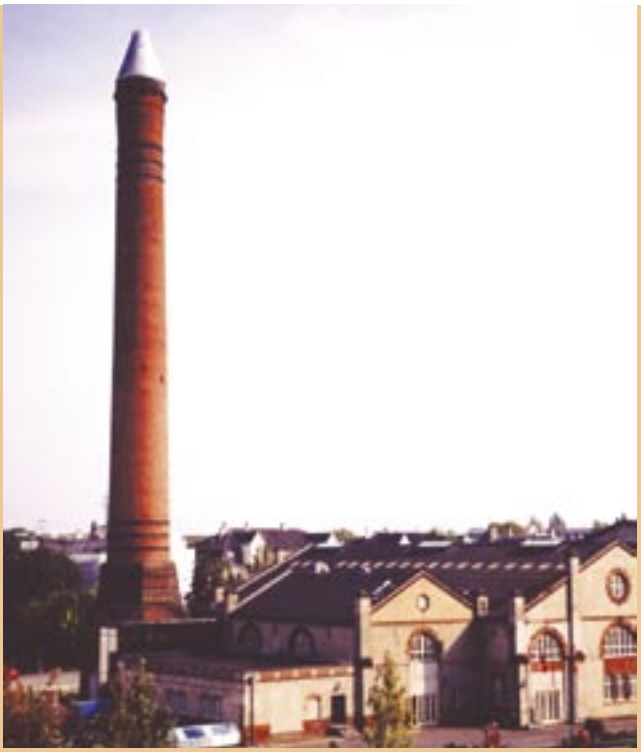
The gate fee at waste-to-energy facilities in Denmark is one of the lowest in Europe and amounts to only DKK200 (€27) per tonne of waste (excluding taxes and VAT). The low gate fee is attributable to the efficiently operated facilities on the one hand and to the extensive energy recovery on the other.

For the individual household, waste treatment by incineration typically costs the same as the household's waste collection bag, i.e. less than DKK2.5 (€0.33) a week. The greater proportion of the waste management costs is therefore to finance the cost of collection, schemes for bulky waste/recycling and hazardous waste as well as taxes and VAT. Furthermore, studies have shown that heat from waste-to-energy facilities is generally the cheapest source of heating in Denmark.

The prominence of waste-to-energy differs widely from country to country in Europe. Apart from Denmark, waste-to-energy is most widespread in Sweden, Switzerland, the Netherlands and Germany. In these countries local governments play a significant role in the organisation of the waste sector. In countries like the UK, where waste is primarily managed by private companies, the greater proportion of the waste is still landfilled and waste-to-energy is less widespread and at relatively high cost.

Incineration of waste in Denmark is extremely efficient, and it is therefore highly unlikely that a reorganisation would lead to improvements and lower gate fees. A recent study performed by the Danish Environmental Protection Agency concluded that, *'all in all it is unlikely that any significant socio-economic benefit would follow from contracting out the task of incineration or liberating the waste flow, ownership and pricing.'*

The possibility of obtaining limited benefits from efficiency improvement should therefore be carefully weighed against the risk of liberalisation in relation to particularly prices, environmentally safe waste treatment and security of supply (heat and electricity).



Development of the waste-to-energy sector

The growing urbanisation in the middle of the 19th Century made it necessary to bring the urban sanitary conditions under control. An act from 1858 stipulated that Copenhagen and all provincial towns in Denmark should adopt sanitary regulations. From this emanated the present system in which the municipalities take care of water supply, sewerage and waste management. At about the same time the first Danish gasworks were built and towards the end of the century the first electricity works were constructed, both owned by municipalities. Later on, district heating also became a typical municipal task. In many of the towns these activities were gathered under the joint term of 'The municipal works'.

The waste collected was landfilled, and at the end of the day it was often burnt. But already by the year 1900 Frederiksberg – an enclave located in the middle of Copenhagen – had run out of available sites for landfills. As a result the municipality built the first waste incineration plant in Denmark, inaugurated in 1903. The energy generated in the process was used for the production of both heat and electricity. The heat was sold to an adjacent hospital. In this way, Frederiksberg also became the first municipality in Denmark to establish a district heating system.

The same situation occurred in two other Danish municipalities, Gentofte and Aarhus, in the 1930s. By the outbreak of the Second World War, Denmark had three municipal waste incineration plants, all with energy recovery. The war and the immediate post-war years delayed the further development of waste incineration, but around 1960 it picked up again. The desire to be able to discard waste in a sanitary manner combined with the realisation that district heating was an appropriate method of heating further drove this development.

The first of these new plants only served one municipality, but in 1965 the first inter-municipal companies were formed for the purpose of establishing and operating a plant for the incineration of the waste generated in the owner municipalities. This has since become the predominant way of organising waste-to-energy facilities in Denmark.

By 1982 Denmark had 48 waste-to-energy facilities. Since then many of the smaller facilities have been closed down and replaced by a few larger ones. By the end of 2005, Denmark had 29 facilities, 21 of which are municipal or inter-municipal.

Further information on the history of waste incineration in Denmark may be found in '100 Years of Waste Incineration in Denmark' (Heron Kleis and Søren Dalager, Babcock & Wilcox Vølund and Rambøll, 2004).

Organisation

Framework conditions

According to the Danish Environmental Protection Act the municipalities are responsible for waste management in Denmark. For many years, it has been their task to collect, treat and dispose of general household waste. Originally, the waste was landfilled, but after 1960 incineration with energy recovery started to gain ground, and by 1982 the number of waste-to-energy facilities had reached 48.

Up until 1973 waste management was by and large not subject to any regulation, but in 1973 the Environmental Protection Act was adopted. The same year the first international oil crisis emerged, which made it clear to Denmark that it needed an energy policy with greater security of supply, while reducing the country's reliance upon oil.

Today, both waste management and energy production are subject to extensive regulations. Waste must first and foremost be reused or recycled. The fraction of the waste that is suitable for incineration and that cannot be reused or recycled must be incinerated in incineration facilities with energy recovery. Only waste that cannot be reused, recycled or incinerated may be landfilled.

The energy must primarily be recovered in combined heat and power (CHP) plants, i.e. facilities that produce both electricity and heat in the form of district heating. All large and medium-sized waste-to-energy facilities have therefore been converted to CHP production during the last 10 years. In addition, the energy policy has promoted a significant extension of the district heating supply.

This policy is further supported by taxes on waste for incineration and landfilling as well as on fossil fuels and electricity and by subsidies for electricity generated by waste incineration.

All in all, this has created favourable conditions for incineration of waste with energy recovery in Denmark – while at the same time securing that the greater part of the waste is reused or recycled.

Waste flow control

Since 1989 the municipalities have been responsible for managing all waste generated within their own boundaries. The municipalities are therefore also obliged to assign treatment and disposal facilities for commercial and industrial waste. In return, the producers of commercial and industrial waste are obliged to use the facilities assigned by the municipalities. This is commonly known as flow control.

One of the consequences of this flow control system is that each municipality – in its own right or through an inter-municipal waste management company – must have incineration and landfill capacity. Usually, the municipalities require that the waste should be delivered at the waste-to-energy or landfill facility that they co-own. In this way, proximity and self-sufficiency are ensured in the management of the waste.

The flow control obligation also means that the municipalities must manage the waste produced by commerce and industry, which can be an important issue when new companies wish to establish themselves in the municipality. The flow control obligation ensures that the responsibility for the waste is taken off the companies and that there is always available treatment capacity.

Waste arisings

In 2003 the total amount of waste generated in Denmark was 12.7 million tonnes. Of this amount 8.4 million tonnes was reused or recycled, while 1.0 million tonnes was landfilled.

The remaining 3.3 million tonnes, corresponding to 26 per cent of the total amount of waste, was incinerated. General household waste accounted for a little less than 1.5 million tonnes, while waste from the service sector amounted to 800,000 tonnes. Bulky waste, industrial waste and waste from wastewater treatment plants amounted to approx. 300,000 tonnes each, while construction and demolition waste represented 100,000 tonnes.

Regulations governing waste management in Denmark

Originally, the municipalities were only obliged to collect and dispose of household waste. However, in the 1980s commerce and industry found it increasingly difficult to dispose of their waste. As at the same time stricter waste flow control was called for in order to maximise re-use and recycling, it was decided to let the local authorities manage all waste as from 1989.

The rules are laid down in the Danish Environmental Protection Act and in the Waste Order issued by the Danish Ministry of the Environment (presently no. 619 of 27 June 2000 with later amendments).

The Act stipulates that the municipalities are responsible for waste management. They must register the existing waste arisings and prepare plans for the management of the waste as well as regulations determining the extent and administration of the waste schemes. The Waste Order also requires that the municipalities must assign waste treatment and disposal facilities for all waste, which in turn must be adhered to by the waste producers.

Denmark has introduced the term 'waste suitable for incineration'. As from 1997 the municipalities had to assign incineration facilities with energy recovery for residual waste suitable for incineration. In other words, from 1997 waste suitable for incineration could no longer be landfilled.

Hence, Denmark was the first country in Europe to introduce a ban on landfilling of waste suitable for incineration. Landfill bans are now part of the EU waste strategy and were recently introduced in Sweden and Germany.

In general, it is prohibited to export waste for disposal. The Danish Environmental Protection Agency may, however, allow certain waste types to be exported, such as residues from flue gas treatment at waste-to-energy facilities, for which there are no suitable treatment plants in Denmark. This also requires permission by the environmental authorities of the country of destination (see also p. 20).

Inter-municipal waste management companies

Most of the Danish municipalities are too small to be able to handle the waste treatment tasks that have been imposed on them in an economically viable manner. As a natural consequence, joint waste treatment facilities have been established. Today, Denmark has approximately 40 inter-municipal waste management companies nationwide.

These public companies are led by a board consisting of municipal council members from the owner municipalities. In this way local anchoring/ownership is ensured.

Sixteen of the waste management companies fully or partly own a waste-to-energy facility. They are all partnerships in which the owner municipalities have joint and several liability to the full extent of their assets for the company's activities and obligations. The same rules apply to the company as if the tasks had been maintained within the framework of the individual municipality.

In addition to incinerating waste, most of the companies also carry out other waste management tasks. Some of them, for example, also distribute the heat generated from the incineration process through their own district heating systems.

Costs that cannot be covered by the sale of the energy generated must be covered by a gate fee, which is charged on the basis of the registered waste amounts. However the companies are non-profit organisations and therefore the gate fee is fixed in such a way that it only covers the costs that cannot be recovered by the earnings generated from the sale of energy.

The companies and the municipalities have together with local district heating companies secured the basis for recovery and extensive utilisation of the energy produced from the waste.

The development from 1994 to 2003 in waste amounts and treatment is illustrated below.

The amount of waste incinerated has increased during the past 10 years from 2.2 to 3.3 million tonnes annually, while the amount of waste landfilled has decreased by about the same amount.

Organisation of the waste-to-energy sector

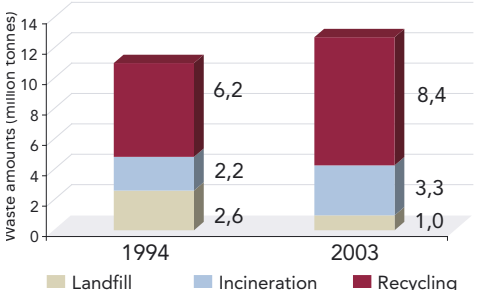
Around 1965 the first inter-municipal waste management companies were established for the purpose of managing the incineration of the waste that was collected in the owner municipalities.

The two oil crises in the 1970s and the consequent extension of the district heating systems contributed to this development. The basis for establishing waste-to-energy facilities with treatment capacities in excess of that required for the waste generated within the municipality where the facility was located had been formed. A number of originally municipal facilities now became the backbone of newly established inter-municipal partnerships.

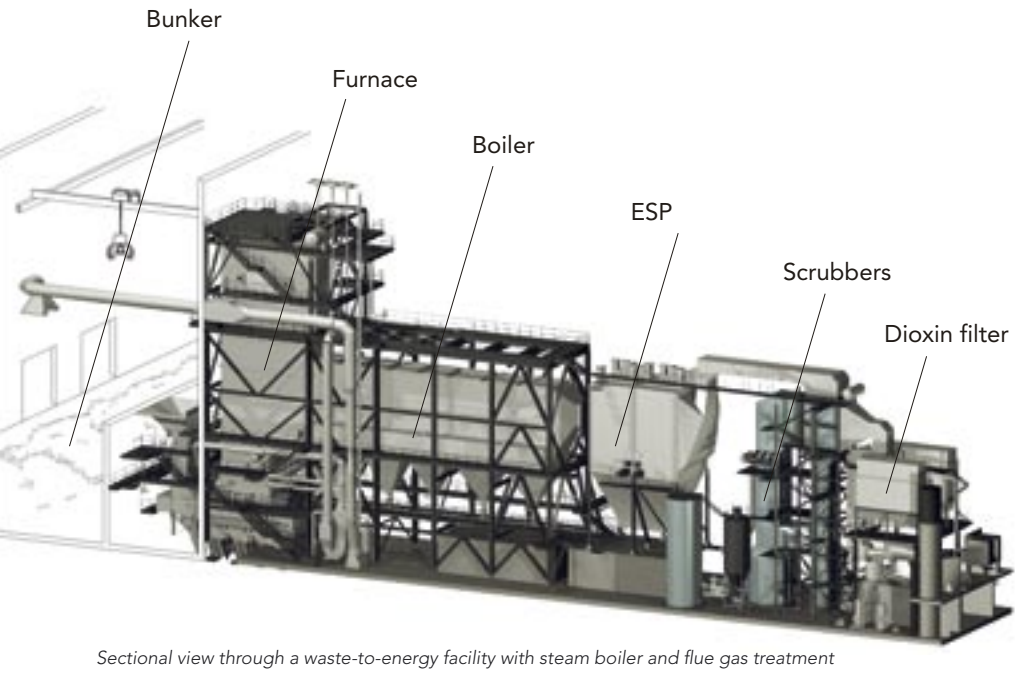
At the end of 2005 there were 29 waste-to-energy facilities in Denmark.

Twenty-one of these facilities are publicly owned by one or more municipalities, while eight are owned and operated by energy companies. These facilities have made binding agreements with the municipalities for treatment of the waste suitable for incineration generated in these municipalities. In this way, the energy companies' waste-to-energy facilities act as contractors for the municipalities involved.

Waste treatment and disposal in 1994 and 2003 (Denmark)



The Danish waste-to-energy facilities



Sectional view through a waste-to-energy facility with steam boiler and flue gas treatment

Design of waste-to-energy facilities

Waste is incinerated in special facilities designed and built specifically for the purpose of disposing of waste from households and enterprises while producing energy.

A waste-to-energy facility consists of the following main components: a reception and waste feeding system, one or more incineration units complete with bottom ash handling system, boiler, flue gas treatment system and stack.

As with all other energy generation facilities, waste-to-energy facilities are designed in accordance with the specific properties of the fuel. Waste is far more complex than conventional fuels.

If the facility is a CHP plant, the boiler is a steam boiler. The steam produced is led to a steam turbine, which drives a power generator. The residual heat of the steam is recovered for the production of district heating.

The facility is dimensioned in accordance with the waste arisings as well as with the potential for selling heat for district heating. With a view to optimising heat sales, waste that does not necessarily have to be incinerated straight away is sometimes put into intermediate storage from summer to winter. Household waste, however, is always incinerated immediately.

The flue gas generated is cleaned of dust, heavy metals, acid gasses (HCl, HF and SO_2), nitrogen oxides (NO_x) and dioxins. This is achieved in up to five subsequent treatment steps. The emission limit values are stipulated in the environmental permit of the facilities, which in turn is based on the Waste Incineration Order issued by the Ministry of the Environment and the underlying EU Waste Incineration Directive (No. 2000/76).

Energy recovery

The energy potential of the waste is recovered to as great an extent as possible. Originally, energy was recovered solely for the production of district heating, but following energy

Denmark's 29 waste-to-energy facilities

Utilisation of waste as a resource

Denmark has succeeded in optimal utilisation of waste as a resource through a close co-operation between municipalities, waste management companies and district heating companies. This can be exemplified by the conditions in southern Zealand where the combination of population distribution, waste levels and a district heating market all combine to create favourable conditions for the positioning of a CHP plant in the largest population centre, Næstved. The inter-municipal waste management company of I/S FASAN has its headquarters in the city of Næstved and includes a number of neighbouring municipalities representing a total of approx. 200,000 inhabitants. The company operates a waste-to-energy facility in Næstved. The inhabitants, commerce and industry annually produce about 100,000 tonnes of waste suitable for incineration. Of this amount Næstved generates approx. 20,000 tonnes. The entire heat production of approx. 200,000 MWh annually is sold to Næstved District Heating Company, which supplies heat to approx. 17,000 consumers. The 40,000 MWh of electricity produced annually is sold to the public grid.

The Waste Incineration Order

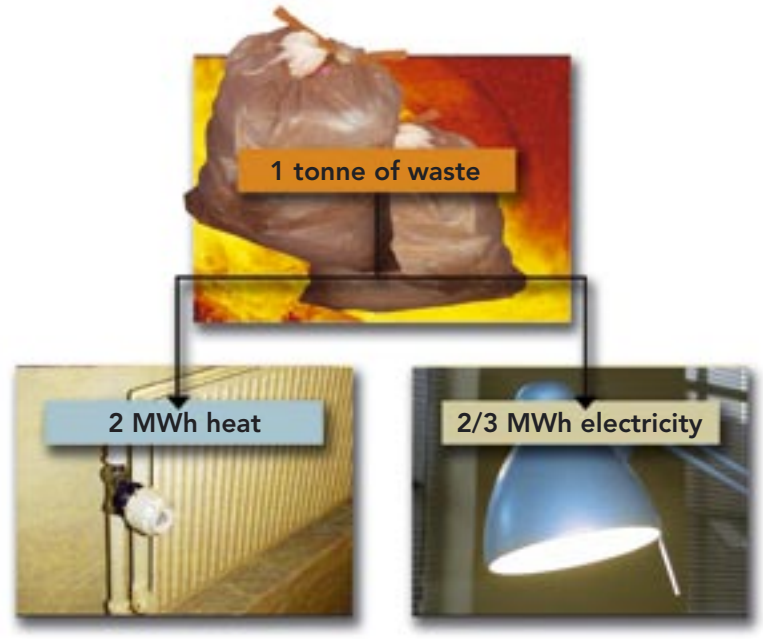
The Order on Incineration of Waste issued by the Ministry of the Environment (No. 162 of 11 March 2003) transposes the EU's Waste Incineration Directive No. 2000/76/EC into Danish legislation. It replaces two orders from 1997, which transposed earlier EU legislation, particularly two directives from 1989 on air emissions from new and existing municipal solid waste incineration facilities.

As compared with the previous orders the emission limit values of carbon monoxide (CO), dust, total organic carbon (TOC), hydrogen chloride (HCl), hydrogen fluoride (HF) and sulphur dioxide (SO_2) as well as of six different heavy metals were tightened. Furthermore, new emission limit values for nitrogen oxides (NO_x) and additionally four heavy metals and dioxins were introduced.

The new requirements became effective on 28 December 2002 for new facilities and for existing facilities on 28 December 2005.

The existing Danish waste-to-energy facilities have therefore in the period of 2003 to 2005 upgraded their flue gas treatment systems with supplementary treatment steps. In some cases, completely new flue gas treatment systems have been estabished. A few minor facilities have chosen to cease operation.

Thus, after 28 December 2005 all waste incineration in Denmark occurs in fully up-to-date facilities and with a minimum impact on the environment.



policy agreements made in 1986 and 1990 all the major facilities have converted to CHP production.

When incinerating 1 tonne of waste approx. 2 MWh district heating and approx 0.67 MWh electricity are produced. Where no electricity is produced, all the energy is recovered in the form of district heating.

According to the statistics of the Danish Energy Agency the calorific value in 2003 was on average 10.5 MJ/kg. Therefore, 4 tonnes of waste substitutes 1 tonne of oil or 1.6 tonnes of coal.

The greater proportion of the waste is biomass, but it does also contain fossil materials such as plastics.

Approx. 20 per cent of the waste consists of non-combustible parts such as glass, iron and other metals. These fractions exit the facility in the bottom ash, which is recycled.

Best available technique

When the environmental permits of the facilities are reconsidered, it must be documented that the best available incineration and fluegas treatment techniques (BAT) are applied.

Emissions

Waste-to-energy facilities emit less pollution per unit of energy input than combustion plants fired with oil or coal.

As a large part of the waste is CO_2 neutral biomass, waste also entails a smaller CO_2 emission per unit of energy input than coal, oil and natural gas. Carbon dioxide is one of the so-called 'greenhouse gases'.

Fuel	Coal	Gas oil	Natural gas	Waste
CO_2 (kg/GJ)	95	74	57	18
CH_4 (g/GJ)	1,5	1,5	15	0,6
N_2O (g/GJ)	3	2	1	1,5
SO_2 (g/GJ)	45	23	0	23,9
NO_x (g/GJ)	130	52	50	124

Emission factors of different fuels.
Source: Danish Energy Agency

Owing to the fact that all the facilities now have dioxin cleaning, dioxin from waste incineration is no longer a problem.

Residues

In the combustion process residues are generated in the form of:

- Bottom ash
- Iron and metals
- Residues from flue gas treatment

Bottom ash

Approximately 20 per cent of the waste by weight leaves the waste-to-energy facility in the form of raw bottom ash. The bottom ash is sorted, and in this process iron and other metals are recovered. The sorted bottom ash is recycled for construction works in accordance with the Residue Order issued by the Ministry of the Environment and Energy (no. 655 of 27 June 2000). In 2003, 645,000 tonnes of bottom ash was produced, and of this amount 629,000 tonnes, corresponding to approx. 98 per cent, was recycled. 15,000 tonnes was landfilled as the environmental requirements for recycling could not be complied with.

Iron and metals

The iron and other metals recovered from the bottom ash make up approx. 50,000 tonnes per year, which is recycled.

Residues from flue gas treatment

Residues from flue gas treatment are sent to special treatment/recovery in Norway or Germany. Approximately half of the amount in the form of fly ash comes from the waste, while the rest is reaction products from the lime and activated carbon that are added in order to clean the flue gas. If a wet flue gas treatment method is applied, the result is a significantly smaller amount of solid residue as well as a certain amount of wastewater. The treatment requirements are stipulated in a wastewater permit. In 2003, 88,000 tonnes of residues were produced in Denmark.

When the waste is incinerated, it is ensured that the non-combustible parts, which would otherwise have been landfilled, are recycled. If this recycling were included in the waste statistics of the Danish Environmental Protection Agency, the amount of recycled waste in 2003 would increase by approx. 8 per cent.

Best available technique (BAT)

An environmental permit is required to operate an incineration facility. A permit can only be granted if the emissions from the facility have been limited by applying the Best Available Technique – BAT.

The term 'best available technique' is defined in EU Directive 96/61/EC on Integrated Pollution Prevention and Control, commonly called the IPPC Directive.

The stipulations of the Directive have been transposed into Danish legislation through the Statutory Order on Approval of Listed Activities (presently no. 943 of 16 September 2004) issued by the Danish Ministry of the Environment.

Article 16, paragraph 2 of the IPPC Directive states that the Commission shall organise an exchange of information on best available techniques. In practice, this is done by publishing BAT Reference Documents (BREFs). The BREF on waste incineration is now available in a finalised draft version and is awaiting formal approval by the Commission.

The document contains 63 specific recommendations concerning design and operation of incineration facilities, and it must be expected that it will be of importance in connection with the development of future facilities.

Energy production and environmental benefits

Elements of the Danish energy policy

In the years following the oil crises in 1973 and 1979 Denmark adopted comprehensive energy legislation. The primary purpose was to increase the security of supply and decrease the reliance upon oil. From around 1990 the objective was also to reduce the Danish contribution to the greenhouse effect.

The means have been manifold, and have included a commitment to establish supply by district heating facilities. District heating is the supply of hot water or steam from CHP plants, waste-to-energy facilities, industrial enterprises, geothermal installations etc.

The municipal council must prepare a plan for the supply of heat in the municipality. They must see to it that district heating projects are carried out, and they must also approve such projects. The Minister of Transport and Energy may, however, direct that specific preconditions shall form the basis of the planning, and can also assume the authority to approve projects.

Since 1990 it has been part of the Danish energy policy that district heating should first and foremost be produced in the form of CHP. This is reflected in the Heat Supply Act already in Article 1, paragraph 2: 'The supply of heat shall be organised with a view to promoting the highest possible degree of cogeneration of heat and power.'

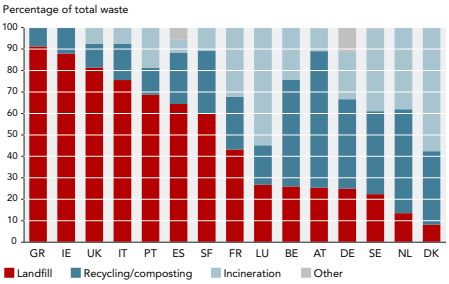
In line with this policy the municipalities with large or medium-sized waste-to-energy facilities received at the beginning of the 1990s a demand requiring the conversion of the heat production to CHP production.

According to the so-called biomass agreement of 14 June 1993 entered into by seven of the political parties in the Danish Parliament at the time, CHP based on waste takes precedence over other fuels.

Waste amounts for incineration

Due to its waste and energy policies Denmark is the country in Europe – measured in kg per capita per annum – that incinerates or recycles the greatest amount of waste and disposes of the smallest amount of waste to landfill.

Treatment form – municipal waste in Western Europe



Note: The figure includes municipal waste only. If industrial/commercial waste is included, the figures will look different. Example, Denmark: Landfill 8 per cent, recycling/composting 66 per cent, incineration 26 per cent.

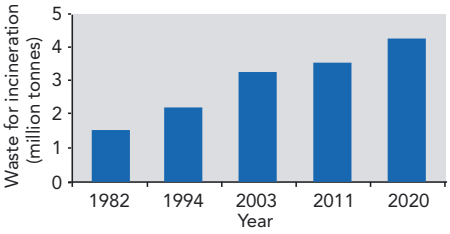
Source publication: e-Digest of Environmental Statistics, Published November 2004. Department for Environment, Food and Rural Affairs http://www.defra.gov.uk/environment/statistics/index.htm

In addition to municipal solid waste incineration facilities, Denmark also has special facilities for the incineration of sewage sludge. There is only one facility in the country that is designed to handle hazardous waste, namely Kommunekemi.

As the first country in Europe, Denmark introduced a ban on landfilling of waste suitable for incineration as per 1 January 1997. This means that the amounts of waste for incineration have in recent years increased far more than the general increase in waste arisings.

The figure overleaf shows the amounts treated in 1982, 1994 and 2003. It also shows the amounts that according to the prognoses of the Danish Environmental Protection Agency must be expected to go to incineration in 2011 and 2020. It can be seen that the amount for incineration is expected to continue its increase.

Waste for incineration (million tonnes)



The development in waste amounts for incineration. Source: Dakofa – Danish Waste Management Association (1985) and waste statistics of the Danish Environmental Protection Agency for 2003.

Energy recovered from waste in Denmark

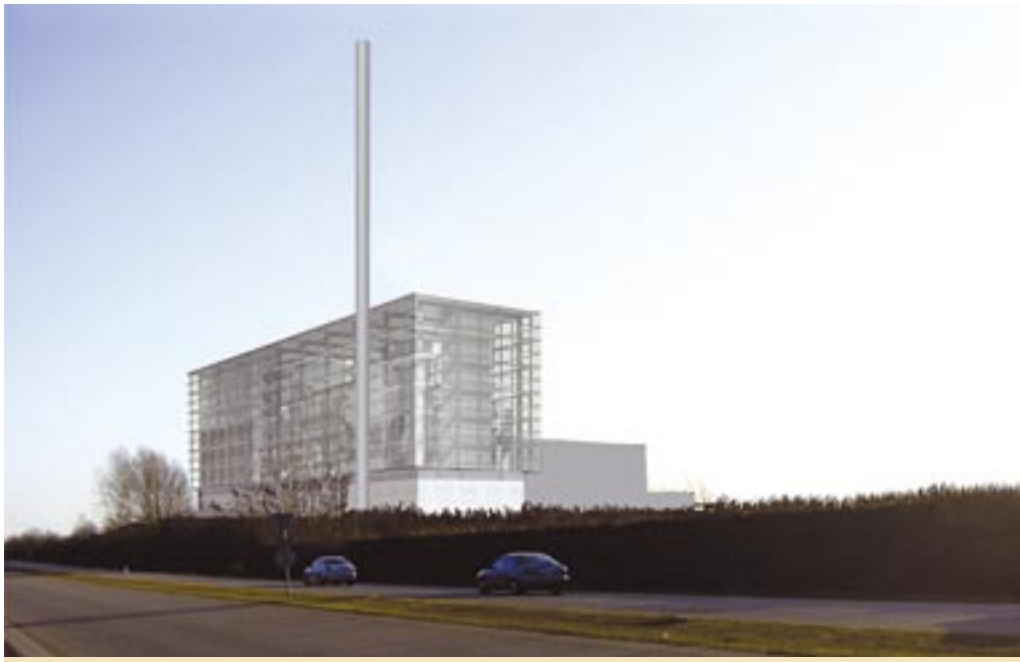
In 2003 Denmark incinerated approx. 3.3 million tonnes of waste. All of the waste was incinerated at facilities with recovery of energy for the production of electricity and/or district heating.

According to the energy statistics of the Danish Energy Agency for that same year, the waste-to-energy facilities produced a total of 1.47 million MWh of electricity and 6.36 million MWh of district heating.

Hence, the waste-to-energy facilities covered approx. 3 per cent of the total Danish electricity production and approx. 18 per cent of the total district heating production in 2003. The heat generated from waste made up approx. 40 per cent of the total heat production from renewable energy sources.

The average Danish household consumes 3,430 kWh of electricity and 17.6 MWh of heat. The electricity produced at the waste-to-energy facilities therefore covers the consumption of approx. 430,000 out of a total of approx. 2.5 million households. As each household consumes more heat than electricity, the heat production covers the consumption of approx. 360,000 households.

The continued extension of district heating has made this development possible. Today, 1.5 million households are supplied with district heating. This is a 50 per cent increase since 1988.



Three acts going hand in hand

For the waste-to-energy facilities there are three acts of decisive importance:

Environmental Protection Act

The Environmental Protection Act with related orders requires that the municipalities shall collect household waste and assign treatment and disposal facilities for commercial and industrial waste. Waste incineration facilities with energy recovery shall be assigned for waste suitable for incineration, which cannot be landfilled.

One could say that the act ensures that the waste-to-energy facilities are supplied with the entire amount of waste suitable for incineration and can therefore act accordingly. Pursuant to the Act, regulations pertaining to pollution from the waste-to-energy facilities have been introduced.

Heat Supply Act

The Heat Supply Act has the objective of promoting the most socio-economic and environmentally friendly utilisation of energy and reducing the reliance of the energy system on oil. The heat supply should therefore preferably come from district heating. The heat supply should be organised with a view to promoting the highest possible degree of cogeneration of heat and power.

This act ensures that the waste-to-energy facilities can be connected to district heating supply systems and therefore can sell the heat produced. The Danish Energy Regulatory Authority – DERA – supervises the pricing of the energy.

Power Supply Act

The Power Supply Act is intended to promote sustainable energy production, including the use of CHP and renewable and environmentally friendly energy sources, while also creating competition on markets for production of and trade in electricity. Specifically, Section 4 of the Act states that municipalities may carry out grid activity and electricity production by waste incineration.

The energy produced must be traded on commercial terms. In order to promote environmentally friendly electricity production, Section 9 of the Act lays down rules for surcharges for electricity produced on the basis of renewable energy sources as well as electricity produced at decentral CHP plants and power production facilities using waste as fuel. The surcharge is reduced proportionally at a market price of more than DKK 0.11 (€ 0.015) per kWh so that it ceases when the market price is DKK 0.34 (€ 0.045) per kWh. In this way, the waste-to-energy facilities are secured a certain minimum price for the electricity produced for a number of years.

Together, the acts indirectly regulate the financial framework of the waste-to-energy facilities, including the balance between the part of the total operating costs covered by sale of energy and the part that has to be covered by the gate fee.

Quantification of environmental benefits

Saved fossil fuels

The energy content of the 3.3 million tonnes of waste incinerated is some 10 million MWh. This energy content corresponds to the following approximate amounts of fossil fuels:

Fuel oil:	1,000,000 m^3
Coal:	1,500,000 tonnes
Natural gas:	900,000,000 m^3

Saved air emissions

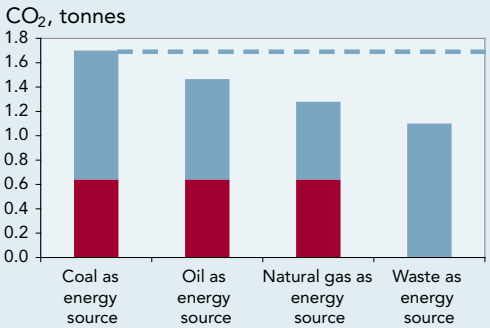
A significant saving of CO_2 emissions is obtained when waste-to-energy facilities in one and the same operation disposes of waste and produces energy. This is illustrated below where the total CO_2 emission from waste incineration is compared with the emission from landfilling (or composting) of 1 tonne of waste and when 10 GJ of electricity and heat is alternatively produced on the basis of coal, oil or natural gas as the source of energy.

The calculation disregards the fact that part of the carbon content of the waste when landfilled is emitted in the form of methane, which is a greenhouse gas with an effect 21 times greater than CO_2, which would further favour waste incineration.

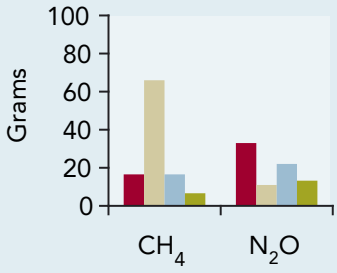
Moreover, the figure below shows the emissions of CH_4, N_2O, SO_2 and NO_x when producing 10 GJ of electricity and heat on the basis of each of the four fuels.

The figure shows that waste incineration results in less CH_4 and N_2O than the other fuels. Since the natural gas is sulphur free, it results in the smallest amount of SO_2 emissions, while the emissions from waste incineration correspond to those of gas oil. With respect to NO_x, coal, natural gas and waste all produce roughly the same quantity of NO_x/kWh, whereas gas oil results in the emission of only half of that of the others.

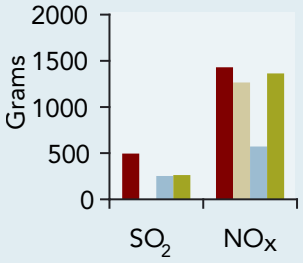
Total CO_2 emission. Disposal of 1 tonne of waste and production of 10 GJ of heat/electricity



Emissions from fossil fuels and waste



Coal combined heat and power
Gas oil heat



Natural gas combined heat and power
Waste incineration

Saved area requirement

Compacted to a volume weight of 0.7 tonnes/m^3 3.3 million tonnes of waste for landfilling requires a volume of 4.7 million m^3. Distributed on an area corresponding to a football field this waste would reach a height of 500 m. Distributed as a cone with the same height as one of Denmark's few 'mountains', Himmelbjerget (147 m), it would require an area with a diameter of 350 m. If the waste were not incinerated, each year areas for a new 'waste Himmelbjerg' would have to be found.

Saved natural resources

Furthermore, it would be necessary to draw on the natural gravel resources in order to substitute the approx. 650,000 tonnes of bottom ash, which was recycled for construction purposes in 2003.

Environmental benefits

When energy is recovered from waste, fossil fuels are substituted. Energy production on the basis of waste also results in lower air emissions than would have been the case with fossil fuels. This particularly applies to carbon dioxide (CO_2).

To this should be added that had the waste been landfilled, it would also have resulted in pollution, not least air pollution in the form of methane (CH_4).

Carbon dioxide and methane as well as nitrous oxide (N_2O) are 'greenhouse gases', which have a climate change impact. On a weight basis, methane has 21 times more greenhouse effect than CO_2.

Denmark has ratified the Kyoto protocol and in this connection committed itself to reducing the total emission of greenhouse gases.

As presented above, waste incineration makes a significant contribution to this reduction.

Landfills for waste are extremely space consuming, so when the waste is incinerated instead, landfill areas are saved. When incinerated, the waste is reduced as follows: by weight by 80-85 per cent and by volume by 95-96 per cent. Finally, incineration makes it possible to recycle the mineral components of the waste (the bottom ash). Hereby, natural raw materials in the form of gravel and iron are saved.

Economic aspects

Economic balance

The Danish waste-to-energy facilities are subject to a cost coverage principle, which means that they can show neither a profit nor a loss. Receipts and expenses must balance within a small time span.

Waste-to-energy facilities are economically controlled by three main factors:

- Fiscal instruments (State taxes)
- Energy earnings from sale of electricity and heat
- Gate fees

Fiscal instruments

Denmark has a general State tax on waste. The tax is differentiated whereby landfill tax (DKK 375 (€ 51)/tonne) is greater than incineration tax (DKK 330 (€ 44)/tonne). It is tax free to recycle waste. This tax structure has been introduced for the purpose of promoting recycling. Denmark's neighbouring countries Sweden and Germany today have no such tax on incineration.

In addition, Denmark has a tax on heat produced from waste of DKK 46.44 (€ 6.19)/MWh and a tax of DKK 10 (€ 1.33)/tonne of sulphur dioxide.

The revenue generated from taxes on incineration and heat produced from waste today amounts to DKK 1.2 billion (€ 160 million) annually.

Energy earnings

If the waste-to-energy facility is a cogeneration plant, the facility will have earnings from sale of both electricity and heat.

Electricity is sold on commercial terms with a subsidy of DKK 0.07 (1 Eurocent)/kWh in order to promote environmentally friendly electricity production from waste incineration. In addition, the facilities which established CHP production capacity before the so-called differentiated tariff system lapsed enjoy transitional terms. For a certain number of years the transitional scheme ensures that the facilities

Heat prices

With a view to protecting the consumer the heat price is, according to the Heat Supply Act, always the lower of the cost-based price and the substitution price. District heating consumers are protected by the Danish Energy Regulatory Authority, DERA.

There is some variation in the waste based heat prices in Denmark depending on the energy sale possibilities of the waste-to-energy facility, its amortisation policy, its age, specific authority requirements and the substitution price in the supply area in question. Heat from waste-to-energy facilities is generally the cheapest form of heating in Denmark.

Cost-based heat price

The cost-based heat price is calculated on the basis of a distribution of the costs between activities relating to the waste incineration and activities relating to the heat production. The distribution is based on the specific conditions pertaining to the incineration and to the heat production.

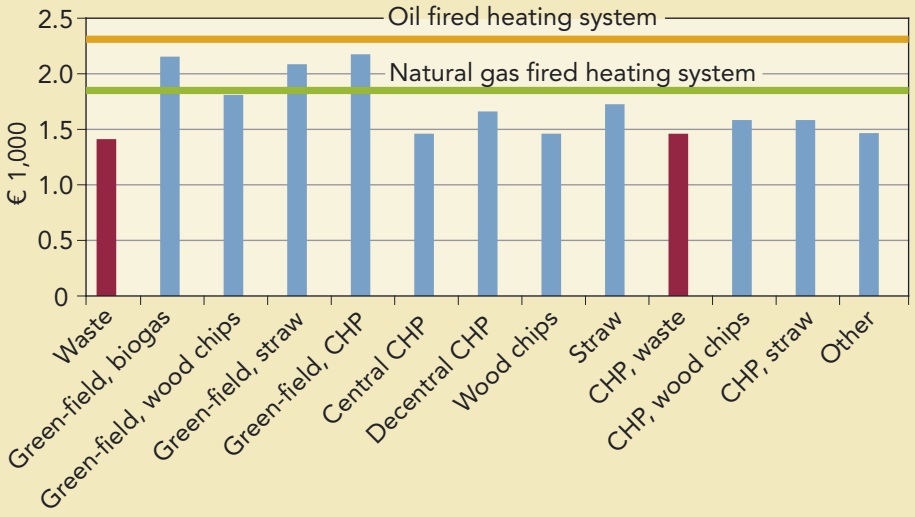
The costs are divided into special costs relating to the waste, special costs relating to heat and joint costs, which include costs of both waste treatment and heat production.

The waste-to-energy facilities must report their heat retail prices once a year to the Danish Energy Regulatory Authority, DERA, and account for the cost distribution between activities relating to waste treatment and heat production.

Substitution price

The substitution price is the heat retail price that the district heating supplied from the waste-to-energy facility could be purchased for from other sources. It must be an actual substitution option, i.e. it must be possible to actually have the heat supplied, and in a legal manner too.

Average heat retail prices according to the Danish District Heating Association, 130 m³ house, including VAT, year 2004



Continuous efficiency improvement

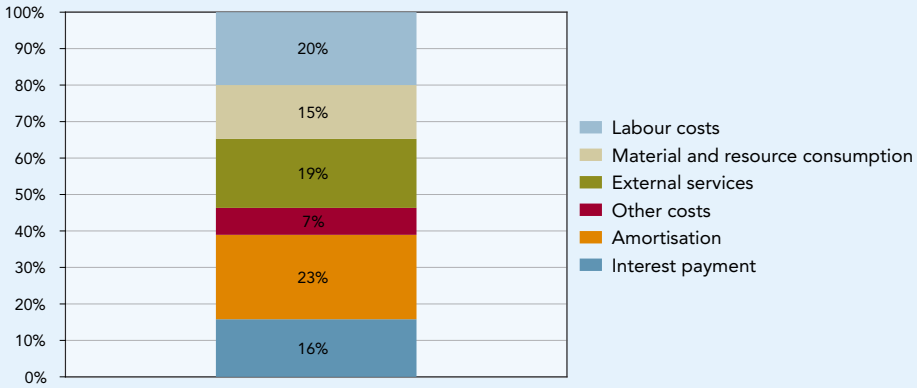
RenoSam, the association of 33 Danish and 2 Faroese waste management companies, is making a targeted benchmarking effort in order to obtain the highest possible degree of efficiency at the Danish waste-to-energy facilities. According to the latest benchmarking statistics the costs of incineration typically amount to DKK 700 (€ 93)/tonne of waste (excluding taxes), while the earnings from sale of heat and electricity amount to DKK 500 (€ 67)/tonne, corresponding to a gate fee of DKK 200 (€ 27)/tonne.

Interest payment and amortisation of the waste-to-energy facilities make up a considerable part of the costs. These costs are fixed and therefore cannot be changed.

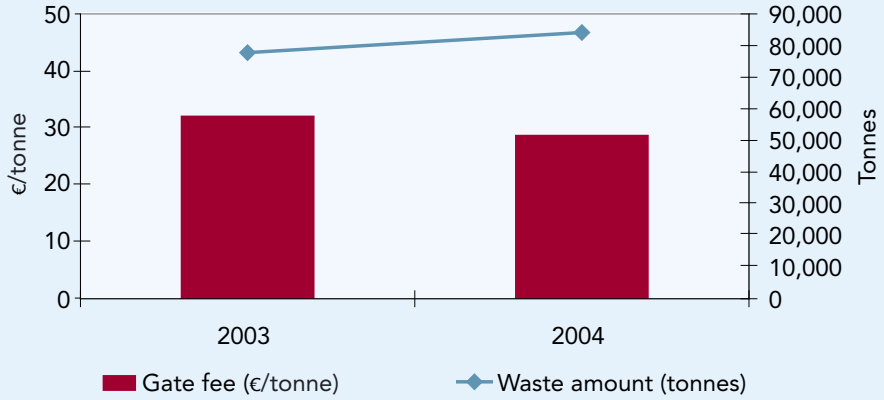
Attempts are constantly made to minimise the operating costs through a balanced optimisation of both operation and human resources.

According to RenoSam's latest benchmarking statistics the waste-to-energy facilities included in the survey have succeeded in increasing their productivity from 2003 to 2004 so that the number of tonnes incinerated has on average increased by 8 per cent. One explanation may be the increased focus on reducing unplanned outages, which has resulted in an even higher availability. The productivity increase means that the net costs of incinerating waste have been reduced by 10 per cent.

Typical distribution of incineration costs



Efficiency improvement – Average for all facilities



obtain an electricity price corresponding to the level at the time when the facilities were required by the Danish Energy Agency to convert to CHP production.

In order to protect the heat consumers, the heat price cannot exceed the lowest of the cost-based price and the substitution price. For this reason the price of heat produced from waste in Denmark is generally lower than the price of other heating sources (cf. figure on p. 13).

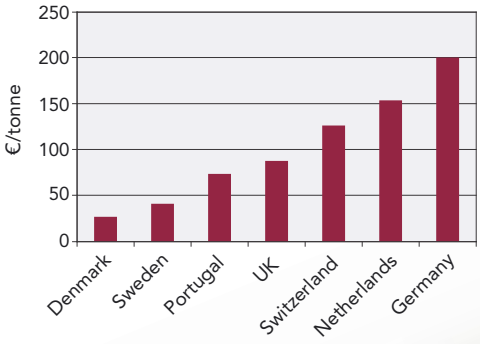
In the event of disputes between the waste-to-energy facility and the heat consumer over the unit price for district heating, a complaint may be lodged with the Danish Energy Regulatory Authority, DERA.

Lowest gate fees in Europe

The part of the expenses that cannot be covered by earnings from sale of electricity and heat must be covered by a gate fee, as the waste-to-energy facilities must be non-profit, i.e. the lower the energy earnings, the higher the gate fee.

Typically, the gate fee, i.e. the actual cost for the household/industry of having its waste in-

Incinerator gate fees in Europe



cinerated, is in the order of DKK 200 (€ 27)/tonne excluding taxes. The Danish gate fees are the lowest in Europe where gate fees of more than DKK 1,500 (€ 200)/tonne may be found.

In an international context the low gate fee in Denmark is attributable partly to the extensive energy recovery from waste and partly to the generally well-operated and efficient facilities in Denmark.

Continued optimisation of operation

The Danish waste-to-energy facilities continuously work on optimising their operation with a view to further reducing the heat price and the gate fee.

More specifically, the efficiency of the relatively capital intensive production facilities has a great impact on the financial situation of the facilities, as outages are very expensive due to the loss of energy earnings in these periods.

Preventive maintenance is therefore of decisive importance. Major savings on maintenance in one year may well result in a postponement of the problems to subsequent years or lead to unplanned outages.

The Danish waste-to-energy facilities are characterised by having an extremely high availability, typically more than 90 per cent of the year.

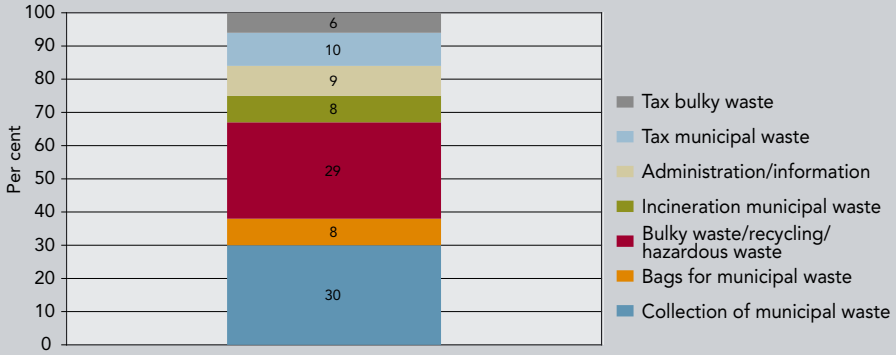
Incineration costs the same as the household's waste collection bag

The greatest proportion of the waste collection charge for a typical household is for the actual waste collection, schemes for bulky waste and recycling as well as taxes to the State.

The Danish waste-to-energy facilities are so well operated that they can provide cheap district heating, electricity and treatment of waste from households in an environmentally friendly manner. The disposal of waste by incineration therefore only makes up a very limited part of the total waste management cost.

A household typically produces 600 kg of waste annually, which is incinerated at a cost of DKK 200 (€ 27)/tonne. This is approximately the same as the price of the waste collection bag at roughly DKK 2.5 (€ 0.33)/week.

Typical composition of waste management fee (excl. VAT)



Liberalisation

Liberalisation of waste incineration

On the international scene there are the following ways of organising waste-to-energy facilities:

1. Public ownership and operation
2. Public ownership and private operation
3. Private ownership and operation

The organisational structure in Denmark includes public ownership and operation (**1**) and private ownership and operation (**3**) by power plants based on long-term contracts with the municipalities. Public ownership and operation (**1**) is the most wide-spread organisational structure in the European countries where incineration is of importance. There are, however, also examples of other organisational structures. In France, for instance, more than 40 per cent of the waste is treated at publicly owned facilities which are privately operated (**2**), and in the UK a large part of the waste-to-energy facilities are privately owned and operated (**3**).

Arguments for private sector involvement

The most commonly used argument for complete liberalisation is that lower treatment costs are obtained through:

- Better risk allocation between the private and the public sector
- Lower costs through improved efficiency
- Application of more innovative solutions

These statements are further analysed below.

The economic benefit is questionable

It is uncertain whether public ownership and private operation and private ownership and operation actually entail an economic benefit. In 2004, the Danish Environmental Protection Agency published its environmental study 'Pros and cons of liberating waste incineration and landfilling. The conclusion is that 'all in all it is unlikely that any significant socio-economic benefit would follow from contracting out the task of incineration or liberating the waste flow, ownership and pricing.' The conclusion is based on the assumption that there might be a possibility of gaining benefits from efficiency improvement, but these benefits are cancelled out by the increased costs relating to covering the risk involved when the responsibility for the waste and the facility is divided.

It is furthermore concluded that when the responsibility for the operation of the plant is transferred to a fully private operator, it may be difficult to ensure an economic benefit. One of the reasons is transaction costs due to:

- Lack of continuous maintenance leading to outages
- Unclear interface between reinvestments and new investments
- Unforeseen breakdown of part components, which cannot clearly be ascribed to the supplier or the operator.

Difficulties in obtaining perfect competition

It is widely believed that it is difficult to create the basis for perfect competition in the incineration sector as the market has many characteristics making perfect competition difficult.

First of all there are significant barriers to entering and exiting the market for waste incineration due to the very capital intensive production facilities involved. Second of all, district heating production is decisive for the gate fee, which is why the demand for district heating will set a limit to where to establish new waste-to-energy facilities. The capacity of the waste-to-energy facilities in Denmark is therefore carefully adjusted to the possibilities of using the heat for district heating.

Shipment of waste

In a liberalised market for waste incineration competition will improve if shipment of waste across the borders of Denmark is allowed as it will be easier to reach the balance between supply and demand. In the short term, this will probably lead to a greater import of waste from Germany, for example, which has too small a capacity and generally high prices of incineration. Thereby, the Danish incineration capacity will be strained and it will be difficult to preserve the present certainty of disposal of the Danish waste.

If the capacity is challenged, this will have an impact on the pricing and lead to higher prices in Denmark. At the same time it is questionable whether the Danish waste tax can be retained in a liberalised market as the tax may be considered a distortion of competition.

The annual Danish State revenue from taxes of some DKK 1.2 billion (€ 160 million) may therefore be at stake.

The 'invisible hand' of the market and perfect competition

The classical economists like Adam Smith (1723-1790) advocated economic liberalism in which the regulation of the State is reduced to a minimum. Instead, the economy is controlled and coordinated by the 'invisible hand' of the market, which according to Adam Smith would without any doubt lead to the largest degree of prosperity for society as a whole.

In a market with perfect competition no individual buyer or seller has any influence over the market as it is the market forces alone that determine price and production. The preconditions for perfect competition can be summarised as follows:

- Many buyers and sellers
- Free access to withdrawal from the market, i.e. no barriers
- Perfect market information
- Homogenous products

Perfect competition and waste-to-energy

The market for waste-to-energy has many characteristics making it difficult to obtain perfect competition.

The establishment of a waste-to-energy facility is very capital intensive and in the order of 100-300 million Euro. This means that the access to the market for new-comers is extremely difficult and risky. This limits the number of potential players and existing players will therefore be able to exert a certain amount of influence upon the market. Consequently, in a liberalised market there will be a risk of creating a market situation in which one or two companies are dominant and thereby an imperfect competitive situation.

Furthermore, it will be decisive for the financial situation of the waste-to-energy facility that there is a suitable demand for district heating. The district heating demand in Denmark is limited and may be subject to competition only in a few areas, which creates a barrier to the access to the market and makes free pricing difficult. On the other hand, this barrier will not be present in countries which do not have district heating systems of any importance. This means that the facilities can

be established without this barrier, but naturally also without earnings from sale of heat and thereby, all other things being equal, a higher gate fee than in Denmark.

On this basis it must be considered difficult to establish perfect competition in a liberalised market. In the event of imperfect competition without the non-profit cost coverage principle, the waste-to-energy facilities would be able to make an extraordinary profit.

Economic consequences of liberalisation

It is disputed whether liberalisation would have an economic consequence in the form of reduced gate fees. One of the difficulties is that the experience of private ownership and operation of waste-to-energy facilities in a liberalised market is extremely limited.

One of the essential elements of the economic assessment is the risk profile of the project in question, as a private operator will cap its exposure to the risk of owning and operating the waste-to-energy facility, and this risk capping will be greater than the one claimed by a public company, cf. the budget statement of the Danish State from 1999:

'The State is likely to be able to cover any given risk cheaper than the private sector. This is due to the fact that the State may spread the risk to the entire population. It is the same principle that applies to the State selfinsurance.'

Even though a private operator, for payment, would take on a risk, the public sector would still have to assume a certain risk, for instance fluctuations in electricity and heat prices and waste supply.

In financial terms, there is no doubt that the public sector can obtain cheaper financing than the private sector.

It is difficult to assess the investment costs across different projects as the investment always depends on specific local factors. However, it is exactly the same technology that is applied – irrespective of organisational structure. For this reason there is no documentation to the effect that there is any difference in private and public investments in waste incineration.

Operation and maintenance may be divided into three components: Consumables, maintenance and staff:

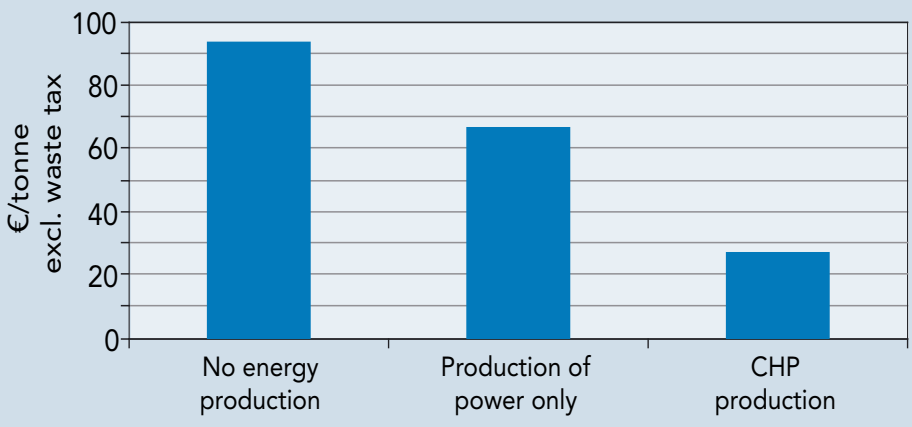
- The amount of consumables for, for instance, flue gas treatment depends on the composition of the flue gas and not on organisational structure.

- Improved maintenance procedures may reduce the number of unplanned outages and thereby increase the treatment capacity. Optimising the capacity at both private and public facilities may reduce treatment costs, cf. RenoSam's benchmarking statistics - although only to a limited extent as the availability in Denmark is already amongst the highest in Europe.

- Private operators employ the same operating staff as public facilities, and also the maintenance systems are the same. Furthermore, both organisational structures use external specialist companies for major maintenance works.

- Similarly, waste-to-energy facilities are today so technically automated that it is difficult to achieve significant savings on human resource optimisation.

Typical gate fees with and without energy production



Waste-to-energy outside Denmark

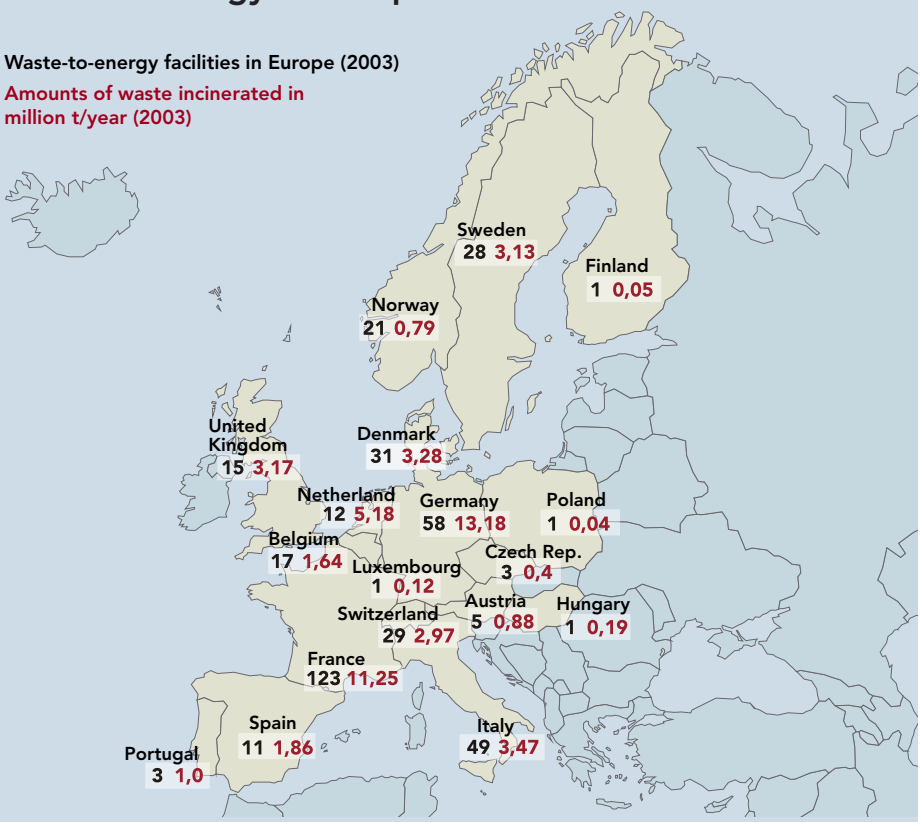
Europe

The EU countries and associated countries are to a significant extent obliged to comply with the environmental acquis of the EU.

Even though the 25 EU member states are directly governed by the same overall legislation, including that on waste management, disposal and incineration, the prominence of incineration differs widely from one EU member country to another.

This situation has been illustrated by the Confederation of European Waste-to-Energy Plants (CEWEP). This confederation has members in 13 European countries, with RenoSam as the Danish member.

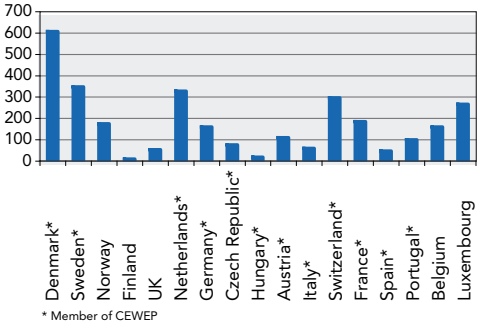
Waste-to-energy in Europe



Number of waste-to-energy facilities and amounts of waste incinerated (million tonnes annually) in Europe. Source: CEWEP (www.cewep.org)

It can be seen that the number of waste-to-energy facilities is greater in France than in any other European country. Germany and Italy are second and third. Germany and France are the countries in Europe that incinerate most waste (tonnes annually). Denmark is fifth, but first in terms of waste amounts incinerated per capita. On the basis of the figures shown in the map it can be calculated that the facilities in the Netherlands are generally very large, but also Portugal and Germany have relatively large facilities. The facilities in Norway, Italy and France on the other hand are generally relatively small.

Average amount of waste incinerated, kg per capita



When the population in each country is taken into consideration, Denmark incinerates the largest amount of waste per capita (including commercial and industrial waste), namely 600 kg annually. Only Sweden, the Netherlands, Switzerland and Luxembourg are anywhere near the same coverage with waste-to-energy facilities for waste suitable for incineration.

Energy production

The energy production per tonne of waste varies from country to country with Denmark and Sweden in the lead.

In the other countries, energy sales are less significant, which is primarily due to the fact that in these countries district heating is not nearly as widespread as in Denmark and Sweden.

Organisation

In Denmark, the majority of the waste-to-energy facilities are owned and operated by the municipalities or by inter-municipal non-profit companies. The same applies to Sweden, Germany, the Netherlands and Switzerland. As described above, these are also the countries where incineration has a predominant position.

In France, the facilities are typically also owned by the public sector, but at many of them the operation responsibility has been conceded to private companies. In the UK, on the other hand, practically all waste-to-energy facilities are privately owned. In terms of waste incinerated per capita incineration in the UK is of modest importance.

Denmark has fully and completely vested the responsibility for waste management in the municipalities, including the designation of recycling options and disposal facilities – full waste flow control. In other countries it is up to the producers of commercial and industrial waste to find recycling outlets or disposal facilities.

Framework conditions

Waste management in Denmark is controlled by the desire to maximise the use of resources, including the energy potential of waste suitable for incineration, and to ensure treatment of commercial and industrial waste. There is a ban on landfilling of waste suitable for incineration, and the waste-to-energy facilities can rely on the reception of the waste suitable for incineration generated within their service area.

Furthermore, the possibilities of selling district heating are good, not only for reasons of climate, but also because the Danish energy policy has made a strong commitment to district heating, self-sufficiency and security of supply.

EU legislation on waste management

Waste Framework Directive
The EU's legislation on waste management is based on the Waste Framework Directive (No. 75/442/EEC as amended by Directive 91/156/EEC), which among others provides a definition of waste and sets out a general ranking of the waste management methods:

- Prevention
- Recovery
- Incineration with energy recovery
- Incineration without energy recovery and disposal

In December 2005 the Commission issued a proposal for a new directive on waste. When adopted the directive will replace the present Waste Framework Directive.

Recognizing that not all waste can be prevented or recovered, the EU has also adopted directives on incineration and landfilling of waste.

Waste Incineration Directive
The Waste Incineration Directive (No. 2000/76/EC) stipulates that waste incineration facilities shall have an environmental permit and in Articles 6, 7 and 8 and in Annexes IV and V lays down rules pertaining to operating conditions and emissions to air and water. The Directive entered into force on 28 December 2002 for new facilities, and the new and stricter requirements had to be fully complied with by existing incineration facilities not later than 28 December 2005.

Landfill Directive
The Landfill Directive (No. 1999/31/EC) generally states (Article 6a) that 'only waste that has been subject to treatment [may be] landfilled. This provision may not apply to inert waste for which treatment is not technically feasible, nor to any other waste for which such treatment does not contribute to the objectives of this Directive, by reducing the quantity of the waste or the hazards to human health or the environment.'

The Directive (Article 5) furthermore requires that the member states shall set up a strategy for the implementation of the reduction of biodegradable waste going to landfill. Such waste shall rather be subject to recycling, composting, biogas production or materials/energy recovery. The strategy shall ensure that the amount of bio-degradable municipal waste going to landfill is reduced as follows: by 2006 to 75 per cent, by 2009 to 50 per cent and by 2016 to 35 per cent of the amount produced in 1995. Member states which in 1995 landfilled more than 80 per cent of their municipal waste may postpone the attainment of the targets by four years.

Finally, the Directive makes a number of specific requirements for the design of and the acceptance of waste at landfills.

The EU's Waste Shipment Regulation

In an attempt to prevent exports of hazardous waste to developing countries the so-called Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal was signed in 1989 within the framework of the OECD. The Convention was ratified by Denmark and the other EU countries as well as the EU as such.

On the basis of the convention, the EU has issued 'Council Regulation (EEC) No. 259/93 of 1 February 1993 on the supervision and control of shipments of waste within, into and out of the European Community', commonly called the Waste Shipment Regulation. This Regulation was revised in 2005.

The revised regulation stipulates that shipments of waste across borders must be subject to notification to the competent authorities in the state of dispatch. These authorities must then transmit the notification to the competent authorities in the state of destination and, if relevant, the state of transit, and a contract with the consignee must be made (Article 4, Article 7.1, and Article 4.4).

Where the waste shipment is intended for disposal, Article 11.1 (a) shall apply: '(...) the competent authorities of dispatch and destination may (...) raise reasoned objections (...) [if] (...) the planned shipment or disposal would not be in accordance with measures taken to implement the principles of proximity, priority for recovery and self-sufficiency at Community and national levels (...) to prohibit generally or partially or to object systematically to shipments of waste (...).' Article 11 presents a couple of other reasons that would justify objections, for example 'that the waste is mixed municipal waste collected from private households' (Article 11.1 (i)).

However, the regulation also states (Article 11.3) that 'In the case of hazardous waste produced in a Member State of dispatch in such a small quantity overall per year that the provision of new specialized disposal installations within that State would be uneconomic, paragraph 1 (a) shall not apply.'

In line with this stipulation, permission would be required from the Danish Environmental Protection Agency if, for instance, Germany were to ship waste for incineration at Danish waste-to-energy facilities.

Denmark may ship flue gas treatment residues to special treatment in Norway and Germany due to the fact that the shipment is covered by the stipulation in Article 11.3.

The 1993 Regulation was transposed into Danish legislation by Orders No. 971 of 19 November 1996 and No. 264 of 3 April 2000 on import and export of waste, issued by the Danish Ministry of Environment. A new order will be issued when the revised regulation comes into force.

Similar conditions are not available to the same extent outside Denmark where many countries are still not able to introduce a ban on landfilling of waste suitable for incineration. The waste-to-energy facilities therefore compete for the waste against landfills and other treatment facilities.

In 1994 Germany adopted the so-called Act for Promoting Closed Substance Cycle Waste Management and Ensuring Environmentally Compatible Waste Disposal. Pursuant to this Act it was decided to no longer dispose of untreated waste to landfill as per 1 June 2005. Germany still has an incineration capacity deficiency.

Other parts of the world

In the rest of the world waste incineration is only found at significant levels in Taiwan, Singapore, Japan and the USA. In the extremely densely populated Japan incineration is the predominant waste treatment method, while the USA only incinerates approx. 14 per cent of the total waste amount. Of this amount approx. 40 per cent is incinerated in the states that lie on the eastern coast.

Challenges in the years to come

Denmark leads the way when it comes to recycling the largest possible amount of waste, recovering the most energy from waste incineration and wasting the fewest possible resources by landfilling of waste.

Therefore, Denmark has a cheap and very well-functioning waste-to-energy sector. It serves both citizens and enterprises in that they can always be certain to dispose of their waste in an environmentally friendly way.

Continued extension necessary

This should preferably continue to be the case, but it requires that the incineration capacity is continuously upgraded and extended. Today, there is a small surplus capacity, but since the amounts of waste continue to increase, the surplus capacity will have disappeared by 2010.

It will take five years to establish new facilities. Therefore Denmark is already now faced with a situation in which it should consider extending the incineration capacity if the country is to extend the guarantee that the waste producers may easily discard their combustible waste.

In countries outside Denmark there is today a significant lack of incineration capacity, which is partly due to uncertainty relating to the framework conditions and partly to the fact that the public sector has contracted out the establishment and operation of waste-to-energy facilities.

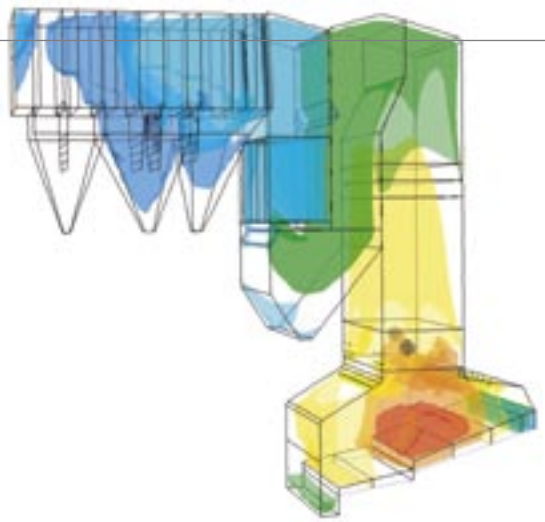
Owing to visionary environmental and energy policies combined with good public planning, Denmark has succeeded in creating the most efficient waste management system in Europe. The country can boast both the highest recycling percentages and the highest efficiency when incinerating its waste, as compared with the rest of Europe. In this system the waste-to-energy facilities are an important cornerstone.

Well-functioning model that should be preserved

In the Danish model it has so far been possible to ensure the necessary treatment capacity at the lowest prices in Europe. When incineration of waste costs the same as the waste collection bag itself, the possibilities of gaining limited benefits from efficiency improvement should be carefully weighed against the risks entailed by liberalisation of the waste-to-energy sector.

Denmark can continue to lead the way in the field of waste-to-energy – if it wants.

Literature



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Waste-to-energy facilities in Denmark

Plant	Owner	Address		No. of lines	Tot. capacity, t/h
Aalborg	I/S Reno-Nord	Troensevej 2,	DK-9220 Aalborg Øst	2	31
Aars	Aars kommune	Dybvad Møllevej 1,	DK-9600 Aars	2	8.5
Århus	Århus kommunale Værker	Ølstedvej 20,	DK-8200 Århus N	3	31.2
Esbjerg	L 90	Måde Industrivej 35,	DK-6705 Esbjerg Ø	1	24
Frederikshavn	Elsam A/S	Vendsysselvej 201,	DK-9900 Frederikshavn	1	5
Glostrup	I/S Vestforbrænding	Ejbymosevej 219,	DK-2600 Glostrup	4	83
Grenå	Grenå kommune	Kalorievej 9,	DK-8500 Grenå	1	2.5
Haderslev	Elsam A/S	Dybkær 2, Marstrup,	DK-6100 Haderslev	2	9
Hammel	Hammel Fjernvarme A.m.b.a.	Irlandsvej 6,	DK-8450 Hammel	2	6
Herning	EG. Jylland	Miljøvej 3,	DK-7400 Herning	1	5
Hjørring	AVV I/S	Mandøvej 8,	DK-9800 Hjørring	2	12
Hobro	I/S Fælles Forbrænding	Hvedemarken 13, Boks 130,	DK-9500 Hobro	2	6.9
Holstebro	Elsam A/S	Energivej 2,	DK-7500 Holstebro	2	18
Horsens	Elsam A/S	Endelavevej 7,	DK-8700 Horsens	2	10
Hørsholm	I/S Nordforbrænding	Savsvinget 2,	DK-2970 Hørsholm	4	19
København	I/S Amagerforbrænding	Kraftværksvej 31,	DK-2300 København S	4	48
Kolding	TAS I/S	Bronzevej 6,	DK-6000 Kolding	1	9.2
Næstved	I/S FASAN	Ved Fjorden 20,	DK-4700 Næstved	3	17
Nykøbing F	I/S REFA	Energivej 4,	DK-4800 Nykøbing F.	3	17
Odense	Elsam A/S, Fynsværket	Havnegade 120, Boks 928,	DK-5100 Odense C	3	32
Rønne	I/S BOFA	Almegårdsvej 8,	DK-3700 Rønne	1	2.5
Roskilde	I/S KARA	Håndværkervej 70,	DK-4000 Roskilde	3	34
Skagen	Skagen kommune	Buttervej 66,	DK-9990 Skagen	1	2
Skanderborg	I/S RENO SYD	Norgesvej 13,	DK-8660 Skanderborg	2	9.5
Slagelse	I/S KAVO	Dalsvinget 11,	DK-4200 Slagelse	2	10
Sønderborg	Sønderborg Kraftvarmeværk I/S	Vestermark 16,	DK-6400 Sønderborg	1	8
Svendborg	Svendborg kommune	Bodøvej 1,	DK-5700 Svendborg	1	6
Thisted	I/S Thyra	Industrivej 9,	DK-7700 Thisted	1	6.4
Vejen	Elsam A/S	Koldingvej 30B,	DK-6600 Vejen	1	4.3

The most efficient waste management system in Europe • Waste-to-energy in Denmark

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RenoSam is the association of 33 Danish and 2 Faroese waste management companies, promoting efficiency and high environmental standards within the field of waste treatment. The association aims to strengthen co-operation between waste management companies; provide information on current activities, operational experience and actual problems; establish working relationships with other associations, institutions, companies, etc. which are engaged in related fields; promote the mutual interests of its members to responsible authorities; and advance education and research within the waste field.

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Rambøll provides waste-to-energy consulting services. The company assists its clients in the planning and implementation of waste-to-energy projects across the world. Its projects involve the establishment of new green-field facilities, capacity extensions, and retrofits or upgrades in order to meet more stringent environmental requirements. Rambøll has been the consultant to the majority of the waste-to-energy facilities established in Denmark.

The most efficient waste management system in Europe

Waste-to-energy in Denmark

Owing to visionary environmental and energy policies combined with coherent public planning, Denmark has developed the most efficient waste management system in Europe.

The Danish waste-to-energy facilities make up the cornerstone of the disposal of non-recyclable waste, and at the same time they produce electricity and heat for approximately 400,000 households in Denmark. This enables them to incinerate waste at a price that is the lowest in Europe – for the benefit of households and enterprises.

The present publication analyses the background for this success and makes recommendations as to how to maintain it.

Reno Sam

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