

Utilisation of ashes from co-combustion of peat and wood

Case study of a modern CFB-boiler in Finland

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Background

- Appr. 500 000 tons of peat and wood ashes are produced in Finland annually
 - Co-combustion in large scale CHP plants utilising fluidized bed boilers (over 100 units in operation)
 - Appr. 50 % is utilised
 - as fertilizers ~ 70 000 t/a
 - in earth construction applications ~ 180 000 t/a
 - Lot of ashes are used in construction of landfill sites, storage fields etc.



Fertilizer use of ashes in Finland

- Regulated by Fertilizer Product Act 539/2006 & Ministry of Agriculture and Forestry Decree on Fertilizer Products 24/11
 - Fly and bottom ashes from combustion of biomass and peat
 - Maximum values for minor elements
 - Maximum loads for Cd and As
 - Minimum values for nutrients
 - Forestry: K+P 2 % & Ca 6 %
 - Other use: Neutralising value 10 % (Ca)
 - Addition of nutrients in the form of inorganic fertilizers products is allowed to granulated ash fertilizers

Element	Maximum concentration for ash fertilizers mg/kg db.	
	Agriculture, landscaping	Forestry
Arsenic, As	25	40
Mercury, Hg	1,0	1,0
Cadmium, Cd	2,5	25
Chromium, Cr	300	300
Copper, Cu	600	700
Lead, Pb	100	150
Nickel, Ni	100	150
Zinc, Zn	1500	4500

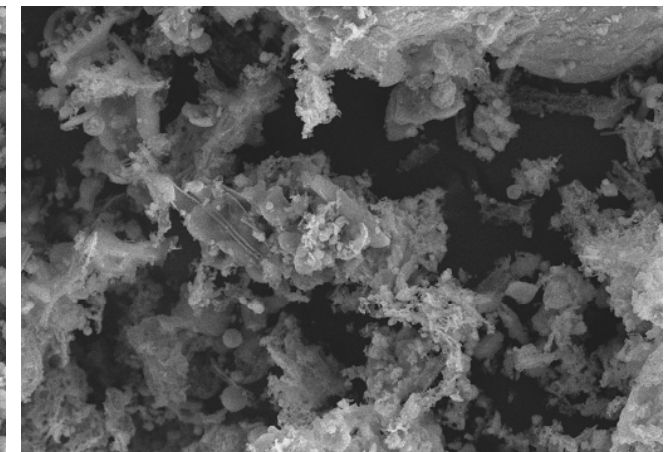
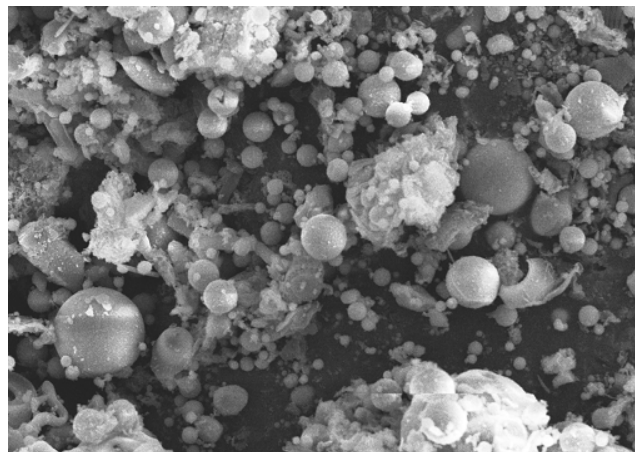
Utilisation of ashes in earth construction applications

- Ashes can be used e.g. in massive structures, in layer stabilisation, as construction material in landfill sites, in embankments, noise barrier walls and other filling applications
- Notification procedure if requirements of Government Decree on recovery of certain wastes in earth construction (Vna 591/2006) are fulfilled
 - Fly and bottom ashes combustion of coal, peat and wood
 - In certain applications
 - Limit values for total content of harmful substances and maximum values for their leaching
- For other ashes and applications: Environmental permit is required
- Technical applicability is as important as environmental applicability!



Other opportunities to utilise peat-wood ashes

- Concrete production: Ashes can be used as binders or aggregates
 - There is no guidelines for biomass ash utilisation in concrete production
 - Comparison of ash properties to limit values set for coal fly ash (EN 450-1)
 - Uniform quality of ash is essential requirement!
- Asphalt filler: Replaces lime filler



Status in utilisation of peat-wood co-combustion ashes

Driving forces

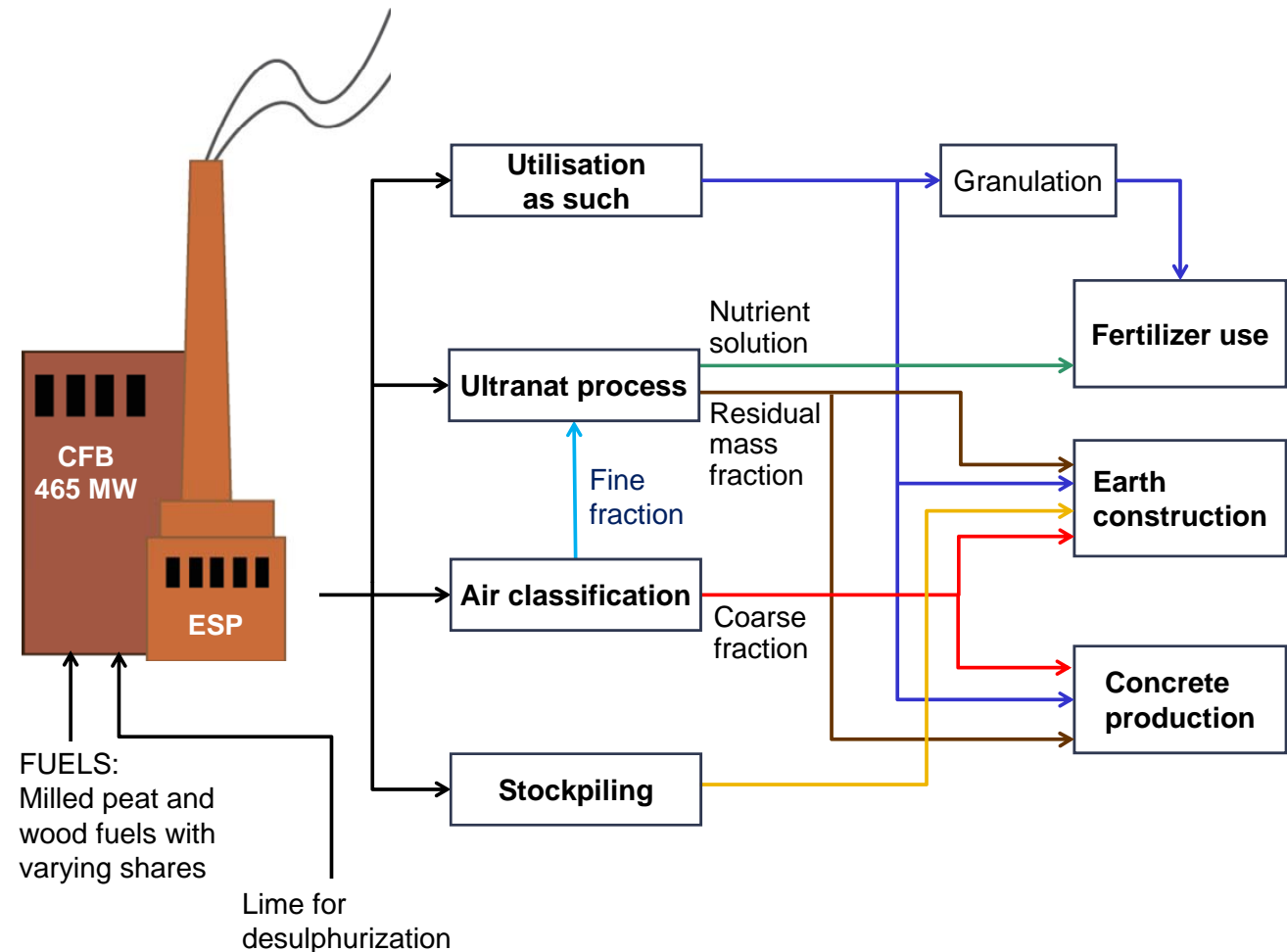
- Ashes can replace non-renewable natural resources
 - Fertilizers
 - Earth construction applications
- Cheaper raw materials are needed e.g. in concrete production
- Waste tax was extended to fly ashes in Finland (Waste Tax Act 1126/2010)
 - 1.1.2011 → 40 €/t
 - 1.1.2013 → 50 €/t
- Refining methods have been developed

Barriers

- Peat-wood ashes don't always fulfill the requirements of Fertilizer Decree or Earth construction Decree
- Environmental permission procedure takes time
- Uncertainty of technical applicability
- Quality variation
 - Fuels, fuel shares, properties of fuels, power output etc.
- Lack of knowledge - Possible users don't know which kind of materials are available

What are the possibilities to utilise peat-wood ashes in Central Finland?

- Characterisation of peat-wood ash samples – environmental and technical applicability
- Refining experiments
- Case study of a modern CFB-Boiler - Keljonlahti CHP-plant



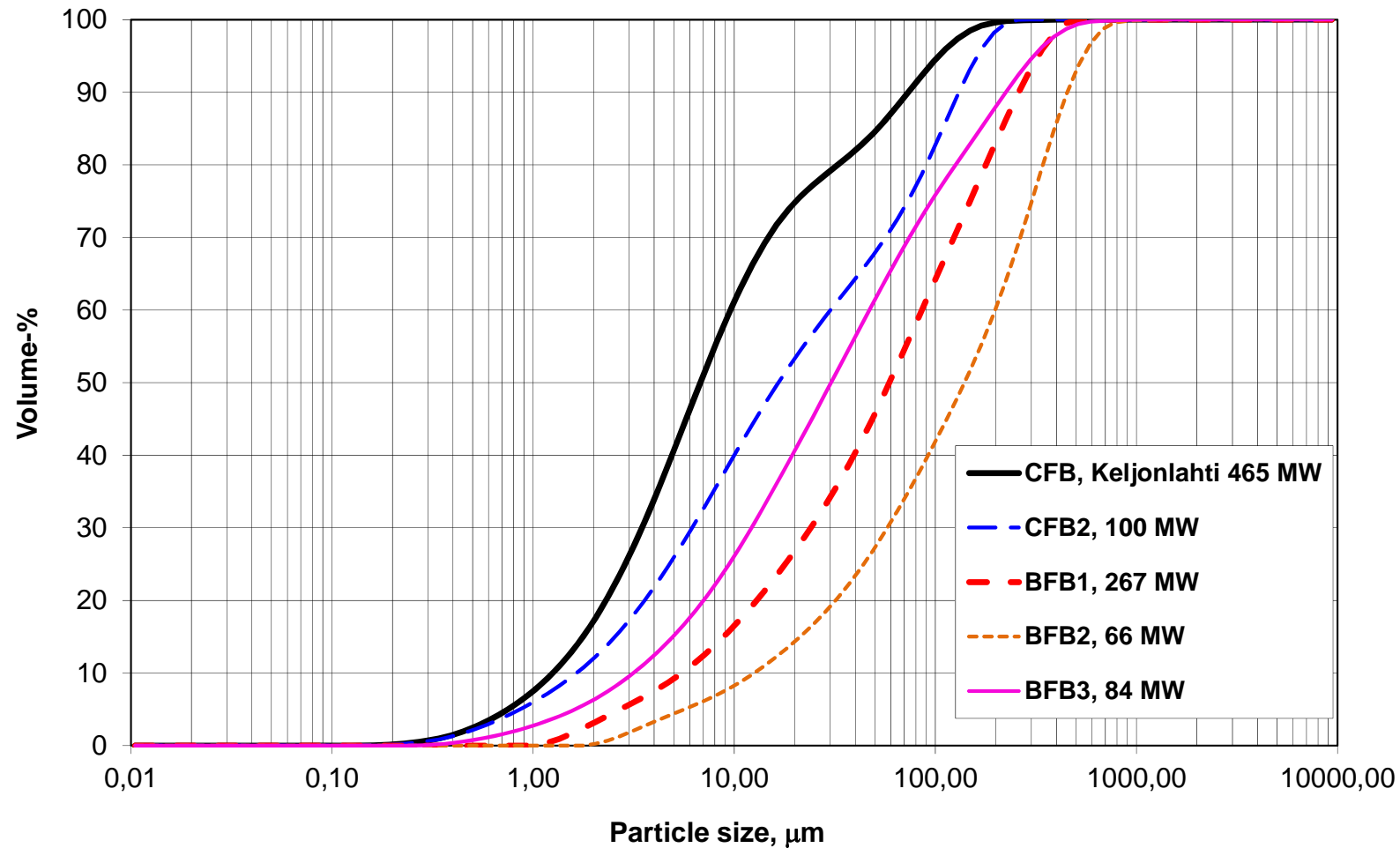
Jyväskylän Voima Oy's Keljonlahti Combined Heat and Power Plant



Photo: Jyväskylän Energia Oy

- Circulating fluidized bed boiler (CFB)
- Thermal capacity: 486 MW
- Start up year: 2010
- Fuels: Milled peat and wood fuels e.g. forest chips, sawdust and bark
- Lime is used for desulphurisation if needed
- Estimated annual ash production:
 - Fly ash 41 000 t
 - Bottom ash 9 000 t

Particle size of fly ash



Concentrations of elements in fly ash of the CFB-boiler

	Element	Concentration in fly ash	Ash fertilizers, max. value for forest use (MMMa 24/11)	Earth construction, max. value for notif. procedure (VNa 591/2006)
Minor element, mg/kg db.	Arsenic, As	30...60	40	50
	Barium, Ba	1200...2100		3000
	Cadmium, Cd	2	25	15
	Chromium, Cr	50...70	300	400
	Copper, Cu	100...300	700	400
	Lead, Pb	40...70	150	300
	Molybdenum, Mo	10...20		50
	Nickel, Ni	30...50	150	
	Vanadium, V	80...130		400
	Zinc, Zn	200...400	4500	2000
Major element or nutrient, %	Calcium, Ca	10...20	Min 8 %	
	Potassium, K	2	P+K min 2 %	
	Phosphorus, P	1		
	Silicon, Si	16...24		
	Iron, Fe	7		
	Aluminium, Al	7		

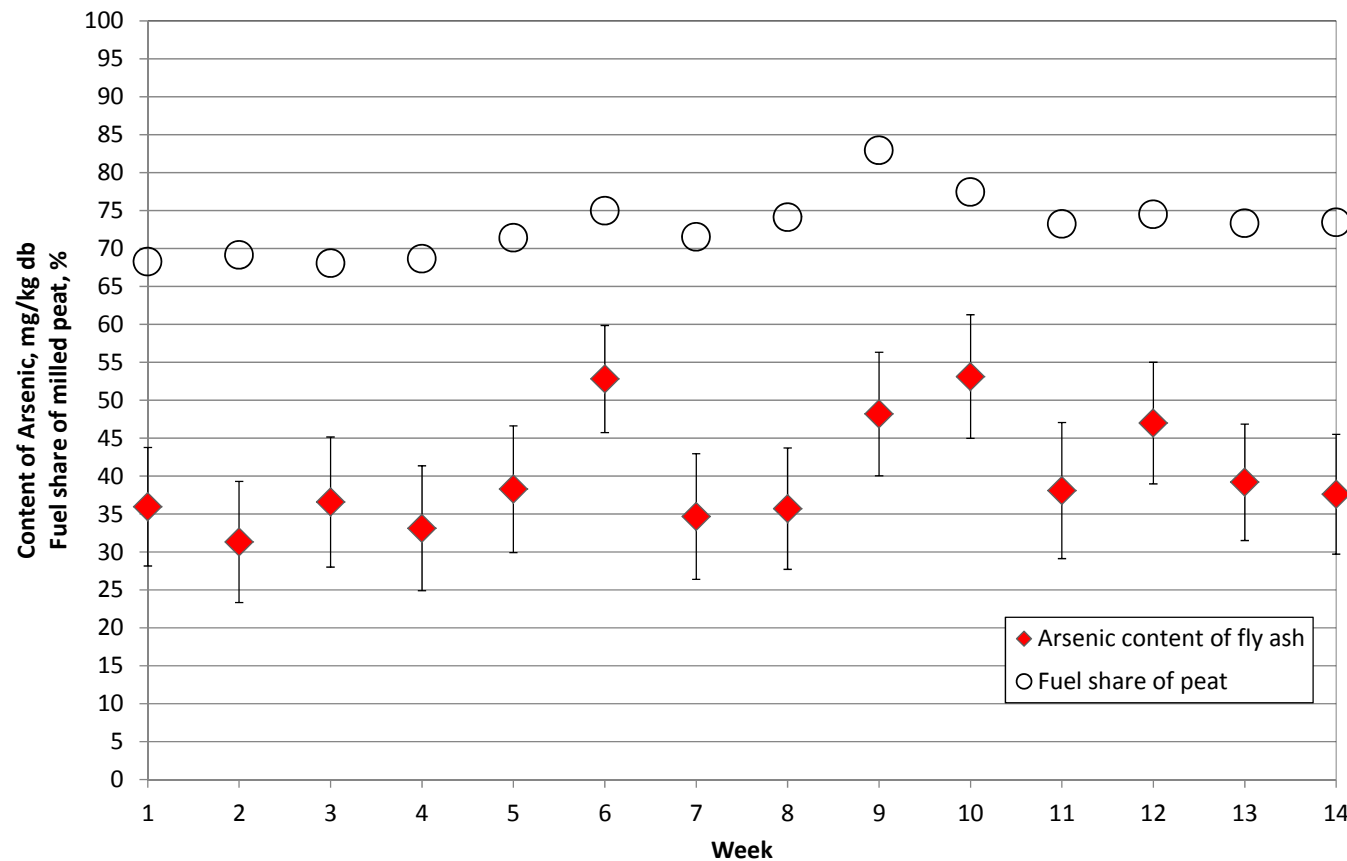
Leaching of harmful substances from peat-wood fly ash EN 12457-3, L/S 10

	Leaching from fly ash mg/kg db.	Earth construction, maximum values, Vna 591/2006	
		Covered structure	Coated structure
Arsenic, As	0.01	0.5	1.5
Barium, Ba	5...120	20	60
Cadmium, Cd	0.002	0.04	0.04
Chromium, Cr	0.08...1.6	0.5	3
Copper, Cu	0.02	2	6
Mercury, Hg	<0.002	0.01	0.01
Molybdenum, Mo	0.5...2.5	0.5	6
Nickel, Ni	0.001	0.4	1.2
Lead, Pb	0.03...0.09	0.5	1.5
Antimony, Sb	<0.01	0.06	0.18
Selenium, Se	0.02...0.05	0.1	0.5
Vanadium, V	0.02	2	3
Zinc, Zn	0.05...0.1	4	12
Chlorine, Cl ⁻	700	800	2400
Fluoride, F ⁻	12...22	10	50
Sulphate, SO ₄ ²⁻	40...4000	1000	10000
Dissolved organic compounds	2	500	500

Utilisation opportunities of CFB peat-wood fly ash

■ Fertilizer use:

- Arsenic content is often too high



Utilisation opportunities of CFB peat-wood fly ash

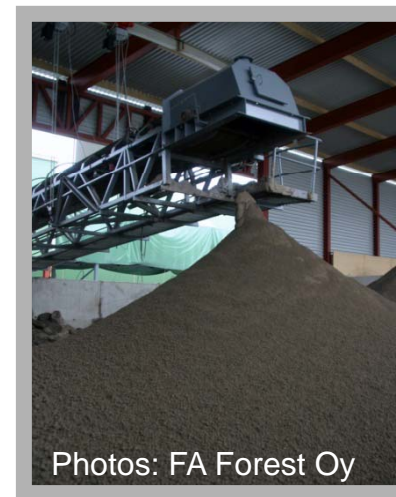
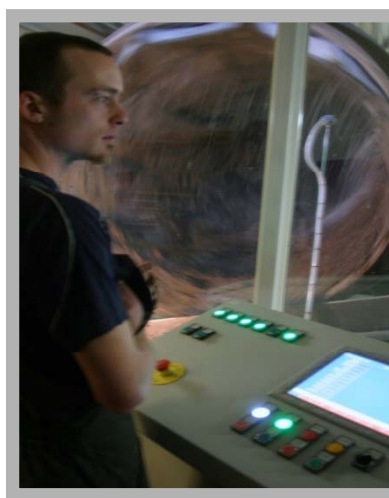
- **Fertilizer use:**
 - Arsenic content is often too high
- **Earth construction:**
 - Environmental permit may be required for all applications
 - Strongly frost susceptible
 - + Suitable for use in embankments, noise barrier walls and other filling applications
 - + Suitable to be used as component of binder admixture in layer stabilisation
 - ? Suitable for massive structures as stabilised
- **Concrete production:**
 - Too fine to be used as aggregate
 - Activity is too low to be used as binder material
 - High contents of free CaO and sulphur compounds



Photo: Andament Oy

Refining tests of CFB peat-wood fly ash

- Stockpiling tests:
 - pH decreases considerably
 - Solubility of barium decreases, but solubility of sulphates increases
- It was impossible to separate different fractions from totally uniform and fine fly ash
- Full scale granulation tests were performed by FA Forest Oy
 - Hard granules were obtained (suitable for fertilizer use)



Refining tests of CFB peat-wood fly ash

- Ultranat method
 - Fly ash was suitable raw material for nutrient solution
 - Utilisation of remaining ash fraction?



Source: Ultranat Oy

Conclusions

- Fly ash utilisation from co-combustion of peat and wood can be difficult
- Properties that may prevent utilisation of peat-wood fly ash
 - Fine particle size (CFB boilers)
 - Arsenic content
 - High content of free calcium oxide
 - Quality variation
- Refining methods should be further developed
- Huge annual amount of fly ash – challenge for utilisation
 - 40 000 fly ash tons is sufficient to
 - Fertilization of 10 000 ha of forest (peatland)
 - Layer stabilisation of 150 road kilometres
 - Construction of 2 – 3 kilometres of noise barrier wall
 - Several utilisation opportunities are needed to reach high utilisation rate!

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