

Environmentally friendly use of non-coal ashes

“The Ash programme”

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www.energiaskor.se

www.askprogrammet.com



Research program

Environmentally friendly use of non-coal ashes

Duration 2002 – 2008, 40 companies and authorities

The Swedish Thermal Engineering Research Institute
(Värmeforsk)

Forestry



- Recycling
- Growth

Environment



- Criterias
- Law
- Test methods
- Quality control

Geotechnics



- Roads
- Surfaces
- Concrete
- Mining

Landfilling



- Dense layers
- Stabilization
- Covering mine tailings

Information

- All reports has an English summary and are found at www.askprogrammet.com
- Summaries and more information about uses of ashes are also found at www.energiaskor.se
- Allaska (All ashes)
 - Database
 - All results from the Ash Programme and some more
 - Environmental and technical results
 - In English and Swedish
 - Are free to all

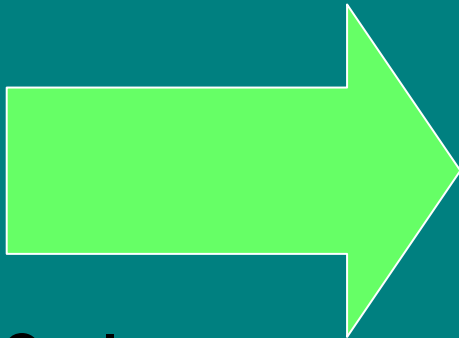
The research program has a width

- Broad Research
 - Environmental technology
 - Environmental law
 - Chemistry
 - Combustion
 - Forestry
 - Biology
 - Pelletizing
 - Mineral technology
 - Land filling
 - Geotechnology
 - Road building
 - Hydrology
 - Cement & concrete
 - Mining
- Participants
 - Authorities
 - Ash producers
 - Boiler producers
 - Consultants
 - End users
 - Scientific researchers

= A very good network
- Applied but also scientific
- Information

Solid Fuels in Sweden

Biofuel



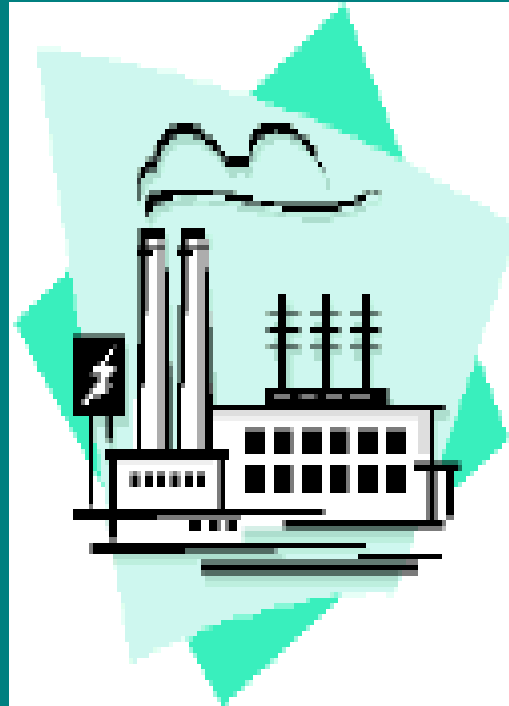
Coal



Waste



Peat



Electricity



Steam for industry



District Heating

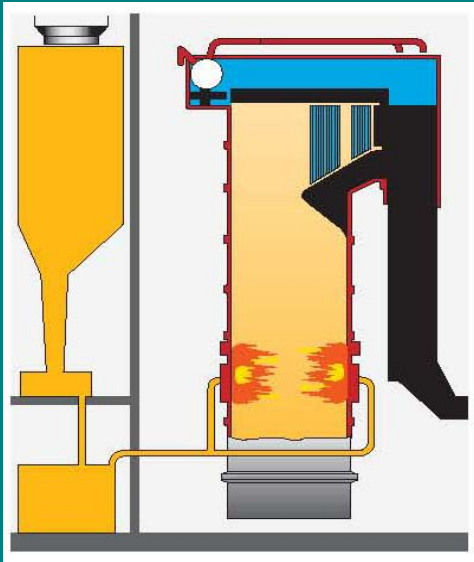


Ashes from different fuels

- 15-25% in municipal wastes
- 5% in peat (can be much more)
- 10-50% in sludge from the paper industry
- 2-4% in bark
- 0,3-0,5% in pure wood
- 8% in coal (Russian steam coal)
- 0,005-0,03% in oil

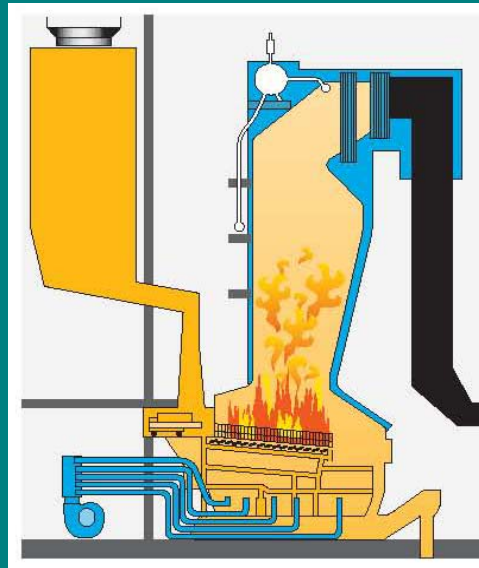
Boilers

(the pictures show rebuilt coal boilers at Söderenergi and their fuels)



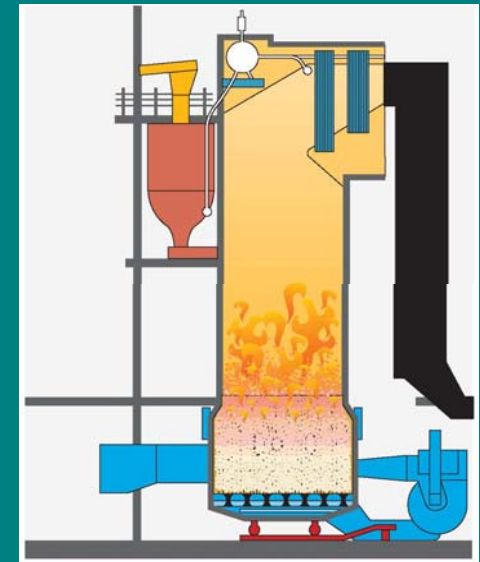
Pulverized fuel boiler
for peat and pellets
(= coal boiler)
 $\approx 1\ 200\ ^\circ\text{C}$

Mostly fly ashes



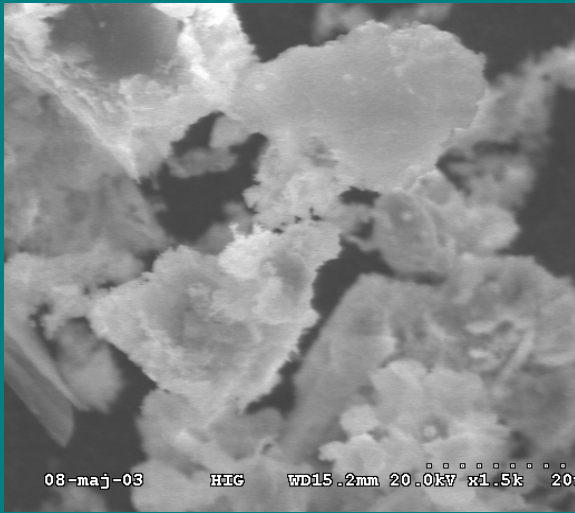
Grate boiler for
industrial wastes
 $\approx 1\ 100\ ^\circ\text{C}$

Mostly bottom ashes

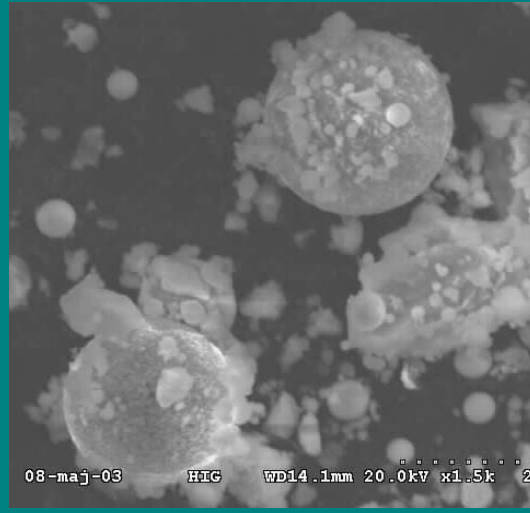


Bubbling fluid bed
for wood chips
and peat
 $\approx 850\ ^\circ\text{C}$
Often as much
fly ashes as
bottom ashes

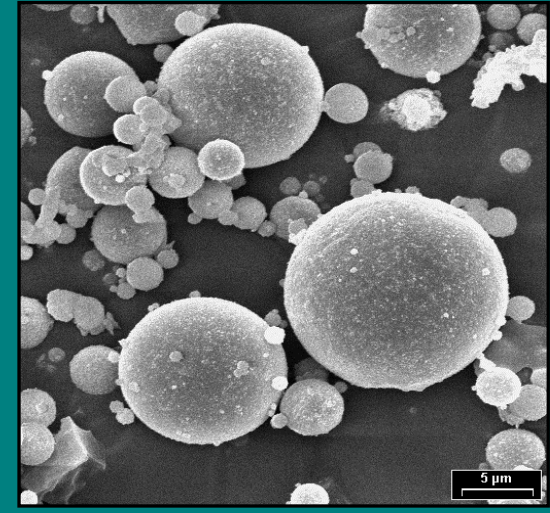
Particle shape of fly ashes



Fluid bed - Biofuel
850 °C



Pulverized fuel boiler –
Peat
1150 °C



Pulverized fuel boiler –
Coal
1200 °C

Ash production in Sweden 2003

Grate Combustion	<u>Bottom ash</u>	<u>Fly ash</u>
Wastes household + ind.	400 000	70 000
Coal + rubber	15 000	10 000
Paper ind. bark sludge	100 000	60 000
Waste from buildings	15 000	5 000
Woodchips/peat	20 000	5 000
Sawmill industry	20 000	10 000
Powder Combustion		
Coal	10 000	30 000
Peat/woodchips etc	25 000	60 000
Fluid Bed Combustion CFBC, BFBC		
Woodchips/peat	25 000	25 000
Paper industry	30 000	70 000
Wastes household + ind.	20 000	30 000
Waste from buildings	15 000	15 000
Coal (PCFBC)	<u>20 000</u>	<u>20 000</u>
Total:	730 000	435 000 (about 20% moisture)



Uses of ashes in Sweden 2005

Forestry	15 000 t FBC wood fly ashes + grate bottom
Road building	20 000 t FBC peat/wood fly ashes
Parking places + other surfaces	40 000 t MSWI bottom ashes
Parking places + other surfaces	90 000 t pF boiler peat/coal + other fly ashes
Surfaces for drying slimes	40 000 t bio fly ashes, some bottom ashes
Filling of former oil storage-cavern	20 000 t CFBC waste fly ashes
Covering of mine tailings	14 000 t CFBC fly ashes
Stabilization of MSWI fly ashes	30 000 t PCFBC coal ashes
Construction material at landfilling	500 000 t MSWI bottom ashes + other ashes
Other	31 000 t
<hr/>	
Total	800 000 t

MSWI = Municipal Solid Waste Incineration

PCFBC = Pressurized Circulation Fluid Bed Combustion

Our aim with ashes

- Ashes shall be used as resources
- Ashes shall be used where the benefits are as great as possible
 - This demands competition between many uses
 - Benefits imply both environmental benefits as well as economical benefits

Recycling of ashes

**Swedish Forest Agency demands recycling of ashes before or after
outtake of wood fuels**

The outtake of both timber and tops & branches for production of energy will increase the outtake of nutrients, mostly basic substances, more than the soil can compensate for in the long run.

Especially a problem in SW of Sweden where acid rains and low buffering capacity are common.



Ashes increase the growth rate on forested organic soils and rich mineral soils.

Recycling of ashes - Nutrients

Guiding minimum concentration values in g/kg according to Swedish Forest Agency

	Current values	Proposed values
Calcium	125	125
Magnesium	20	15
Potassium	30	30
Phosphorus	10	7
Zinc	1	0,5

Fluid bed bottom ashes and diluted ashes like paper sludge ashes contain less nutrients. The limit 7 for P is most likely given to be able to allow recycling of CFB fly ashes and grate bottom ashes. However, peat as fuel may dilute and lessen P.

Recycling of ashes - Environment

- Basic substances like ashes effect the nitrogen balance
 - may increase the growth rate on soils rich in nitrogen
 - may decrease the growth rate on soils poor in nitrogen
- Basic substances may brun the soil
 - burnt soil is restored in 3 years (Swedish Environmental Research Institute)
- Wood ashes contain heavy metals
 - but a cadmium atom from recycled ash is not more dangerous than coming from a decaying branch
- Ashes contain salts
 - the osmotic pressure must not be too high
- **ASHES MUST MATURE BEFORE THEY ARE RECYCLED**

Recycling of ashes – Trace elements

Maximum allowed concentrations in mg/kg dry substance (Swedish Forest Agency)

	Current	Proposed
Boron	500	800
Copper	400	400
Zinc	7000	7000
Arsenic	30	30
Lead	300	300
Cadmium	30	30
Chromium	100	100
Mercury	3	3
Nickel	70	70
Vanadium	70	70
PAH	2	?

ASHES:

MSWI ashes exceed these limits.

Recycled wood ashes often contain a lot of As.
Some peat ashes may contain a lot of As.

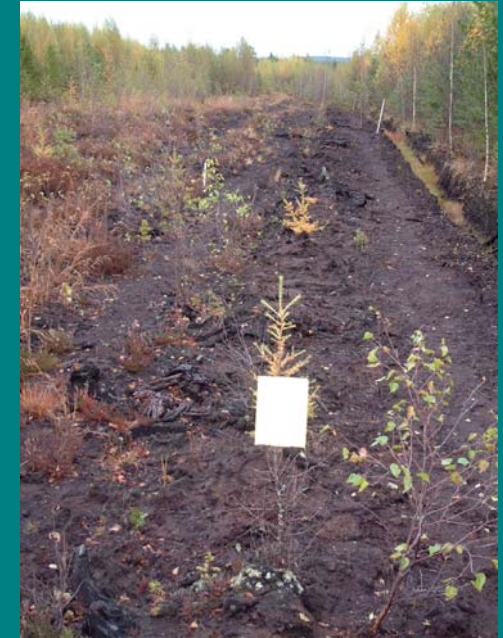
Salix and most likely pine wood may contain a lot of Cd, especially fly ashes from grate boilers.
V may be critical for fly ashes from grate boilers.

PAH should be low, but it is hard to determine an exact limit value.

Cs137 should be lower than 10 kBq/kg dry substance.

Recycling of/fertilizing with ashes to forests

- Returns P, K, Ca, Mg to the forests
- Lowers the acidification of the soils and waterstreams
- Increases the growth rate on organic and some minerogenic soils
- The high pH effects the nitrogen balance in the soils



Test surfaces
with without
ash fertilizing on peat soil

Ashes to forests



The ashes must be treated before recycling: Matured, self hardened, crushed and sieved (as in the picture) or pelletized ashes.
Only fly ashes with low or moderate content of unburnt may be used. Ashes with more than 20% TOC is probably not possible to use.

Ashes increase the growth rate on forested organic soils and rich mineral soils. The forest owner should then be able to pay for parts of the ash recycling.

RecAsh

Regular recycling of wood ash to prevent waste production

- A newly finished EU Life-Environment project
- Is a good description for recycling of ashes to forests
- A handbook is available “From extraction of forest fuels to ash recycling”
- Read more in English: www.recash.info

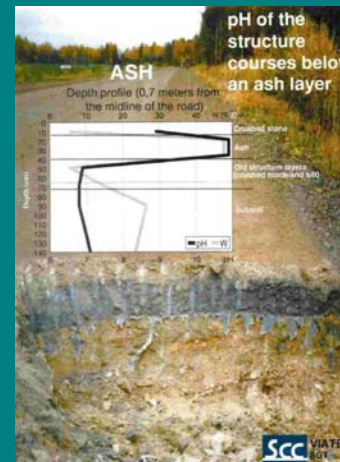
Constructions with bio fly ashes



This plant for recycling of household wastes is built on a light weight construction made of fly ashes on clay soil



Fly ashes have transformed this to a very good road



Lahtinen has shown that fly ashes in the sub base layer give frost resistant roads

Fly ashes in roads and surfaces

Every mixture has given good results in roads and surfaces

Bilder från Rv 90 och Ålandtippen (blandning)



Main road 90 -
Stiffer with ash
No negative environmental
impact

- Mixtures: 100% fly ashes, 30-90% gravel, 0,5% cement, 5-30% bottom ashes, 50% fibre sludge
- Unburnt worsen the qualities
- The most exciting application is:
Stabilization of weak road materials with about 10% ashes

It is a moderate risk for health and environment

- For ashes from wood, peat, bark and sludge from the paper industry
- Even for MSWI bottom ashes
- Dust on vegetables is most critical during building, utilization and demolition
- The surface should be covered with at least gravel as surface course
- Recycled wood chips may be risky (As)
- Creosote should not be risky

Fly ashes in roads



- The film "Ash – a road to success" is available at www.energiaskor.se
 - Higher frost resistance
 - Higher bearing capacity
 - Less maintenance
 - Less material used
 - Better economy
 - Saved natural resources

Constructions with grate bottom ashes

- **Good road material**

- Good bearing capacity
- Moderate strength
- Relatively lightweight material
- 15% in crushed rock = good screening curve
- Qualities should be measured with functional methods
- Handbook MSWI bottom ashes in roads

- **Low risk for health and environment**

- Low risk in roads/surfaces especially if they are covered
- Should be reused when the road is no longer used

- **Landfills**

- Good filler material
- Drainage material



Dense layers of ashes and municipal sludges or calcium bentonite

when finalizing landfills

- It is dense $< 10^{-9}$ m/s
- Ash provides a shear strength of 30 kPa
- Longlasting thanks to:
 - Bentonite because it is Ca and not Na between the layers
 - Sludge because of no biological and very slow chemical degradation thanks to high pH, salts, low percolation



Dense layer trails at Dragmossen with 50/50 flyash and sludge

Covering mine tailings

Very big potential market for fly ashes



Gillervattnet tailing pond at Boliden

A layer of fly ash between layers of municipal sludge prevents oxygen from reaching the sulphuric tailings. We are looking for plants that will give an “eternal” protecting top layer.

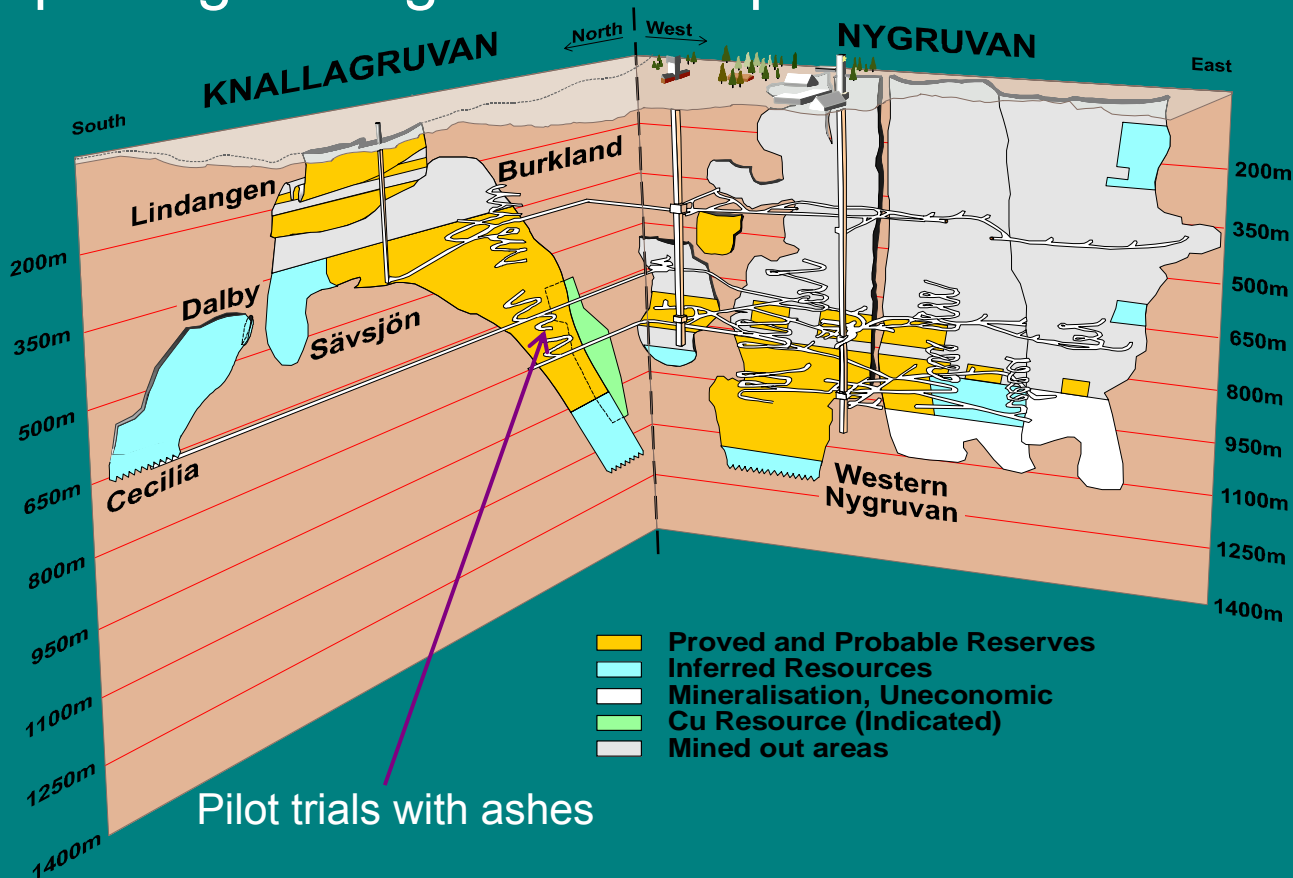


Covering mine tailings with ash and municipal sludge



Replacing Portland cement

Even non-coal ashes give similar reactions like cement. It can replace at least 50% of the Portland cement in stop filling mining and in simple concrete.



Zink mine

Tailings and cement/ash are pumped into the mine cavities

Calculation of health risk if ash is left in roads that are no longer used

If:

The ash is placed on the surface

- Dust on a person for 40 days per annum
- Oral intake of ash
- Intake of 1 kg per annum of eatable vegetables that have absorbed metals from the ash

In that case the following figures should be used as limit values if ash is left in surfaces

As 15 mg/kg dry substance

Pb 1 500 mg/kg dry substance

Cd 60 mg/kg dry substance

Hydrogen

- Metallic aluminium in ashes originates from waste
- In basic aquatic environment, i.e. when ash is wetted
 - the protective oxide layer is dissolved
 - aluminium corrodes
 - hydrogen gas is developed
- Explosions have occurred!
- Al⁰ is present mostly in
 - bottom ashes (cans etc) from grate incinerators
 - fly ashes (foils) from fluid bed incinerators
- The Ash programme has written a recommendation (in Swedish)

Environmentally friendly uses of ashes 2006-2008

The Ash programme will continue to at least 2008.

GOAL:

”At the end of 2008 it shall be possible to find environmentally friendly applications for 90% of the ashes produced in Sweden”