Incineration

Incineration is a waste treatment technology that involves the combustion of organic materials and/or substances.[1] Incineration and other high temperature waste treatment systems are described as "thermal treatment". Incineration of waste materials converts the waste into incinerator bottom ash, flue gases, particulates, and heat, which can in turn be used to generate electric power. The flue gases are cleaned of pollutants before they are dispersed in the atmosphere.

Spittelau incineration plant in Vienna.

Incineration with energy recovery is one of several waste-to-energy (WtE) technologies such as gasification, Plasma arc gasification, pyrolysis and anaerobic digestion. Incineration may also be implemented without energy and materials recovery.

In several countries there are still expert and local community concerns about the environmental impact of incinerators (see The argument against incineration).

In some countries, incinerators built just a few decades ago often did not include a materials separation to remove hazardous, bulky or recyclable materials before combustion. These facilities tended to risk the health of the plant workers and the local environment due to inadequate levels of gas cleaning and combustion process control. Most of these facilities did not generate electricity.

Incinerators reduce the mass of the original waste by 80–85 % and the volume (already compressed somewhat in garbage trucks) by 95-96 %, depending upon composition and degree of recovery of materials such as metals from the ash for recycling.[2] This means that while incineration does not completely replace landfilling, it reduces the necessary volume for disposal significantly. Garbage trucks often reduce the volume of waste in a built-in compressor before delivery to the incinerator.

Alternatively, at landfills, the volume of the uncompressed garbage can be reduced by approximately 70% with the use of a stationary steel compressor, albeit with a significant energy cost. In many countries simpler waste compaction is a common practice for compaction at landfills.

Incineration has particularly strong benefits for the treatment of certain waste types in niche areas such as clinical wastes and certain hazardous wastes where pathogens and toxins can be destroyed by high temperatures. Examples include chemical multi-product plants with diverse toxic or very toxic wastewater streams, which cannot be routed to a conventional wastewater treatment plant.

SYSAV incineration plant in Malmö, Sweden capable of handling 25 metric tons (28 short tons) per hour household waste. To the left of the main stack, a new identical oven line is under construction (March 2007).

Waste combustion is particularly popular in countries such as Japan where land is a scarce resource. Denmark and Sweden have been leaders in using the energy generated from incineration for more than a century, in localised combined heat and power facilities supporting district heating schemes.[3] In 2005, waste incineration produced 4.8 % of the electricity consumption and 13.7 % of the total domestic heat consumption in Denmark.[4] A number of other European Countries rely heavily on incineration for handling municipal waste, in particular Luxembourg, the Netherlands, Germany and France.[2]

History

The first incinerators for waste disposal were built in Nottingham by Manlove, Alliott & Co. Ltd. in 1874 to a design patented by Albert Fryer. They were originally known as Destructors.[5]

Technology

An incinerator is a furnace for burning waste. Modern incinerators include pollution mitigation equipment such as flue gas cleaning. There are various types of incinerator plant design: moving grate, fixed grate, rotary-kiln, fluidised bed.

Private burn pile / barrel

The burn pile is one of the simplest and earliest forms of waste disposal, essentially consisting of a mound of combustible materials piled on bare ground and set on fire. Indiscriminate piles of household waste are strongly discouraged and may be illegal in urban areas, but are permitted in certain rural situations such as clearing forested land for farming, where the stumps are uprooted and burned.[6] Rural burn piles of organic yard waste are also sometimes permitted, though not asphalt shingles, plastics, or other petroleum products.[6]

Burn piles have the potential to spread uncontrolled fires, if for example wind blows burning material off the pile into surrounding combustible grasses or onto buildings. As interior structures of the pile are consumed, the pile can shift and collapse, spreading the burn area. Even in a situation of no wind, small lightweight ignited embers can lift off the pile via convection, and waft through the air into grasses or onto buildings, igniting them.

The burn barrel is a somewhat more controlled form of private waste incineration, containing the burning material inside a metal barrel, with a metal grating over the exhaust. The barrel prevents the spread of burning material in windy conditions, and as the combustibles are reduced they can only settle down into the barrel. The exhaust grating helps to prevent the spread of burning embers. Typically steel 55-gallon drums are used as burn barrels, with air vent holes cut or drilled around the base for air intake.[7] Over time the very high heat of incineration causes the metal to oxidize and rust, and eventually the barrel itself is consumed by the heat and must be replaced.

Private burning of dry cellulosic/paper products is generally clean-burning, producing no visible smoke, but the large amount of plastics in household waste can cause private burning to create a public nuisance and health hazard, generating acrid odors and fumes that make eyes burn and water. The temperatures in a burn barrel are not regulated, and usually do not reach high enough or for enough time to completely break down chemicals such as dioxin in plastics and other waste chemicals. Plastics and other petroleum products must therefore be separated and sent to commercial waste disposal facilities.

Private rural incineration is typically only permitted so long as it is not a nuisance to others, does not pose a risk of fire such as in dry conditions, and the fire is clean-burning, producing no visible smoke. People intending to burn waste may be required to contact a state agency in advance to check current fire risk and conditions, and to alert officials of the controlled fire that will occur.[8]

Moving grate

The typical incineration plant for municipal solid waste is a moving grate incinerator. The moving grate enables the movement of waste through the combustion chamber to be optimised to allow a more efficient and complete combustion. A single moving grate boiler can handle up to 35 metric tons (39 short tons) of waste per hour, and can operate 8,000 hours per year with only one scheduled stop for inspection and maintenance of about one month's duration.[9] Moving grate incinerators are sometimes referred to as Municipal Solid Waste Incinerators (MSWIs).


Control room of a typical moving grate incinerator overseeing two boiler lines

The waste is introduced by a waste crane through the "throat" at one end of the grate, from where it moves down over the descending grate to the ash pit in the other end. Here the ash is removed through a water lock.

Part of the combustion air (primary combustion air) is supplied through the grate from below. This air flow also has the purpose of cooling the grate itself. Cooling is important for the mechanical strength of the grate, and many moving grates are also water cooled internally.

Municipal solid waste in the furnace of a moving grate incinerator capable of handling 15 metric tons (17 short tons) of waste per hour. The holes in the grate elements supplying the primary combustion air are visible.

Secondary combustion air is supplied into the boiler at high speed through nozzles over the grate. It facilitates complete combustion of the flue gases by introducing turbulence for better mixing and by ensuring a surplus of oxygen. In multiple/stepped hearth incinerators, the secondary combustion air is introduced in a separate chamber downstream the primary combustion chamber.

According to the European Waste Incineration Directive, incineration plants must be designed to ensure that the flue gases reach a temperature of at least 850 °C (1560 °F) for 2 seconds in order to ensure proper breakdown of toxic organic substances. In order to comply with this at all times, it is required to install backup auxiliary burners (often fueled by oil), which are fired into the boiler in case the heating value of the waste becomes too low to reach this temperature alone.

The flue gases are then cooled in the superheaters, where the heat is transferred to steam, heating the steam to typically 400 °C (752 °F) at a pressure of 40 bars (580 psi) for the electricity generation in the turbine. At this point, the flue gas has a temperature of around 200 °C (392 °F), and is passed to the flue gas cleaning system.

In Scandinavia scheduled maintenance is always performed during summer, where the demand for district heating is low. Often incineration plants consist of several separate 'boiler lines' (boilers and flue gas treatment plants), so that waste can continue to be received at one boiler line while the others are subject to revision.

Fixed grate

The older and simpler kind of incinerator was a brick-lined cell with a fixed metal grate over a lower ash pit, with one opening in the top or side for loading and another opening in the side for removing incombustible solids called clinkers. Many small incinerators formerly found in apartment houses have now been replaced by waste compactors.

Rotary-kiln

The rotary-kiln incinerator[10] is used by municipalities and by large industrial plants. This design of incinerator has 2 chambers: a primary chamber and secondary chamber. The primary chamber in a rotary kiln incinerator consist of an inclined refractory lined cylindrical tube. Movement of the cylinder on its axis facilitates movement of waste. In the primary chamber, there is conversion of solid fraction to gases, through volatilization, destructive distillation and partial combustion reactions. The secondary chamber is necessary to complete gas phase combustion reactions

The clinkers spill out at the end of the cylinder. A tall flue gas stack, fan, or steam jet supplies the needed draft. Ash drops through the grate, but many particles are carried along with the hot gases. The particles and any combustible gases may be combusted in an "afterburner".[11]

Fluidized bed

A strong airflow is forced through a sandbed. The air seeps through the sand until a point is reached where the sand particles separate to let the air through and mixing and churning occurs, thus a fluidised bed is created and fuel and waste can now be introduced.

The sand with the pre-treated waste and/or fuel is kept suspended on pumped air currents and takes on a fluid-like character. The bed is thereby violently mixed and agitated keeping small inert particles and air in a fluid-like state. This allows all of the mass of waste, fuel and sand to be fully circulated through the furnace.

Specialized incineration

Furniture factory sawdust incinerators need much attention as these have to handle resin powder and many flammable substances. Controlled combustion, burn back prevention systems are essential as dust when suspended resembles the fire catch phenomenon of any liquid petroleum gas.

Use of heat

The heat produced by an incinerator can be used to generate steam which may then be used to drive a turbine in order to produce electricity. The typical amount of net energy that can be produced per tonne municipal waste is about 2/3 MWh of electricity and 2 MWh of district heating.[2] Thus, incinerating about 600 metric tons (660 short tons) per day of waste will produce about 400 MWh of electrical energy per day (17 MW of electrical power continuously for 24 hours) and 1200 MWh of district heating energy each day.

Pollution

Incineration has a number of outputs such as the ash and the emission to the atmosphere of flue gas. Before the flue gas cleaning system, the flue gases may contain significant amounts of particulate matter, heavy metals, dioxins, furans, sulfur dioxide, and hydrochloric acid.

In a study from 1994, Delaware Solid Waste Authority found that, for same amount of produced energy, incineration plants emitted fewer particles, hydrocarbons and less SO_2, HCl, CO and NO_x than coal-fired power plants, but more than natural gas fired power plants.[12] According to Germany's Ministry of the Environment, waste incinerators reduce the amount of some atmospheric pollutants by substituting power produced by coal-fired plants with power from waste-fired plants.[13]

Gaseous emissions

Dioxin and furans

The most publicized concerns from environmentalists about the incineration of municipal solid wastes (MSW) involve the fear that it produces significant amounts of dioxin and furan emissions.[14] Dioxins and furans are considered by many to be serious health hazards.

In 2005, The Ministry of the Environment of Germany, where there were 66 incinerators at that time, estimated that "...whereas in 1990 one third of all dioxin emissions in Germany came from incineration plants, for the year 2000 the figure was less than 1 %. Chimneys and tiled stoves in private households alone discharge approximately twenty times more dioxin into the environment than incineration plants."[13]

According to the United States Environmental Protection Agency, incineration plants are no longer significant sources of dioxins and furans. In 1987, before the governmental regulations required the use of emission controls, there was a total of 10000 grams (350 oz) of dioxin emissions from U.S. incinerators. Today, the total emissions from the 87 plants are only 10 grams (0.35 oz) yearly, a reduction of 99.9 %.

Backyard barrel burning of household and garden wastes, still allowed in some rural areas, generates 580 grams (20 oz) of dioxins yearly. Studies conducted by the US-EPA[15] demonstrate that the emissions from just one family using a burn barrel produces more emissions than an incineration plant disposing of 200 metric tons (220 short tons) of waste per day.

Dioxin cracking methods and limitations

Generally the breakdown of dioxin requires exposure of the molecular ring to a sufficiently high temperature so as to trigger thermal breakdown of the strong molecular bonds holding it together. Small pieces of fly ash may have a slight thickness to them, and too quick of a high temperature exposure may only degrade dioxin on the surface of the ash. For a large volume air chamber, too quick of exposure may also result in only some of the exhaust gases reaching the full breakdown temperature. For this reason there is also a time element to the temperature exposure to ensure heating completely through the thickness of the fly ash and the volume of waste gases.

There are tradeoffs between increasing either the temperature or exposure time. Generally where the molecular breakdown temperature is higher, the exposure time for heating can be shorter, but excessively high temperatures can also cause wear and damage to other parts of the incineration equipment. Likewise the breakdown temperature can be lowered to some degree but then the exhaust gases would require a greater lingering period of perhaps several minutes, which would require large/long treatment chambers that take up a great deal of treatment plant space.

A side effect of breaking the strong molecular bonds of dioxin is the potential for breaking the bonds of nitrogen gas (N_2) and oxygen gas (O_2) in the supply air. As the exhaust flow cools, these highly reactive detached atoms spontaneously reform bonds into reactive oxides such as NO_x in the flue gas, which can result in smog formation and acid rain if they were released directly into the local environment. These reactive oxides must be further neutralized with selective catalytic reduction (SCR) or selective non-catalytic reduction (see below).

Dioxin cracking in practice

The temperatures needed to break down dioxin are typically not reached when burning of plastics outdoors in a burn barrel or garbage pit, causing high dioxin emissions as mentioned above. While plastic does usually burn in an open-air fire, the dioxins remain after combustion and either float off into the atmosphere, or may remain in the ash where it can be leached down into groundwater when rain falls on the ash pile.

Modern municipal incinerator designs include a high temperature zone, where the flue gas is ensured to sustain a temperature above 850 °C (1560 °F) for at least 2 seconds before it is cooled down. They are equipped with auxiliary heaters to ensure this at all times. These are often fueled by oil, and normally only active for a very small fraction of the time.

For very small municipal incinerators, the required temperature for thermal breakdown of dioxin may be reached using a high-temperature electrical heating element, plus a selective catalytic reduction stage.

CO_2

As for other complete combustion processes, nearly all of the carbon content in the waste is emitted as CO_2 to the atmosphere. MSW contains approximately the same mass fraction of carbon as CO_2 itself (27%), so incineration of 1 ton of MSW produces approximately 1 ton of CO_2.

If the waste was landfilled, 1 ton of MSW would produce approximately 62 cubic metres (2200 cu ft) methane via the anaerobic decomposition of the biodegradable part of the waste. This much methane has more than twice the global warming potential than the 1 ton of CO_2, which would have been produced by incineration. In some countries, large amounts of landfill gas are collected, but still the global warming potential of the landfill gas emitted to atmosphere in the US in 1999 was approximately 32 % higher than the amount of CO_2 that would have been emitted by incineration.[16]

In addition, nearly all biodegradable waste has biological origin. This material has been formed by plants using atmospheric CO_2 typically within the last growing season. If these plants are regrown the CO_2 emitted from their combustion will be taken out from the atmosphere once more.

Such considerations are the main reason why several countries administrate incineration of the biodegradable part of waste as renewable energy.[17] The rest – mainly plastics and other oil and gas derived products – is generally treated as non-renewables.

Different results for the CO_2 footprint of incineration can be reached with different assumptions. Local conditions (such as limited local district heating demand, no fossil fuel generated electricity to replace or high levels of aluminum in the waste stream) can decrease the CO_2 benefits of incineration. The methodology and other assumptions may also influence the results significantly. For example the methane emissions from landfills occurring at a later date may be neglected or given less weight, or biodegradable waste may not be considered CO_2 neutral. A recent study by Eunomia Research and Consulting on potential waste treatment technologies in London demonstrated that by applying several of these (according to the authors) unusual assumptions the average existing incineration plants performed poorly for CO_2 balance compared to the theoretical potential of other emerging waste treatment technologies.[18]

Other emissions

Other gaseous emissions in the flue gas from incinerator furnaces include sulfur dioxide, hydrochloric acid, heavy metals and fine particles.

The steam content in the flue may produce visible fume from the stack, which can be perceived as a visual pollution. It may be avoided by decreasing the steam content by flue gas condensation and reheating, or by increasing the flue gas exit temperature well above its dew point. Flue gas condensation allows the latent heat of vaporization of the water to be recovered, subsequently increasing the thermal efficiency of the plant.

Flue gas cleaning

The quantity of pollutants in the flue gas from incineration plants is reduced by several processes.

Particulate is collected by particle filtration, most often electrostatic precipitators (ESP) and/or baghouse filters. The latter are generally very efficient for collecting fine particles. In an investigation by the Ministry of the Environment of Denmark in 2006, the average particulate emissions per energy content of incinerated waste from 16 Danish incinerators were below 2.02 g/GJ (grams per energy content of the incinerated waste). Detailed measurements of fine particles with sizes below 2.5 micrometres ($PM_{2.5}$) were performed on three of the incinerators: One incinerator equipped with an ESP for particle filtration emitted 5.3 g/GJ fine particles, while two incinerators equipped with baghouse filters emitted 0.002 and 0.013 g/GJ $PM_{2.5}$. For ultra fine particles ($PM_{1.0}$), the numbers were 4.889 g/GJ $PM_{1.0}$ from the ESP plant, while emissions of 0.000 and 0.008 g/GJ $PM_{1.0}$ were measured from the plants equipped with baghouse filters.[19] [20]

Acid gas scrubbers are used to remove hydrochloric acid, nitric acid, hydrofluoric acid, mercury, lead and other heavy metals. Basic scrubbers remove sulfur dioxide, forming gypsum by reaction with lime.[21]

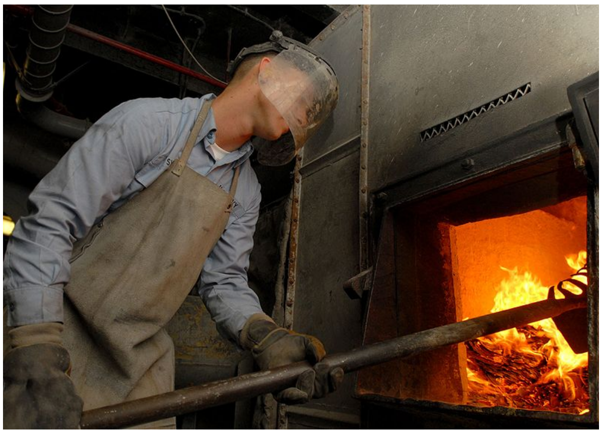
Waste water from scrubbers must subsequently pass through a waste water treatment plant.

Sulfur dioxide may also be removed by dry desulfurisation by injection limestone slurry into the flue gas before the particle filtration.

NO_x is either reduced by catalytic reduction with ammonia in a catalytic converter (selective catalytic reduction, SCR) or by a high temperature reaction with ammonia in the furnace (selective non-catalytic reduction, SNCR). Urea may be substituted for ammonia as the reducing reagent but must be supplied earlier in the process so that it can hydrolyze into ammonia. Substitution of urea can reduce costs and potential hazards associated with storage of anhydrous ammonia.

Heavy metals are often adsorbed on injected active carbon powder, which is collected by the particle filtration.

Solid outputs


Operation of an incinerator aboard an aircraft carrier

Incineration produces fly ash and bottom ash just as is the case when coal is combusted. The total amount of ash produced by municipal solid waste incineration ranges from 4-10 % by volume and 15-20 % by weight of the original quantity of waste,[2] [22] and the fly ash amounts to about 10-20 % of the total ash. The fly ash, by far, constitutes more of a potential health hazard than does the bottom ash because the fly ash often contain high concentrations of heavy metals such as lead, cadmium, copper and zinc as well as small amounts of dioxins and furans.[23] The bottom ash seldom contain significant levels of heavy metals. In testing over the past decade, no ash from an incineration plant in the USA has ever been determined to be a hazardous waste. At present although some historic samples tested by the incinerator operators' group would meet the being ecotoxic criteria at present the EA say "we have agreed" to regard incinerator bottom ash as "non-hazardous" until the testing programme is complete.

Other pollution issues

Odor pollution can be a problem with old-style incinerators, but odors and dust are extremely well controlled in newer incineration plants. They receive and store the waste in an enclosed area with a negative pressure with the airflow being routed through the boiler which prevents unpleasant odors from escaping into the atmosphere. However, not all plants are implemented this way, resulting in inconveniences in the locality.

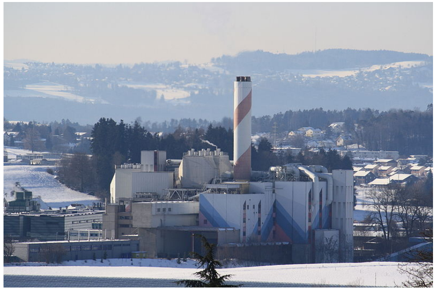
An issue that affects community relationships is the increased road traffic of waste collection vehicles to transport municipal waste to the incinerator. Due to this reason, most incinerators are located in industrial areas. This problem can be can avoided to an extent through the transport of waste by rail from transfer stations.

The debate over incineration

Use of incinerators for waste management is controversial. The debate over incinerators typically involves business interests (representing both waste generators and incinerator firms), government regulators, environmental activists and local citizens who must weigh the economic appeal of local industrial activity with their concerns over health and environmental risk.

People and organizations professionally involved in this issue include the U.S. Environmental Protection Agency and a great many local and national air quality regulatory agencies worldwide.

The argument for incineration


Kehrichtverbrennungsanlage Zürcher Oberland (KEZO) in Hinwil, Switzerland

- The concerns over the health effects of dioxin and furan emissions have been significantly lessened by advances in emission control designs and very stringent new governmental regulations that have resulted in large reductions in the amount of dioxins and furans emissions.[13]
- The U.K. Health Protection Agency concluded in 2009 that "Modern, well managed incinerators make only a small contribution to local concentrations of air pollutants. It is possible that such small additions could have an impact on health but such effects, if they exist, are likely to be very small and not detectable."[24] .
- Incineration plants can generate electricity and heat that can substitute power plants powered by other fuels at the regional electric and district heating grid, and steam supply for industrial customers. Incinerators and other waste-to-energy plants generate at least partially biomass-based renewable energy that offsets greenhouse gas pollution from coal-, oil- and gas-fired power plants.[25] The E.U. considers energy generated from biogenic waste (waste with biological origin) by incinerators as non-fossil renewable energy under its emissions caps. These greenhouse gas reductions are in addition to those generated by the avoidance of landfill methane.
- The bottom ash residue remaining after combustion has been shown to be a non-hazardous solid waste that can be safely put into landfills or recycled as construction aggregate. Samples are tested for ecotoxic metals.[26] .
- In densely populated areas, finding space for additional landfills is becoming increasingly difficult.
- Fine particles can be efficiently removed from the flue gases with baghouse filters. Even though approximately 40 % of the incinerated waste in Denmark was incinerated at plants with no baghouse filters, estimates based on measurements by the Danish Environmental Research Institute showed that incinerators were only responsible for approximately 0.3 % of the total domestic emissions of particulate smaller than 2.5 micrometres ($PM_{2.5}$) to the atmosphere in 2006.[20] [19]
- Incineration of municipal solid waste avoids the release of methane. Every ton of MSW incinerated, prevents about one ton of carbon dioxide equivalents from being released to the atmosphere.[16]
- Incineration of medical waste and sewage sludge produces an end product ash that is sterile and non-hazardous.
- Most municipalities that operate incineration facilities have higher recycling rates than neighboring cities and counties that do not send their waste to incinerators.[27] This is in part due to enhanced recovery of ceramic materials reused in construction, as well as ferrous and in some cases non-ferrous metals that can be recovered from combustion residue.[28] Metals recovered from ash would typically be difficult or impossible to recycle through conventional means, as the removal of attached combustible material through incineration provides an alternative to labor- or energy-intensive mechanical separation methods.
- Volume of combusted waste is reduced by approximately 90%, increasing the life of landfills. Ash from modern incinerators is vitrified at temperatures of 1000 °C (1830 °F) to 1100 °C (2010 °F), reducing the leachability and toxicity of residue. As a result, special landfills are generally no longer required for incinerator ash from municipal waste streams, and existing landfills can see their life dramatically increased by combusting waste, reducing the need for municipalities to site and construct new landfills.[29] [30]

The argument against incineration

Decommissioned Kwai Chung Incineration Plant from 1978. As of late February 2009, it has been demolished.

- The Scottish Protection Agency's (SEPA) comprehensive health effects research concluded "inconclusively" on health effects in Oct. 2009. The authors stress, that even though no conclusive evidence of non-occupational health effects from incinerators were found in the existing literature, "small but important effects might be virtually impossible to detect". The report highlights epidemiological deficiencies in previous UK health studies and suggests areas for future studies.[31] The U.K. Health Protection Agency produced a lesser summary in September 2009.[24] Many toxiocologists criticise and dispute this report as not being comprehensive epidemiologically, thin on peer review and the effects of fine particle effects on health.
- The highly toxic fly ash must be safely disposed of. This usually involves additional waste miles and the need for specialist toxic waste landfill elsewhere. If not done properly, it may cause concerns for local residents.[32] [33]
- Some people are still concerned about the health effects of dioxin and furan emissions into the atmosphere from old incinerators; especially during start up and shut down, or where filter bypass is required.
- Incinerators emit varying levels of heavy metals such as vanadium, manganese, chromium, nickel, arsenic, mercury, lead, and cadmium, which can be toxic at very minute levels.
- Incinerator Bottom Ash (IBA) has elevated levels of heavy metals with ecotoxicity concerns if not reused properly. Some people have the opinion that IBA reuse is still in its infancy and is still not considered to be a mature or desirable product, despite additional engineering treatments. Concerns of IBA use in foam concrete have been expressed by the UK Health and Safety Executive in 2010 following several construction and demolition explosions. In its guidance document, IBA is currently banned from use by the UK Highway Authority in concrete work until these incidents have been investigated.[34]
- Alternative technologies are available or in development such as Mechanical Biological Treatment, Anaerobic Digestion (MBT/AD), Autoclaving or Mechanical Heat Treatment (MHT) using steam or plasma arc gasification PGP, or combinations of these treatments. Erection of incinerators compete with the development and introduction of other emerging technologies. A UK government WRAP report, August 2008 found that in the UK median incinerator costs per ton were generally higher than those for MBT treatments by £18 per metric ton; and £27 per metric ton most for modern (post 2000) incinerators.[35] [36]
- Building and operating waste processing plants such as incinerators requires long contract periods to recover initial investment costs, causing a long term lock-in. Incinerator lifetimes normally range 25–30 years. This was highlighted by Peter Jones, OBE, the Mayor of London's waste representative in April 2009.[37]

- Incinerators produce fine particles in the furnace. Even with modern particle filtering of the flue gases, a small part of these is emitted to the atmosphere. $PM_{2.5}$ is not separately regulated in the European Waste Incineration Directive, even though they are repeatedly correlated spatially to infant mortality in the UK (M.Ryan's ONS data based maps around the EfW/CHP waste incinerators at Edmonton, Coventry, Chineham, Kirklees and Sheffield).[38] [39] [40] Under WID there is no requirement to monitor stack top or downwind incinerator $PM_{2.5}$ levels.[41] Several European doctors associations (including cross discipline experts such as physicians, environmental chemists and toxicologists) in June 2008 representing over 33,000 doctors wrote a keynote statement directly to the European Parliament citing widespread concerns on incinerator particle emissions and the absence of specific fine and ultrafine particle size monitoring or in depth industry/ government epidemiological studies of these minute and invisible incinerator particle size emissions.[42]
- Local communities are often opposed to the idea of locating waste processing plants such as incinerators in their vicinity (the Not In My Back Yard phenomenon). Studies in Andover, Massachusetts strongly correlated 10% property devaluations with close incinerator proximity.[43]
- Prevention, waste minimisation, reuse and recycling of waste should all be preferred to incineration according to the waste hierarchy. Supporters of zero waste consider incinerators and other waste treatment technologies as barriers to recycling and separation beyond particular levels, and that waste resources are sacrificed for energy production.[44] [45] [46]
- A 2008 Eunomia report found that under some circumstances and assumptions, incineration causes less CO_2 reduction than other emerging EfW and CHP technology combinations for treating residual mixed waste.[18] The authors found that CHP incinerator technology without waste recycling ranked 19 out of 24 combinations (where all alternatives to incineration were combined with advanced waste recycling plants); being 228% less efficient than the ranked 1 Advanced MBT maturation technology; or 211% less efficient than plasma gasification/autoclaving combination ranked 2.
- Some incinerators are visually undesirable. In many countries they require a visually intrusive chimney stack.
- If reusable waste fractions are handled in waste processing plants such as incinerators in developing nations, it would cut out viable work for local economies. It is estimated that there are 1 million people making a livelihood off collecting waste.[47] .

Trends in incinerator use

The history of municipal solid waste (MSW) incineration is linked intimately to the history of landfills and other waste treatment technology. The merits of incineration are inevitably judged in relation to the alternatives available. Since the 1970s, recycling and other prevention measures have changed the context for such judgements. Since the 1990s alternative waste treatment technologies have been maturing and becoming viable.

Incineration is a key process in the treatment of hazardous wastes and clinical wastes. It is often imperative that medical waste be subjected to the high temperatures of incineration to destroy pathogens and toxic contamination it contains.

Incineration in North America

The first incinerator in the U.S. was built in 1885 on Governors Island in New York.[48] In 1949, Robert C. Ross founded one of the first hazardous waste management companies in the U.S. He began Robert Ross Industrial Disposal because he saw an opportunity to meet the hazardous waste management needs of companies in northern Ohio. In 1958, the company built one of the first hazardous waste incinerators in the U.S.[49] The first full-scale, municipally operated incineration facility in the U.S. was the Arnold O. Chantland Resource Recovery Plant, built in 1975 and located in Ames, Iowa. This plant is still in operation and produces refuse-derived fuel that is sent to local power plants for fuel.[50] The first commercially successful incineration plant in the U.S. was built in Saugus, Massachusetts in October 1975 by Wheelabrator Technologies, and is still in operation today.[22]

There are several environmental or waste management corporations that transport ultimately to an incinerator or cement kiln treatment center. Currently (2009), there are three main businesses that incinerate waste: Clean Harbours, WTI-Heritage, and Ross Incineration Services. Clean Harbours has acquired many of the smaller, independently run facilties, accumulating 5–7 incinerators in the process across the U.S. WTI-Heritage has one incinerator, located in the southeastern corner of Ohio (across the Ohio River from West Virginia).

Several old generation incinerators have been closed; of the 186 MSW incinerators in 1990, only 89 remained by 2007, and of the 6200 medical waste incinerators in 1988, only 115 remained in 2003.[51] No new incinerators were built between 1996 and 2007. The main reasons for lack of activity have been:

- Economics. With the increase in the number of large inexpensive regional landfills and, up until recently, the relatively low price of electricity, incinerators were not able to compete for the 'fuel', i.e., waste in the U.S.
- Tax policies. Tax credits for plants producing electricity from waste were rescinded in the U.S. between 1990 and 2004.

There has been renewed interest in incineration and other waste-to-energy technologies in the U.S. and Canada. In the U.S., incineration was granted qualification for renewable energy production tax credits in 2004.[52] Projects to add capacity to existing plants are underway, and municipalities are once again evaluating the option of building incineration plants rather than continue landfilling municipal wastes. However, many of these projects have faced continued political opposition in spite of renewed arguments for the greenhouse gas benefits of incineration and improved air pollution control and ash recycling.

Incineration in Europe

In Europe, with the ban on landfilling untreated waste, scores of incinerators have been built in the last decade, with more under construction. Recently, a number of municipal governments have begun the process of contracting for the construction and operation of incinerators. In Europe, some of the electricity generated from waste is deemed to be from a 'Renewable Energy Source (RES)' and is thus eligible for tax credits if privately operated. Also, some incinerators in Europe are equipped with waste recovery, allowing the reuse of ferrous and non-ferrous materials found in landfills. A prominent example is the AEB Waste Fired Power Plant.[53] [54]

Incineration in the United Kingdom

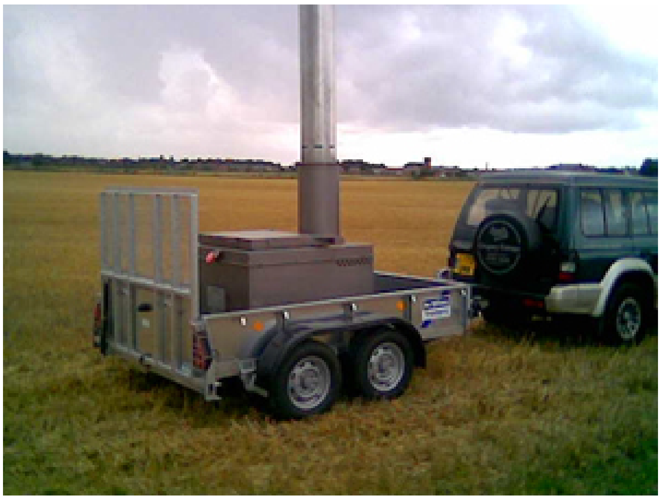
The technology employed in the UK waste management industry has been greatly lagging behind that of Europe due to the wide availability of landfills. The Landfill Directive set down by the European Union led to the Government of the United Kingdom imposing waste legislation including the landfill tax and Landfill Allowance Trading Scheme. This legislation is designed to reduce the release of greenhouse gases produced by landfills through the use of alternative methods of waste treatment. It is the UK Government's position that incineration will play an increasingly large role in the treatment of municipal waste and supply of energy in the UK.

In the UK in 2008, plans for potential incinerator locations exists for approximately 100 sites. These have been interactively mapped by UK NGO's.[55] [56] [57] [58]

See the list of incinerators in the UK.

Small incinerator units

Small scale incinerators exist for special purposes. For example, the small scale[59] incinerators are aimed for hygienically safe destruction of medical waste in developing countries. Small incinerators can be quickly deployed to remote areas where an outbreak has occurred to dispose of infected animals quickly and without the risk of cross contamination.


An example of a low capacity, mobile incinerator.

See also

- Cremation
- Gasification
- Gasification, gasifier, pyrolysis, pyrolyser
- Incinerating toilet
- Plasma Gasification
- List of solid waste treatment technologies
- Mobile incinerator
- Pyrolysis
- Thermal treatment
- Waste Incineration Directive
- Waste management
- Waste-to-energy

External links

Anti-incineration groups

- UK Without Incineration Network [60]

British Society for Ecological Medicine

- The Health Effects of Waste Incinerators [61]

Burn barrels

- Burn Barrel Organization [62]
- EPA Fact Sheet [63]
- Emissions Information [64]

EU information

- EU Directive on waste incineration [65]
- BREF Drafts & Papers [66]

International Solid Waste Association position

- position papers [67]

Overviews

- Incineration article [68]
- FAQ's on incineration [69]

Tutorial

- Flash presentation of SYSAV [70], a large incineration plant in Malmö, Sweden.
- Incineration Tutorial [71] from Rensaleer Polytechnic Institute

Diagrams

- Diagram of a rotary-kiln incinerator [72]

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Exemptions. The following woodburning facilities are exempt from licensing and all requirements of this section, although a burning permit from the department may still be required during certain times of the year in counties within a forest fire control area. These exempt facilities may not burn wet combustible rubbish, garbage, oily substances, asphalt, plastic or rubber products, unless these substances are exempt under s. NR 429.04.
(a) Burning of trees, limbs, stumps, brush or weeds, except for yard waste, as a result of agricultural or silvicultural activities, if the burning is conducted on the property where the waste is generated.
(d) Burning of yard waste and small quantities of dry combustible household rubbish, including paper, cardboard and clean untreated wood from a single family or household, on property where it is generated, unless prohibited by local ordinance.

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