Overview of options for utilization of biomass ash

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Biomass ash is “the third problem”

First problem: Where do I get a large enough supply of cheap fuel?

Second problem: How do I get the installation running and stable?

Third problem: What do I do with all those ashes?

PANIC!!!

Quick scan for solutions:
“Can’t we use the appropriate disposal routes?”
“In concrete, of course, just like coal ashes!”
“The recycling company is taking care of that.”
“Well, I think we need to landfill it, but that is so expensive”

Contents

- Introduction
  - Diversity of ashes
- Overview of applications for ashes
  - Bulk/niche applications
  - List of over 20 ash utilization options
  - Focus on building products
- Concluding remarks

Large variations in ashes

1. Large variations in (biomass) fuels = large variations in ash composition
2. Typically from any kind of thermal installation two main kinds of ashes emerge:
   - bottom ashes, from below the flame
   - fly ashes, removed from flue gas
3. Three commonly used types of installations:
   - Pulverized fuel: 90% fly ash, 10% bottom ash
   - Fluidized bed: 50% fly ash, 50% bottom ash
   - Grate stoker: 5% fly ash, 90% bottom ash
4. Three commonly used combustion processes:
   - stand-alone biomass: “pure” biomass ashes
   - direct co-firing: biomass ashes mixed with coal ashes
   - indirect co-firing (= gasification): “pure” ashes, but often high-C

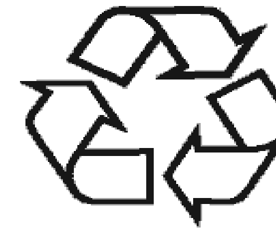
Diversity in composition of ashes

	Grate stoker Green mix Bottom ash	Grate stoker Green mix Fly ash	CFB comb. Green mix Fly ash	CFB gasif. Demolition wood Fly ash
Ash (wt%)	99.7	98.3	95	35
K (wt%)	7.5	37.5	2.8	0.7
P (wt%)	0.6	1.4	2.7	0.14
Ca (wt%)	16.6	2.5	13.7	4.9
Mg (wt%)	1.7	0.4	1.2	0.6
S (wt%)	0.7	11.6	0.9	0.6
Si (wt%)	22.1	0.23	19.3	7.6
Pb (mg/kg)	440	1300	120	4500
Zn (mg/kg)	450	10800	470	4000
Cd (mg/kg)	6	40	4	8
Cl (mg/kg)	7000	125000	0.3	10000

All numbers are on dry basis

Numbers are indications, real ash compositions show large variations

Recycling of wood ash



- Legally possible for ashes from **clean** wood waste
  - Scandinavia, Austria, Germany in forestry
- Sweden is leading
  - Prerequisite for “Whole Tree Harvesting”
  - WTH = 30% more fuel in form of forest residue
  - Ashes locally used
  - 50% of ashes (technically) suitable
  - Handbook from RECASH Project

- Limitations
  - Not all land owners want it – recreation
  - Unknown origins, blends, e.g. imported fuel
  - Unacceptable levels of contaminants, even from clean biomass fuel

Landfill - The bottom-line

- Combustion ashes can be landfilled without much difficulties
  - Costs vary between countries
  - Classification varies from inert to hazardous waste
  - Bottom ash or sintered ash: from almost nothing to € 100 per ton
  - Fly ashes: from € 50 - € 300 per ton

- Extremely simplified calculation
  - Ash content of average biomass: 4% (dry basis)
  - Gate fee for average biomass ash: € 100/ton
  - Cost of ash disposal: € 4 per ton dry fuel
  - Compare: prices for biomass fuel € 0 - 40 per ton

How to turn biomass ashes into something useful?

Bulk and niche applications

- **Bottom ash** is typically used in road construction or other landscaping, due to low nutrient content and limited leaching
- For **fly ash** the situation is more difficult
- Besides large diversity in qualities, also large diversity in quantities
  - Bulk solutions most urgent
  - Niche solutions possible for smaller volumes
  - Bulk applications are still needed
- Three generic bulk applications
  - Fuel (high-carbon ashes only)
  - Fertilizer
  - Building material

White pieces from combustion fly ash
Black pieces from gasification fly ash

"Utilization of biomass as fertilizer - as old as agriculture"

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Farmer in Madagascar preparing his land

http://www.ingafoundation.org/the-homaray-project-madagascar/

Direct utilization as fertilizer

- Advantages
  - P and K fertilizer
  - Nutrients 100% from a biological source
  - Saving mineral (non-sustainable) resources
- Disadvantages
  - No N in the ashes; less-soluble P
  - Low nutrient levels compared to heavy metals (especially Cd, also As, Zn)
  - Often large amount of inerts
  - **Consistency in quality and quantity needed**
- Potential use as soil improver, especially when having high Ca and Mg, e.g. when dolomite is used as bed material in combustion/gasification.

Utilization as raw material in fertilizer production

- Utilization as raw material for fertilizer more flexible, since only end product must comply with legislation, origin of minerals not relevant.

- Essentially, the same issues apply as for direct utilization
- Advantages:
  - K and P from a sustainable source
- Disadvantages:
  - No N in ashes
  - Low nutrient content
  - Inerts
  - Consistency in quality and quantity

- P and K from mineral sources are cleaner and more reliable

Direct utilization as building material

- Utilization as building material is a sustainable form of utilization:
  - Saving mineral sources
- Bottom ashes are being utilized as building material in direct applications
  - From fluidized bed combustion/gasification: mainly sand
  - From grate stokers in granulate (0-40 mm)
  - Generally: replacing other sand, gravel and granulates in road construction, infrastructural works and landscaping
- Fly ashes are unlikely to find *direct* applications as building material

Bottom ash used in road construction

Standardized application as binder in concrete, cement and mortars

- Main application, replacing portland cement
  - Fly ash from coal have good pozzolan properties
  - No burning of lime → smaller carbon foot print
  - Portland cement minimal emission 760 kg CO_2/ton
  - Large market
  - Pure coal ashes are most attractive, not too much biomass ashes, e.g. due to free lime
  - Known standards, EN-450, EN-196, EN-197, etc.

Other application in building products

- Clinker production
  - Replacement of clay

- Bricks and other ceramics
  - Replacement of clay and fillers

Low-quality concrete products

- General characteristics
  - No reinforcement = no corrosion
  - Limited forces exerted
- Examples
  - Segmented retainer walls (SRW), e.g. “Earth Blocks” or “Noppenblokken”
  - Concrete pavement tiles

Special case for non-reinforced concrete

- Artificial reefs and protection of piers and sea barriers
  - Trials in USA, Japan, Netherlands, UK
  - Slow release of minerals, back into eco-system
  - No evidence was found for transfer of heavy metals from the reef blocks to the epifauna

Vitrification - smelting

- High-temperature treatment → synthetic basalt
  - Energy intensive
  - Expensive
  - Minimal leaching risks → unrestricted use
- Vitrification is common practice in Japanese waste incineration

Test block made at ECN

Basalt blocks used to protect sea walls

Search for solutions – KEMA – ECN project

- Project of ECN/KEMA consortium resulted in a list of options
  - List of over 20 ash utilization options
  - Screened for technologically feasible
  - Ranked for technical and economically feasibility in Dutch situation

Agentschap NL
Ministerie van Economische Zaken

KEMA

- Report recently changed from 'confidential' to 'public'

"Identification of bulk and niche applications of ashes derived from co-combustion, co-gasification and biomass combustion"
KEMA Report no 50780586.61 0-TOS/ECC 08-9280, Arnhem, 20 March 2009, Authors: A.J. Sarabèr and L.F.A.G. Overhof

Over 20 potential applications for biomass ashes

No	Application	Function	Sector
1	Binders alternative for standard cement	Component	Building industry and civil engineering
2	C-fix	Filler	
3	Concrete (products) low quality	Reactive filler	
6	Road Construction material	Binder/Raw material	
7	Sand-lime bricks	Filler	
8	infrastructural works (embankments, fillings)	Filling material	
9	Soil stabilization	Binder	
10	Synthetic aggregates[1]	Raw material	
11	Fuel	Combustion	Energy production[2]
12	Back-filling mining	Filler	Mining
13	Polymers	Filler	Industry
14	Metals	Filler	
15	Phosphor production	Raw material	
16	Zeolites	Raw material	
17	Metals recovery	Raw material	
18	Mineral fibers	Raw material	
19	Soil improvement and fertilizer	Product/Raw material	Agriculture
20	Neutralisation of waste acids	Product	Environmental technology
21	Adsorption material	Raw material	
22	Impermeable layer	Raw material	

1 including synthetic basalt

2 including indirect energy production in industry

Most attractive option from KEMA/ECN study: Light-weight aggregates

- Experimental results:
  - Good fysical and mechanical properties
  - High K and Ca content lower production temperature
  - When applied in concrete, leaching the same as for regular materials

- Techno-economic evaluation:
  - Production costs: ca. 45 €/ton (excluding profit from sale of aggregates)
  - E.g. Trefoil and Lytag
  - Consistency is a key factor
  - Less avoided CO_2 emission than for replacement as cement

Concluding remarks

- In all applications, **consistency** is a key factor
  - Ash delivered with a predictable, constant quality
  - Constant low quality is better than fluctuations in high quality

- Quantity is other key factor
  - Only a few kiloton ash per year → almost nobody will contemplate using it
  - For products with high added value → competition with virgin materials
  - Lucky matches and niche applications may exist

- Other conclusions
  - Clean biomass does not guarantee clean ashes
  - There is no single solution for "biomass ash", because the is no single biomass ash.
  - Landfill is in many cases the most cost-effective alternative
  - Slow transition to controlling the ash composition in biomass installations

Thank you for your attention

To be continued…

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