BENEFICIAL USE AND RECYCLING OF MUNICIPAL WASTE COMBUSTION RESIDUES--A COMPREHENSIVE RESOURCE DOCUMENT

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ABSTRACT

This paper summarizes some of the information contained in a comprehensive document about the beneficial use of municipal waste combustion (MWC) residues. The document entitled **"Beneficial Use and Recycling of Municipal Waste Combustion Residues – A Comprehensive Resource Document"**, presents information from world-wide sources and contains numerous references. Information is presented on ash characteristics, environmental considerations when using ash, guidelines for selected use applications, information on federal and state regulations concerned with ash, and many other topics important to consider when implementing ash use projects. Results of several studies evaluating risks associated with ash use are presented including potential environmental and human health exposure pathways that should be considered when evaluating the acceptability of alternative uses.

Information presented on ash use practices in several other countries show that ash use is much more prevalent in some of these countries than in the United States. Information presented in the document, including results from numerous studies, demonstrates that ash can and is being used safely. The document was produced at the National Renewable Energy Laboratory (NREL) with support from the U.S. Department of Energy. Copies may be obtained by calling NREL Document Distribution 303.275.4363 and requesting publication NREL/BK-570-25841. This paper briefly describes what is in each chapter and summarizes some of the key information in the document.

CHAPTERS IN THE DOCUMENT

The following presents the title and a brief description of the contents of each chapter:

Chapter 1 – Background

This chapter provides an historical overview of ash management in the United States, some information on the sources of various ash streams, and discusses some earlier studies.

Chapter 2 – the Nature of Ash

Chapter 2 presents detailed data on the physical and chemical properties of MWC ash. Results of characterizing ash and ash products for use in selected projects is also presented.

Chapter 3 – Productive Use of Ash

This chapter discusses potential uses for the ash, commercial experiences, and guidelines for some specific uses.

Chapter 4 – Research and Demonstration Projects

Chapter 4 presents a compilation of and discusses MWC ash demonstrations. Discussions of selected research projects are included.

Chapter 5 – Management of Municipal Waste Combustion Ash in Other Countries

In this chapter, information is presented on ash management and use in Bermuda, Japan, the Netherlands, Denmark, Germany, France, Sweden, and the United Kingdom.

Chapter 6 – Environmental Considerations

This chapter discusses issues that are important to human health and the environment when implementing ash use projects. Fugitive dust, laboratory and field leaching of ash, leaching tests and similar topics are discussed. Results of TCLP testing of ash from several WTE facilities are included. Results of several risk assessments conducted for ash use projects are presented.

Chapter 7 – Regulations and Policies

Federal and state regulations and policies that affect MWC ash use are presented. Potential liability issues and how they can be managed are discussed.

RESULTS OF SELECTED RISK ASSESSMENTS

Risk assessments discussed in the document include the following uses:

- combined ash as landfill daily cover
- combined ash as final cover (bottom layer)
- use of Treated Ash Aggregate (TAA) as a roadway

base, as a structural fill, as daily and final landfill covers, as an aggregate substitute in asphalt concrete paving, and reuse and final disposal of paving material containing TAA. Production of asphalt containing TAA, storage in stockpiles, loading and unloading, and transporting of TAA were also evaluated. A brief description of TAA is provided later in this paper.

- Boiler Aggregate™ used to produce asphalt, placement of the Boiler Aggregate™ asphalt product, use as an unregulated fill, and milling and excavation for reuse of Boiler Aggregate™ asphalt. Stockpiling, handling and transporting operations were also evaluated. A brief description of Boiler Aggregate™ is provided later in this paper.
- Combined ash as a 30% substitution in bituminous pavement.

Although each risk assessment covered a specific situation, they generally evaluated the non-carcinogenic and carcinogenic effects on receptors from exposure to As, Ba, Cd, Cr, Pb, Hg, Ni, Se, Ag, and dioxin and furan congeners. Key receptors included nearby residents, workers, adults and children visiting a site, those that could be exposed to runoff, fugitive dust, etc. Direct and indirect exposure pathways evaluated included inhalation of fugitive ash dust on- and off-site, incidental ingestion and dermal contact with ash and ash products, residential exposure to soils potentially contaminated with particulates and/or leachates from ash and ash products, and similar pathways. In the case of landfill final cover, exposure pathways also included incidental ingestion and dermal contact with surface water and sediment while swimming in a nearby harbor and consumption of fish from the harbor. Exposure from ingestion of food grown in soils potentially contaminated with TAA was also evaluated. Also included was ingestion of drinking water containing leachate from Boiler Aggregate™ stockpiles, a road base and a recycled asphalt product pile.

Results of these risk assessments were favorable to ash use. Using EPA and other approved methods for conducting risk assessments, results in all cases showed that use of the ash would pose no unacceptable risks to human health or the environment. Hazards evaluated were below all applicable health criteria and non-carcinogenic and carcinogenic risks were well within US EPA recommended goals.

GUIDELINES FOR ASH BENEFICIAL USE

The document reviews several different sources for information on experiences and guidelines useful for the development of ash use applications. Specific guidance is provided for such items as mix design, material processing (ash segregation, metals removal, blending, etc), engineering properties, environmental considerations, and similar items important for asphalt paving, granular base for roadways, formulation of concrete products, and similar uses. Although the sources differed somewhat in their content, there were no substantial contradictions among them. The document also contains numerous references to ASTM methods and standards applicable to the testing of ash and ash products. This information will be useful to readers in the development of draft specifications and practices applicable to their desired use, ash source, and market circumstances.

LEACHING OF MWC ASH

In preparing the document, the authors reviewed numerous sources on the leaching of ash. Data is presented from several field studies that characterized the leachates from ash monofills, TCLP testing of ash from several waste-to-energy (WTE) facilities, and leaching of products containing ash. Several points are clear from reviewing this data. These include:

- No single leach test, including the TCLP, is adequate to fully and accurately predict the potential for an ash or an ash product to release constituents of concern under field disposal and beneficial use conditions.
- Laboratory leach test routinely overestimate the potential for constituents of concern to leach from an ash and ash product when compared to actual leaching from ash monofills and ash use in field applications.
- Modern waste-to-energy facilities routinely pass the requirements of the TCLP.
- Metal concentrations in leachates from ash monofills evaluated over time have routinely met ground water standards and often meet drinking water standards.
- Although leachates from combined ashes in monofills have low concentrations of heavy metals; the total dissolved salts concentrations may be several orders of magnitude above drinking water standards.
- If detected at all, levels of dioxins/furans in ash and ash leachates were extremely low and considered not to be a concern when evaluating the environmental and health consequences of using ash.

TCLP TESTING OF ASH FROM THE H-POWER WTE PLANT

An interesting observation made concerned the levels of metals found in the ash from the H-Power WTE plant in

Honolulu. Staff at the plant have conducted TCLP testing over a nine year period. While the ash met the requirements of the TCLP, a significant result was that in all cases, except for Ba, there has been a downward trend in the concentrations of the metals in the ash. During the nine years, there have been no additional recycling initiatives instituted that could have caused this trend. Therefore, a plausible conclusion is that original efforts to reduce Pb and Hg in consumer products, and similar efforts have reduced the amounts of these constituents in the waste going to the WTE facility.

RESEARCH AND DEMONSTRATION PROJECTS

The document discusses 40 different demonstration projects using ash in asphalt paving, in concrete, portland cement, and as landfill cover. Several vitrification studies are reviewed. Many of the these projects followed laboratory and simulation research. The document does not provide details from the literature citations on ash research, since there are over 450 citations plus another 80 to 90 papers from the 10 Annual International Conferences on Municipal Solid Waste Ash Utilization. Sources for these citations are provided in addition to several key research projects supported by the US EPA.

ASH MANAGEMENT IN OTHER COUNTRIES

The document reviews ash management practices in Bermuda, Japan, the Netherlands, Denmark, Germany, France, Sweden, and the United Kingdom. The countries discussed, except perhaps Sweden, are increasingly relying on the use of combustion with energy recovery as a major component of their waste management strategies. This is the result of policies similar to Germany's requirements that residues contain only small quantities of carbon before they can be landfilled (See Table 1), and a more realistic view of what can be recycled economically. These countries also require separation of the residues for utilization, and generally use only the bottom ash, except perhaps the Netherlands who have used some fly ash to produce asphalt fillers.

Most of the countries view the ash as a resource to be recycled, rather than a waste to be disposed into a landfill, provided utilization is protective of the environment. Several have established criteria and procedures for determining acceptable use and disposal options, and all continue to support research and development efforts for improved treatment and use technologies.

France established requirements as shown in Table 2 to determine when bottom ash is acceptable for utilization. Bottom ash with low leaching characteristics (Category V) can be used immediately. Bottom ash in category M can be

TABLE 1: CRITERIA THAT RESIDUES IN GERMANY MUST MEET BEFORE LANDFILLING

Parameter	LF Class 1	LF Class 2	LAGA*
Loss on Ignition wt.	3%	5%	
Total Organic Carbon wt.	1%	3%	1%
CL (mg/L)			250
Cu (mg/L)	1	5	0.3
Zn (mg/L)	2	5	0.3
Cd (mg/L)	0.05	0.1	0.005

*LAGA - Board of German States of Ministers set these limits for bottom ash use in road construction.

TABLE 2: THE CATEGORIES OF BOTTOM ASH IN FRANCE IS BASED ON ASH CHARACTERISTICS

	V	M	L
%Unburnt Material	<5%	<5%	>5%
Hg*	<0.2	in between	>0.4
Cd*	<1	in between	>2
Pb*	<10	in between	>50
As*	<2	in between	>4
CrVI*	<1.5	In between	>3
Sulfates*	<10,000	in between	>15,000
T.O.C.*	<1,500	in between	>2,000

*mg/kg of dry matter

stored (aged) for as long as 12 months and its characteristics after storage determine if it can be used. Bottom ash in Category L must be landfilled. Before establishing these requirements, France sampled ash from ten facilities to determine, among other study objectives, how the ashes would compare to the requirements in Table 2. Only the ash from one facility met the requirements of Category V, four fell into Category M, and five into Category L. The report noted, however, that the plants were being efficiently operated during the ash sampling. After nine months of maturation (aging) seven of the ashes met requirements of Category V, one fell into Category M, and two into

Category L. Based on these results, France then evaluated methods for maturation of ashes. Three leaching test and several geotechnical tests were used to evaluate the ashes. The French concluded that when bottom ash is produced under good combustion conditions and maturation, it is a satisfactory replacement for gravel.

An interesting observation regarding the Netherlands was that for several different years, the Netherlands used more ash than they produced. They stockpiled ash in years when demand was lower than production, indicating their belief that the ash is a resource rather than a waste.

THE ISSUE OF LIABILITY

In 1998, the Municipal Waste Management Association published results of an analysis of liability issues associated with beneficial use of MWC residues. The analysis was conducted by the law firm of Decotiis, Fitzpatrick & Gluck. Results of the analysis demonstrates that local governments that generated MWC ash, which when tested does not exhibit hazardous characteristics, have several levels of protection against environmental liability. This is the case if they (1) provide the ash to a bona fide recycling operation; (2) the recycler or the local government treats the ash, if necessary, to satisfy state and federal laws; (3) the recycler has obtained all necessary state and local approvals; (4) the MWC ash is used in products that are introduced into the economic mainstream in a manner that limits the potential for human exposure. The report provides details to explain each of these and presents results of court cases that provide legal precedent.

ASH MANAGEMENT IN THE UNITED STATES

In 1995, only about 6% of the ash produced in the United States went to some beneficial use, much of this in landfills. The Solid Waste Association of North America surveyed MWC facilities in 1996. Of the 81 responses, which represented about half of the ash produced in the United States, only about 20 per cent reported some beneficial use of ash. All used ash free of asphalt or portland cement in the following applications:

- Daily landfill cover, ten locations
- Intermediate landfill cover, three locations
- Final landfill cover, one location
- On-site landfill roads, eight locations
- Landfill berms, two locations
- Undisclosed other uses, five locations.

Commercial Operations

American Ash Recycling (AAR), headquartered in Jacksonville, Florida, offers complete design, permitting, financing, construction, and operation to produce a processed ash for beneficial use and recycling. AAR processes combined ash for metals recovery, removes unburned material, and adds WES-PHix® to stabilize heavy metals in the ash. The treated ash is then graded into sizes suitable for use as an aggregate. At the time of writing the document, AAR was operating facilities in Tennessee and Pennsylvania. AAR also licensed its ash recycling technology to Kurita Water Industries, Ltd., Japan, in 1997.

Engineered Materials Company, a subsidiary of Energy Answers Corporation produces Boiler Aggregate™. Boiler Aggregate™ is produced from processing ash to remove ferrous metals and screening to desired particle size ranges. Engineered Materials company received a beneficial use determination from the state of Massachusetts Department of Environmental Protection in December 1996 for use of their product in paving projects. The first Boiler Aggregate™ was produced at the SEAMASS facility in Rochester, Massachusetts. A second source is from the Energy Answers waste combustion facility in Pittsfield, Massachusetts. Engineered Materials has offices in Rochester, Massachusetts and Albany, New York.

Rolite, Inc. produces a round, uniformly graded ash product for use in several applications. It has been used as landfill daily and final cover, landfill gas venting layer, structural fill, drainage fill, and road base. Rolite was approved for landfill use in Delaware, New York, and Pennsylvania. It operates an ash treatment and recycling facility in New Castle, Delaware, where the principal source of ash since 1995 has been the Camden Resource Recovery Facility.

Wheelabrator Environmental systems, Inc. has two patented processes for treating ash to reduce leachability of metals. The WES-PHix® process is a phosphate and lime treatment and is used at a number of facilities in the United states and Japan. The second process produces a produce referred to as McKaynite which can be use to replace natural rock aggregate in asphalt concrete, as road base materials, and as landfill cover. Although Florida, in 1993, approved McKaynite aggregate for road construction and as a substitute for soil cover at landfills, no commercial projects were implemented.

In 1993 Florida, after successful demonstrations, also approved the use of an ash product called PermaBase Plus produced by Lyses Shell. The developer purchased Lysee shell and changed the name to Caloosa Shell. No sales of PermaBase Plus occurred and it was withdrawn from the market. Other companies may have engaged in the beneficial use of ash, but their activities have not been widely reported.

SUMMARY COMMENTS

Although the evidence is overwhelming that ash can be used safely, the United States still disposes most of its ash into landfills. Some of reasons for this are:

- Continued concerns about environmental liability. Although the document discusses how these can be managed, this still remains a concern.
- Reluctance on the part of state and local permitting officials to address new issues. Routinely under staffed, they are very cautious about approving permits for new projects using new and, to them, unknown materials. The ash recycler's job becomes harder, but it is up to them to educate the permitting officials about ash use.
- Costs associated with obtaining permits can be very high. Often because permitting officials are reluctant to accept data form other states, they continually request additional information. This results in long delays and drives up the cost.
- Lack of markets for ash products and poor economics. Some consider this the main impediment to widespread use of ash. Since numerous studies have demonstrated that ash products perform well in several civil engineering applications, this may improve as more ash is used and more experience is gained on its performance. Also, in areas where landfill costs are higher than the national average, and natural aggregates are in short supply, the economics of ash use should improve.
- Lingering concerns about the safety of using ash. Overcoming this concern will continue to require addressing these concerns in a manner that is easily understood and from credible sources.

Hopefully some of the positive steps taken by Florida, Massachusetts, and Pennsylvania will be examples for other states and help increase the use of MWC ash in the future.