



# Fine particles in WtE bottom ash

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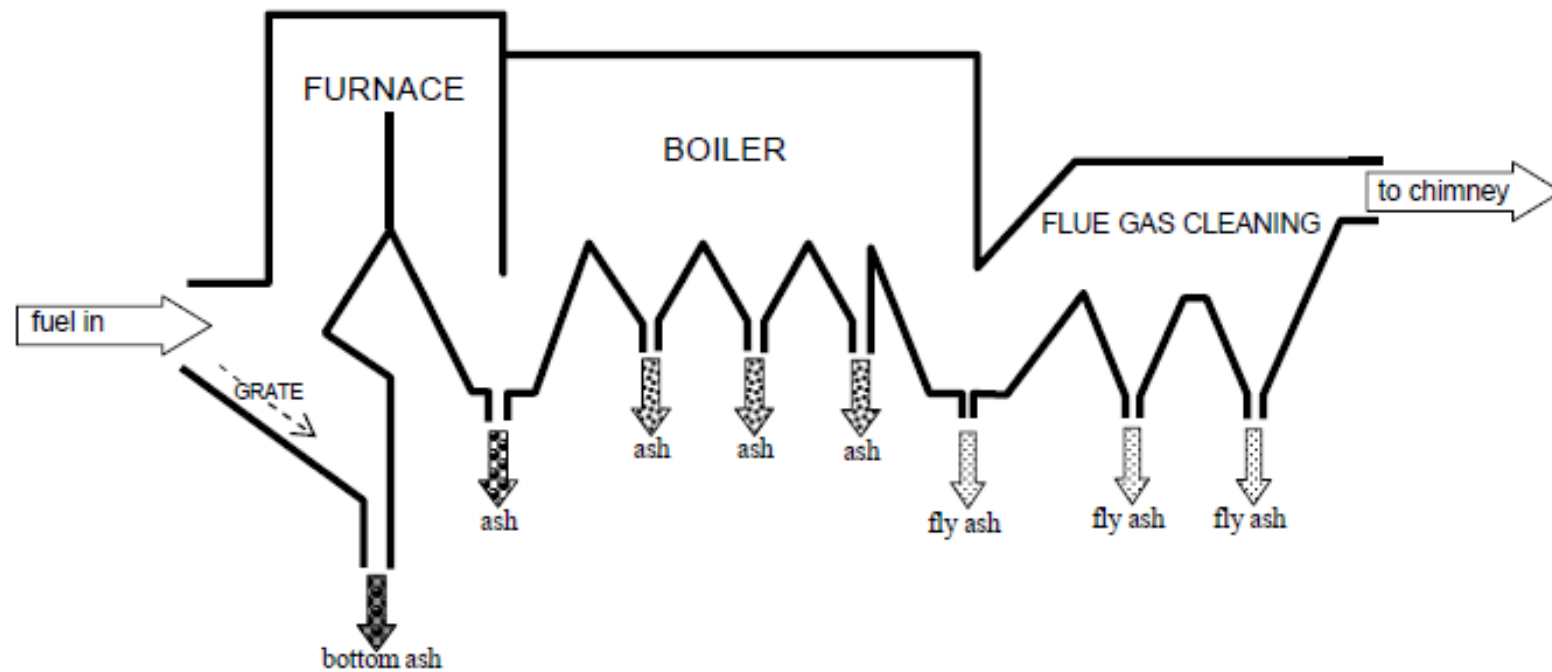
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# Problem and purpose

- MSWI or W-t-E bottom ash is often not harmless enough: too much salt, too high a concentration of heavy metals
- Common knowledge conclusion: the cause of the problem is the content of fine particles
- Quick fix: depart from usual procedure and don't mix the first boiler ash (<0.5 mm) with bottom ash
- Purpose of the project: put numbers to that

# Högdalen P4 furnace

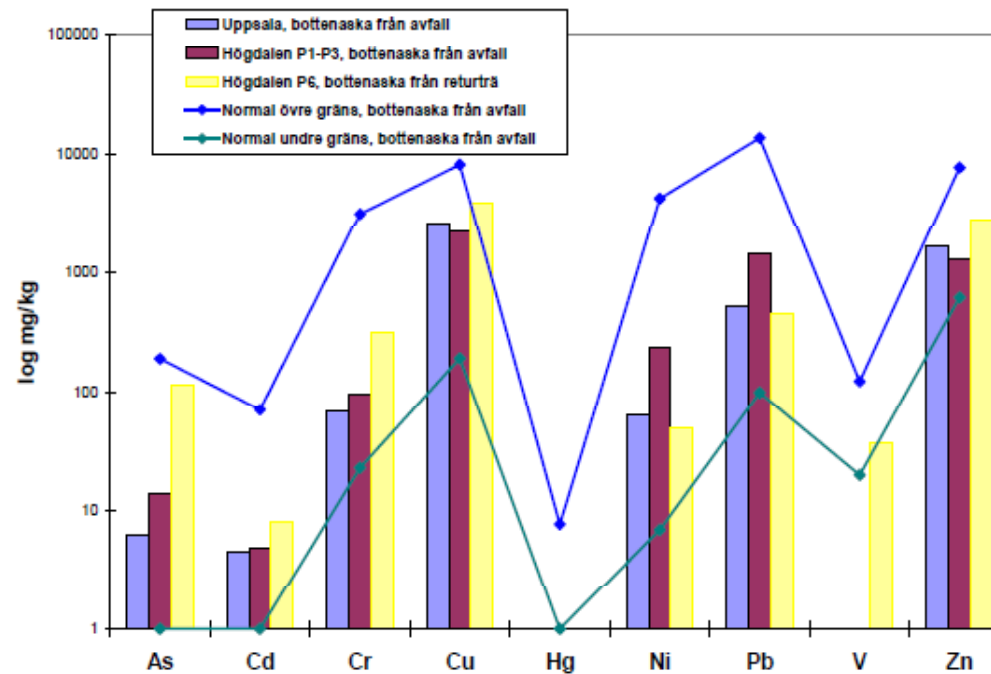




# Results

- Yes, W-t-E bottom ash becomes less objectionable if one does not mix it with the fine first boiler ash
- Yes, W-t-E bottom ash becomes less objectionable if one discards the  $< 2$  mm fraction
- Yes, W-t-E bottom ash becomes even less objectionable if one washes away the layer of fine dust on the particles
- The price is: the binding properties disappear and the ash becomes a ballast

# The project's practical planning problem: variation





# Adopted procedure

- A reference sample was taken on 16/6 2010
- For 24 hrs, the first boiler ash was diverted from the bottom ash, the water in the extraction bath changed and a "project" sample was taken on 9/6
- Both samples were mixed (separately) and left to mature in plastic pails
- When they were deemed to have matured, samples were taken for tests – in triplicate
- The samples were also sieved into fractions  $> 8$  mm, 4 – 8 mm, 2 – 4 mm and  $< 2$  mm - duplicates

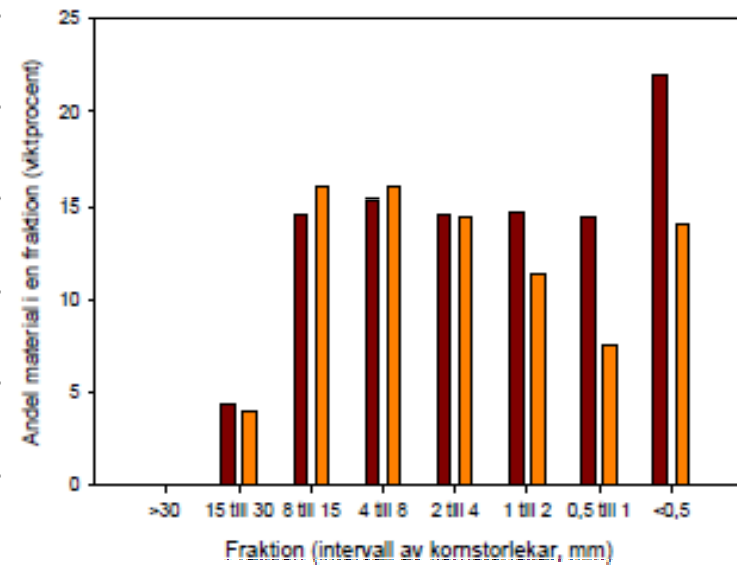
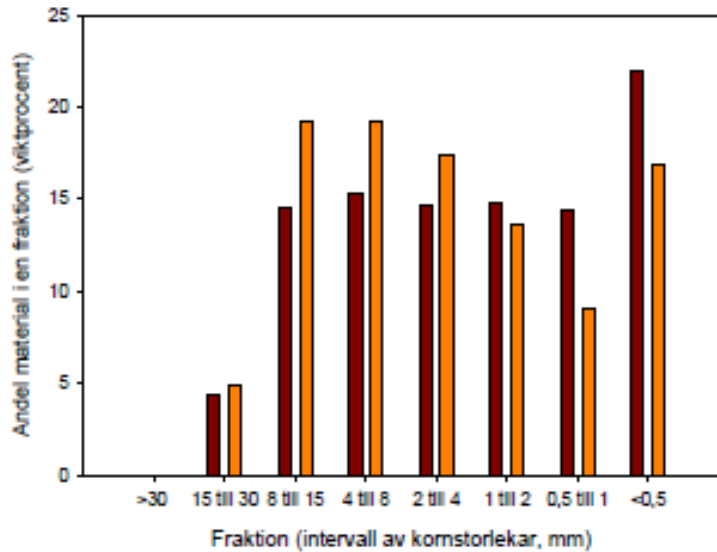


# Tests

- Particle size distribution
- pH
- Chemical composition
- TOC, LOI<sub>550</sub>
- Leaching at L/S=10

# Particle size distribution

Left: actual results, right: scaled (> 2 mm sum)





# Concentrations in the samples

	<b>TOC</b>	<b>Sulphur</b>	<b>Chlorine</b>	<b>Cd</b>	<b>Pb</b>
	%	g/kg	g/kg	mg/kg	mg/kg
Reference	0.4	29	8.1	6	1620
Project	1.5	4.8	3.3	1.6	723
<i>Fractions of the project sample</i>					
>8 mm	0.6	2.7	1.5	1.0	920
4-8 mm	1.1	4.6	2.5	1.6	685
2-4 mm	1.8	6.1	3.8	2.0	950
<2 mm	2.5	10.4	6.0	2.8	685



# Leaching at L/S=10

	<b>DS</b>	<b>SO<sub>4</sub></b>	<b>Cl</b>	<b>Cd, Pb</b>	<b>DOC</b>
	g/kg	g/kg	g/kg	mg/kg	mg/kg
Reference	38	14	9	<LOQ	553
Project	18	3	3	<LOQ	1230
<i>Regulatory references (2003/33/EC and NV Handbook 2010:1)</i>					
<i>Non-hazard.</i>	60	20	15	1/10	800
<i>Inert</i>	4	1	0.8	0.04/0.5	500
<i>Benign</i>	-	0.20	0.13	0.02/0.2	-



# Sulphate and chloride leaching from the sample fractions

Sample	Sulphate		Chloride	
	Reference	Project	Reference	Project
Total	13.7	3.0	8.6	2.7
> 8 mm	13.5	1.7	3.5	1.4
4 – 8 mm	15.0	2.7	7.4	2.0
2 – 4 mm	15.5	3.6	7.6	3.2
< 2 mm	17.5	4.7	8.6	5.0



# Copper

(mg/kg)	Concentration		Leaching, L/S=10	
	Reference	Project	Reference	Project
Total	1900	2800	12	19
> 8 mm	4150	1850	5	12
4 – 8 mm	2200	3750	13	18
2 – 4 mm	3300	3200	12	30
< 2 mm	1950	7000	12	38



So...

## Successes

- Results make sense, so sampling was OK
- Withholding the first boiler ash (<0.5 mm) improved the properties
- Less S/SO<sub>4</sub> (clearly) and less Cl as well

## But...

- The BA did not become 2003/33/EC inert
- All fractions' properties were influenced when the first boiler ash was withheld
- Dusty materials



# Extension of the project

- Discard the < 2 mm fraction for both samples (reference and project)
- Wash with 2 volumes (L/S=2) NaHCO<sub>3</sub> solution, with 2 mol HCO<sub>3</sub> per mol SO<sub>4</sub>
- Rinse twice with one volume (L/S=1) tap water
- New tests, but no duplicates

# Wash away the dust

(red figures, results that don't make sense: single samples)

	Reference			Project		
	All	> 2 mm	Washed	All	> 2 mm	Washed
<i>Concentration (mg/kg)</i>						
S	28 600	4 900	3 500	4 800	< 1 500	< 1 500
Cl	8 100	1 000	650	3 300	930	300
Cu	1 900	3 700	1 600	2 800	1 100	1 600
<i>Leaching at L/S=10 (mg/kg)</i>						
SO <sub>4</sub>	13 700	15 000	4 300	3 000	2 000	750
Cl	8 600	4 800	560	2 700	1 900	260
Cu	12	7.3	0.65	19	16	2.9



# Steps in improvements

- Withhold first boiler ash, 10-15 % less ash, good
- Discard  $< 2\text{mm}$  fraction, 20-40 % less ash, better
- Wash away the dust, 15 % less ash, best



# From a regulatory point of view

- The reference sample was 2003/33/EC non-hazardous
- We believe that the project sample is too
- The washed project sample is close to inert except for DS, Cu and Sb who are slightly above limit
- Nothing helps against NV Handbook 2010:1 limits for free use on concentrations or leaching of salts
- We actually needn't have bothered with treatment for trace elements: all (except Cu) were below NV limit already in the reference sample



# Conclusions

- Removing fine particles improves the environmental properties of bottom ash
- Danish experience is correct
- The first boiler ash is not the only source of dust or fine particles
- The ash loses its binding properties and becomes a ballast when fine fractions are removed
- We have put figures on "what everybody knows"
- We strongly believe in next quick fix: dry bottom ash extraction



# Credits

- Värmeforsk, report number 1186
- Swedish Waste Management Association, report number U2011:17
- Fortum Värme
- Svenska Energiaskor
- Vattenfall
- CBI, for lending their laboratory facilities