

THE MANAGEMENT OF RESIDUES FROM THERMAL PROCESSES

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SUMMARY

In the majority of the International Energy Agency (IEA) and International Solid Waste Association (ISWA) member countries, the introduction of stricter legislation on the amount of municipal solid waste (MSW) going to landfill has led to an increased growth in the combustion of MSW in Energy from Waste (EfW) treatment plants. The residues arising from the combustion of MSW can either be disposed of or potentially put to beneficial use, either directly or after pre-treatment. Utilisation of MSW ash residues in viable applications has the potential to generate an income and reduce the amount of residue going to landfill. The overall objectives of this project have been to review the current practice in management of solid residues generated from MSW EfW treatment plant and to report on the future trends and prospects for the utilisation, treatment and disposal of residues. In order to fulfil the objectives of the study, information on current practices and issues for MSW ash residue management was sought from EfW plant operators in IEA/ISWA member countries and other major sources.

In IEA/ISWA member countries, EfW facilities are dominated by mass burn plant and the main component of the solid residues is bottom ash, which represents around 30% by weight of the original waste. Bottom ash represents the residuals from the combustion of MSW, after the removal of the ferrous metal fraction and has the consistency of sandy gravel. Fly ash and air pollution control (APC) residues arise from the particulate removal systems during cleaning of the flue gas and represent around 4% by weight of the original waste. These residues consist of fine particulates (that have been entrained in the gas stream) and the reagents/products (such as lime or activated carbon and salts) removed from the flue gas stream. The major components in all waste ash residue streams were the inorganic salts of silicon, aluminium, calcium and iron. Fly ash and APC residues can also contain substantial levels of chlorine and organic carbon. These, together with sodium, potassium, magnesium and sulphate, were shown to be highly soluble in aqueous media. Potentially harmful material, such as heavy metals and traces of micropollutants, were also present in all ash residues and tended to be enriched in the fly ash and APC streams.

Different waste sources and combustion processes generate residues with significantly different chemical and physical characteristics. Knowledge of the waste ash residue characteristics is essential to determine appropriate management practices, utilisation opportunities and to ensure minimal environmental impact. The principal constraints to the development of viable utilisation options are the potential for the release of contaminants through leaching or dust emission, the amount of processing required and the quality control (i.e. chemical and physical property variability) of the residues. Various techniques have been developed aimed at improving MSW ash residue properties to allow beneficial use or to fix the contaminants in the residue matrix, thus leading to less stringent disposal regimes and lower environmental impact.

Bottom ash from mass burn EfW treatment facilities is considered to have the greatest potential for utilisation because it typically has the lowest levels of contaminants, has physical properties similar to lightweight aggregates and represents over 80 weight percent of the total residues generated.

However, the amount of bottom ash which is utilised throughout the IEA/ISWA member countries, varies significantly from 0% to almost 100%. To date, the main applications for bottom ash are as an aggregate replacement in asphalt used for binder or base courses for road/pavement construction. Other potential applications for MSW bottom ash include embankment fill; aggregate for concrete building blocks; daily cover material for landfills; and noise or wind barriers. Pre-treatment techniques used to improve the chemical integrity and structural durability of the residue prior to re-use applications typically involve screening of oversized components, removal of ferrous metal and weathering. These techniques are recognised low cost procedures and, in the majority of IEA/ISWA member countries, utilising bottom ash in road construction or civil engineering applications has been shown to be an economically viable option compared to disposal.

Utilisation options for fly ash and APC residues are more limited due to their fine particle size and the presence of relatively high levels of contaminants. Potential uses identified include fillers for asphalt; as a filler/pozzolanic additive in concrete; and as a grout in coalmines. Although, these applications typically require pre-treatment of the residues using more cost intensive procedures (such as solidification/ stabilisation, chemical and thermal processes), re-use may be the more economically attractive option in countries with high costs for disposal of these residues to landfill.

Disposal practices for ash residues from EfW treatment facilities vary widely across the world. In the majority of IEA/ISWA member countries bottom ash is classified as non-special waste and monofill represents the most common method of disposal. Disposal costs for MSW ash residues vary significantly throughout the IEA and ISWA member countries; the main cost variant for bottom ash disposal being the waste/landfill tax.

Stricter disposal regulations exist for fly ash and APC residues due to their finer particle size and the presence of higher concentrations of leachable/toxic metals. In certain countries, disposal of untreated special (hazardous) wastes (e.g. fly ash and APC residues) is being restricted to mono-filling at fully contained landfills situated on non-aquifers. Whilst in others, landfilling of untreated fly ash and/or APC residues has been prohibited. These residues require pre-treatment, such as solidification and stabilisation, to improve their environmental quality prior to disposal. In both cases, disposal costs for fly ash and APC residues were significantly higher than for bottom ash due to additional treatment process costs or higher landfill taxes. In certain countries employing high disposal charges, the cost benefits incurred from down grading of the waste disposal categorisation for treated APC residues, from special to non-special waste, was reported to outweigh the treatment costs.

A number of incentive schemes and marketing strategies to promote MSW ash residue utilisation were identified by the study EfW plant operators. These included fiscal incentives, such as implementation of taxes if the ash residues are not utilised and are disposed of at landfill sites; gaining market acceptance through demonstration schemes for re-use applications; and by the introduction of specification standards to promote the idea that MSW ash residues can be a predictable and environmentally sound commodity. The major disincentives identified were the presence of contaminants and residue/product variability issues which has led to a perceived public opinion that re-use products from waste ash residues are of inferior quality. In certain IEA/ISWA member countries, the lack of consistent and appropriate regulations and specification standards for residue re-use applications and the lack of knowledge of viable re-use applications and end-use markets were also identified as being barriers to the development of MSW residue utilisation. The main economic barriers were the lower costs of natural minerals compared to ash residues, higher treatment/manufacturing costs, transport costs limiting markets to nearby locations and, in certain countries, the relatively low cost of landfill.

High landfill charges and limits on organic materials to landfill are prompting research into the benefits and consequences of alternative approaches for the management of ash residues from EfW facilities other than landfilling. Waste ash residues are considered to have the potential to have a

harmful impact on environmental quality. Consequently, a large amount of R&D is being conducted concerning the properties of these residues, the development of improved techniques for treating ash residues and development of specification standards MSW ash residues and their products. Research and development projects, involving small scale through to pilot plant scale demonstration trials, are also being carried out to establish viable options for MSW ash residue utilisation.

Recommendations

- Efforts should be made to reduce the amount of MSW ash residues for disposal, by considering alternative utilisation options that are economically and environmentally attractive.
- Ways of improving the quality and reducing the variability of MSW ash residues are required to encourage the perception that ash residues are a valuable product rather than a waste stream.
- In order to promote the idea that MSW ash residues can be a predictable commodity, it is important to adopt regulations and specification standards for use of ash residue products in all contemplated applications.
- Efforts should be made to further investigate the potential for using bottom ash in added value and other applications. This work should involve or lead to further trials at demonstration scale to provide appropriate evidence of the benefits, in terms of product performance, economic viability and environmental impact, and how best they can be achieved.
- Operators of EfW treatment plants, marketing bodies and potential end users should be encouraged to take a proactive role in research and development projects designed to seek sustainable approaches for the management of residue streams. This should also involve trial and demonstration schemes for improved treatment techniques and viable re-use applications to ensure that key issues for the utilisation of MSW ash residues are addressed.
- Efforts should be made to develop more cost-effective methods for treating fly ash and APC residues to allow beneficial use or to incur less stringent disposal regimes.

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ACRONYMS and ABBREVIATIONS

APC	Air Pollution Control
BPEO	Best Practicable Environmental Option
CFBC	Circulating Fluidised Bed Combustion
CHP	Combined Heat and Power
DETR	Department of Environment, Transport and the Regions
DOC	Dissolved Organic Carbon
EA	Environment Agency
EfW	Energy from Waste
EPA	Environmental Protection Agency
ESP	Electrostatic Precipitator
ETR	Ecological Tax Reform
EU	European Union
EWA	Energy from Waste Association
IAWG	International Ash Working Group
IEA	International Energy Agency
ISWA	International Solid Waste Association
FBC	Fluidised Bed Combustion
MW	Megawatts (10^6 W)
MSW	Municipal Solid Waste
PAH	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyls
PCDD	Polychlorinated dibenzo-p-dioxins
PCDF	Polychlorinated dibenzofurans
R&D	Research and Development
RDF	Refuse Derived Fuel
SEPA	Scottish Environment Protection Agency
SWR	Special Waste Regulations
TCDD	2,3,7,8-Tetrachlorinated dibenzo-p-dioxin
TEQ basis	2,3,7,8-Tetrachlorinated dibenzo-p-dioxin toxic equivalent, based on the 1989 International toxic equivalency factors
TOC	Total Organic Carbon
TWh	Terawatt hours (10^{12} Wh)
UK	United Kingdom
WHRG	Waste Heat Recovery Generator

GLOSSARY

APC residues	Air Pollution Control residues comprise (i) dry and semi-dry scrubber systems involving the injection of an alkaline powder or slurry to remove acid gases and particulates and flue gas condensation/reaction products (scrubber residue); (ii) fabric filters in bag houses may be used downstream of the scrubber systems to remove the fine particulates (bag house filter dust) and (iii) the solid phase generated by wet scrubber systems (scrubber sludge). APC residues are often combined with fly ash.
Bottom Ash	Comprises heterogeneous material discharged from the burning grate of the incinerator (grate ash) and material that falls through the burning grate to be collected in hoppers below the furnace (grate riddlings).
CFBC	Circulating Fluidised Bed Combustion is a combustion system in which the fuel (usually processed waste fuels such as coarse refuse-derived fuel) are burnt in a fine inert material fluidised by a high velocity air stream. The off-gas and entrained solids are separated in a high efficiency cyclone and the solids are returned to the bed.
Co-disposal	Co-disposal is the practice of the mixing wastes of different origins in the same landfill.
EfW	Energy from Waste, also known as waste to energy (WTE), is the conversion of waste into a useable form of energy, e.g. heat or electricity. A common conversion process is waste combustion.
FBC	Fluidised Bed Combustion is a combustion system in which a fine inert material, such as sand, is maintained in a fluid condition by air blowing upwards through it. Used in combination with processed waste fuels, such as coarse refuse-derived fuel.
Fly Ash	Finely divided particles of ash which are normally entrained in the combustion gases. Fly ash is recovered from the gas stream by a combination of precipitators and cyclones.
Mass-Burn Incineration	The incineration of waste in a grate combustion system.
Monofill	Landfill site practice whereby only one type of waste material (e.g. MSW bottom ash) is placed in landfill.
MSW	Municipal Solid Waste is waste which is collected for treatment and disposal by a local authority. MSW generally comprise waste from households, civic amenity sites, street sweepings, local authority collected commercial waste, and some non-hazardous industrial waste.
Pozzolan	A silica-rich or silica and alumina-rich material which in itself possesses little or no cementitious value, but which will, in finely divided form and in the presence of moisture, react chemically with calcium hydroxide to form compounds possessing cementitious properties.
RDF	Refuse Derived Fuel is a fuel product recovered from the combustible fraction of household waste.