Coal Ash Utilisation and its Environmental Implications
Update on the EC’s attitude – A Demonstrational Case Study -

Hans-Joachim Feuerborn

European Coal Combustion Products Association
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1. Introduction

- Production of CCPs in Europe (EU15) was 61 million tonnes in 2007
- Out of this about 50 million tonnes of coal ash
- Total production of CCPs in EU 27 is estimated to be more than 100 million tonnes annually in EU 27
- 10 new Member States joined the EU in 2004
- 2 new Member States joined the EU in 2007
Use of CCPs

The CCPs are mainly utilised in the building material industry, in civil engineering, in road construction, for construction work in underground coal mining as well as for recultivation and restoration purposes in open cast mines.

The majority of the CCPs is produced to meet certain requirements of standards or other specifications with respect to utilisation in certain areas.
1. Introduction

Influences on CCPs utilisation and production

- Retrofitting of existing and construction of new coal-fired power plants (LCPD, energy demand, ..)
- Environmental legislation
  - REACh regulation
- Revision European standards and national regulations
e.g.  EN 450, EN 13282, EN 14227, EN 13055
- Revision of the CPD - implementation of ER 3
2. Coal ash production and utilisation

Development of CCP production (EU 15) from 1993 to 2007

FGD = flue gas desulphurization gypsum; SDA = spray dry absorption product; FBC = fluidized bed combustion ash; BS = boiler slag; BA = bottom ash; FA = fly ash
2. Coal ash production and utilisation

Utilisation, temporary stockpile and disposal of CCPs in Europe (EU 15) in 2007
2. Coal ash production and utilisation

Utilisation of fly ash in the construction industry and in underground mining in Europe (EU 15) in 2007

- Concrete Addition: 29.5%
- Concrete Blocks: 5.8%
- Blended Cement: 14.5%
- Road Construction, Filling Application: 19.0%
- Cement Raw Material: 26.9%
- Infill: 3.4%
- Others: 1.0%

Total utilisation: 20.0 million tonnes
2. Coal ash production and utilisation

Utilisation of **bottom ash** in the construction industry and in underground mining in Europe (EU 15) in 2007

- Road Construction, Filling Application: 36.5%
- Concrete Blocks: 45.3%
- Cement/Mortar: 13.4%
- Concrete: 2.7%
- Others: 2.1%

**Total utilisation: 2.5 million tonnes**
3. Sustainability / Environmental considerations

- saving of natural resources
  - mining
  - processing
  - transport
- reduction of energy demand
- reduction of emissions (CO₂) needed for or result from manufacturing process of products which are replaced

- CCPs are fine grained raw materials
- CO₂ reduction in
  - cement production (0.7 to 1.2 kg CO₂ per kg clinker, dep. on fuel)
  - concrete when fly ash is used as conc. add.
- saving of drying energy when fly ash is used to dry wet raw materials
4. Revision of the Waste Directive

Revised Waste Directive
Proposal by the European Parliament and the Council for the waste hierarchy:

*Article 4 “Waste hierarchy”*

1. The following waste hierarchy shall apply as a priority order in waste prevention and management legislation and policy:

(a) prevention
(b) preparing for re-use
(c) recycling
(d) other recovery, e.g. energy recovery; and
(e) disposal
4. Revision of the Waste Directive

Article 4 “Waste hierarchy” (2)

2. When applying the waste hierarchy referred to in para. 1, member states shall take measures to encourage the options that deliver the best overall environmental outcome. This may require specific waste streams departing from the hierarchy where this is justified by life cycle thinking on the overall impact of the generation and management of such waste.
4. Revision of the Waste Directive

Article 4 “Waste hierarchy” (3)

Member states shall ensure that the development of waste legislation and policy is a fully transparent process, observing existing national rules about the consultation and involvement of citizens and stakeholders.

Member states shall take into account the general environmental protection principals of precaution and sustainability, technical feasibility and economic viability, protection of resources as well as the overall environmental, human health, economic and social impacts, in accordance with articles 1 and 13.
4. Revision of the Waste Directive

Revised Waste Directive

Proposal by the European Parliament and the Council for the definition of by-products:

**Article 5 “By-products”**

„A substance or object, resulting from a production process, the primary aim of which is not the production of that item, may be regarded as not being waste referred to in point (1) of Article 3 but as being a by-product only if the following conditions are met:
4. Revision of the Waste Directive

(a) **further use of the substance or object is certain**

(b) **the substance or object can be used directly without any further processing other than normal industrial practice**

(c) **the substance or object is produced as an integral part of a production process; and**

(d) **Further use is lawful, i.e. the substance or object fulfils all relevant product, environmental and health protection requirements for the specific use and will not lead to overall adverse environmental or human health impacts.**
4. Revision of the Waste Directive

Article 6 “End-of-waste” (1)

1. Certain specified waste shall cease to be waste within the meaning of point (1) of Article 3 when it has undergone a recovery, including recycling, operation and complies with specific criteria to be developed in accordance with the following conditions:

   (a) the substance or object is commonly used for specific purposes;

   (b) a market or demand exists for such a substance or object;
Article 6 “End-of-waste” (2)

(c) the substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products; and

(d) the use of the substance or object will not lead to overall adverse environmental or human health impacts.

The criteria shall include limit values for pollutants where necessary and shall take into account any possible adverse environmental effects of the substance or object.
4. Revision of the Waste Directive

Article 5 “By-products”, para 2

On the basis of the conditions laid down in paragraph 1, measures may be adopted to determine the criteria to be met for specific substances or objects to be regarded as a by-product and not as waste referred to in point (1) of Article 3. These measures, ...

Article 6 “end-of-waste”, para 2

The measures relating to the adoption of such criteria and specifying the waste, designed to amend non-essential elements of this Directive, by supplementing it, shall be adopted in accordance with the regulatory procedure with scrutiny referred to in Article 39(2). End-of-waste specific criteria should be considered, among others, at least for aggregates, paper, glass, metal, tyres and textiles.
IPTS project: End-of-waste-criteria

*The Institute for Prospective Technological Studies (IPTS) and DG Joint Research Centre (JRC) were ordered by the Commission to develop a general methodology for determining end-of-waste criteria.*

*The main objective of the project is to identify those waste streams where the use of "end of waste" could be appropriate as well as*

- to develop a set of criteria enabling the selection and comparison of potential waste streams
- to analyse the waste streams by applying the criteria
- to propose a list of waste streams with their relative importance.
In Europe, non registered substances can not be placed on the market after 1st June 2008 any more!

Each producer or importer of coal combustion products (CCPs) placed on the market as construction materials have to register their substances.

The registration requires i.a. comprehensive information about human toxicology and ecotoxicology of the substances.
5. REACH Regulation

EINECS – European Inventory of existing commercial chemical substances

Start notification of „new substances“  end of pre-registration  end of registration

>1.000 t/a  >100 t/a  > 1 t/a


ELINCS registration of new chemicals

REACH
5. REACH Regulation

REACH Information requirements – dossier/report

The information requirements are based on the total volume of the substance manufactured and imported per year.

- 1 – 10 t/a: Annex VII
- 10 – 100 t/a: Annex VII, VIII
- 100 – 1000 t/a: Annex VII – IX
- > 1000 t/a: Annex VII – X

Technical dossier

Chemical safety report
5. REACH Regulation

REACH Information requirements - tests

**Phys.-chem.**
- Density
- Melting / Boiling point
- Water solubility
- Vapour pressure
- Partition coefficient
- Flash point
- Flammability
- Explosive properties
- Surface tension
- Oxidative properties
- Granulometry
- Stability in organic solvents
- Identity of degradation products
- Dissociation constant
- Viskosity

**Toxicology**
- Acute toxicity (oral)
- Skin irritation (in oral)
- Eye irritation (in vitro)
- Skin sensibilisation
- Mutagenicity (Ames test)
- Skin irritation (in vivo)
- Eye irritation (in vivo)
- In-vitro Cytogenicity
- In vitro mutagenicity (mammalian cells)
- Acute toxicity (dermal/inhalative)
- Subacute toxicity (28 d Test)
- Reproductive/developmental toxicity, (Screening test)
- Toxicokinetic
- Subchronic Toxicity (90 d test)
- Reproductiontoxizität
- Developmental toxicity
- 2-generation-reproductive toxicity
- Carcinogenicity

**Eco-toxicology**
- Akute Daphnia toxicity
- Algae toxicity
- Biotic degradation
- Short-term toxicity fish
- Respiration inhibition test
- Abiotic degradation
- Adsorption/desorption
- Daphnia reproduction test
- Long-term toxicity fish
- Biotic degradation in water
- Biotic degradation in soil
- Biotic degradation in sediment
- Identification of degradation products
- Bioaccumulation in fish
- Short-term toxicity invertebrates
- Soil microorganisms
- Short-term toxicity plants
- Environmental fate
- Long-term toxicity terr. invertebrates
- Long-term toxicity sediment organisms
- Long-term toxicity birds
### 5. REACH Regulation

#### CCPs and REACH – Status of Pre-/registration activities

<table>
<thead>
<tr>
<th>EC-Nr.</th>
<th>EC-Name /preSIEF</th>
<th>Number pre-registered Parties</th>
<th>CCPs</th>
<th>preSIEF-facilitator</th>
<th>consortia</th>
</tr>
</thead>
<tbody>
<tr>
<td>231-900-3</td>
<td>Calcium sulphate</td>
<td>1578</td>
<td>FGD-gypsum</td>
<td>EUROGYPSUM</td>
<td>Calcium sulphate consortium</td>
</tr>
<tr>
<td>300-212-6</td>
<td>Ashes (residues) Cenospheres</td>
<td>113</td>
<td>CE</td>
<td>B-Lands Consult</td>
<td>Not defined</td>
</tr>
<tr>
<td>270-708-4</td>
<td>Slags, coal</td>
<td>524</td>
<td>FA, BA, BS, FBC-ash, CE?, BMA?</td>
<td>EVONIK Steag</td>
<td>Ash-REACH-Consortium By-Products Consortium</td>
</tr>
<tr>
<td>302-652-4</td>
<td>SDA-product - &gt;10% ash - &lt; 10% ash</td>
<td>99, 11</td>
<td>SDA-product</td>
<td>B-Lands Consult -</td>
<td>By-Products Consortium -</td>
</tr>
<tr>
<td>297-049-5</td>
<td>Biomass ash</td>
<td>97</td>
<td>BMA</td>
<td>Södra?-</td>
<td>Not defined</td>
</tr>
</tbody>
</table>
European Standards are – once prepared - subject of revision in a five year term.

Selected standards recently revised or under revision are:

- EN 450  Fly ash for concrete
- prEN 13282  Hydraulic road binder
- EN 14227  Hydraulically bound mixtures
- EN 13055  Aggregates
4. Revision of European Standards

Revision of EN 450: Provisions for fly ash from co-combustion

4.1 Co-combustion materials

Fly ash from co-combustion as defined in 3.2 is obtained from pulverised coal fired simultaneously with co-combustion materials as listed in Table 1.

Existing:

The minimum percentage, by dry mass, of coal (Kc) shall not be less than 80 % and the maximum proportion of fly ash derived from co-combustion materials (M) shall not be greater than 10 % when calculated from the Formula (1):

New:

The maximum percentage, by dry mass, of co-combustion materials (Ki) shall be 40 % by mass and the maximum proportion of fly ash derived from co-combustion materials (M) shall not be greater than 25 % by mass.
4. Revision of European Standards

Revision of EN 450: Limiting parameters for co-combustion materials (basis table 1 of new EN 450-1)

<table>
<thead>
<tr>
<th>Type</th>
<th>Limited by</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Solid Bio Fuels complying with CEN/TS 14588 including animal husbandry residues</td>
<td></td>
</tr>
<tr>
<td>green wood 1</td>
<td>Co-combustion fuel based</td>
</tr>
<tr>
<td>green wood 2</td>
<td>Co-combustion fuel based</td>
</tr>
<tr>
<td>green wood 3</td>
<td>Co-combustion fuel based</td>
</tr>
<tr>
<td>bark wood</td>
<td>reactive CaO</td>
</tr>
<tr>
<td>Cacao shells</td>
<td>Na₂O equivalent (K)</td>
</tr>
<tr>
<td>palm kernels</td>
<td>total P₂O₅</td>
</tr>
<tr>
<td>poultry dung</td>
<td>reactive CaO</td>
</tr>
<tr>
<td>2 Animal meal (meat and bone meal)</td>
<td></td>
</tr>
<tr>
<td>meat &amp; bone meal</td>
<td>total P₂O₅</td>
</tr>
<tr>
<td>3 Municipal sewage sludge</td>
<td></td>
</tr>
<tr>
<td>municipal sewage sludge</td>
<td>total P₂O₅</td>
</tr>
<tr>
<td>4 Paper sludge</td>
<td></td>
</tr>
<tr>
<td>Paper sludge</td>
<td>CaO</td>
</tr>
<tr>
<td>5 Petroleum coke</td>
<td></td>
</tr>
<tr>
<td>Petroleum Cokes</td>
<td>-*</td>
</tr>
<tr>
<td>6 Virtually ash free liquid and gaseous fuels</td>
<td></td>
</tr>
<tr>
<td>Industrial HC liquid</td>
<td>Co-combustion fuel based</td>
</tr>
</tbody>
</table>
# 4. Revision of European Standards

## Revision of EN 450: Existing and revised chem. requirements

<table>
<thead>
<tr>
<th>Property</th>
<th>Unit</th>
<th>Existing</th>
<th>Revised</th>
</tr>
</thead>
<tbody>
<tr>
<td>loss on ignition (LOI) class A</td>
<td>% by mass</td>
<td>≤ 5.0</td>
<td>≤ 5.0</td>
</tr>
<tr>
<td>class B</td>
<td></td>
<td>2.0 - 7.0</td>
<td>≤ 7.0</td>
</tr>
<tr>
<td>class C</td>
<td></td>
<td>4.0 - 9.0</td>
<td>≤ 9.0</td>
</tr>
<tr>
<td>chloride (Cl⁻)</td>
<td>% by mass</td>
<td>≤ 0.10</td>
<td>n.m.</td>
</tr>
<tr>
<td>sulphuric anhydride (SO₃)</td>
<td>% by mass</td>
<td>≤ 3.0</td>
<td>n.m.</td>
</tr>
<tr>
<td>free calcium oxide (CaO)</td>
<td>% by mass</td>
<td>≤ 2.5</td>
<td></td>
</tr>
<tr>
<td>reactive calcium oxide (CaO)</td>
<td>% by mass</td>
<td>≤ 10.0</td>
<td>n.m.</td>
</tr>
<tr>
<td>reactive silicon dioxide (SiO₂)</td>
<td>% by mass</td>
<td>≥ 25</td>
<td>n.m.</td>
</tr>
<tr>
<td>sum SiO₂ + Al₂O₃ + Fe₂O₃</td>
<td>% by mass</td>
<td>≥ 70</td>
<td>n.m.</td>
</tr>
<tr>
<td>total content of alkalis (Na₂O equivalent)</td>
<td>% by mass</td>
<td>≤ 5.0</td>
<td>n.m.</td>
</tr>
<tr>
<td>magnesium oxide (MgO)</td>
<td>% by mass</td>
<td>≤ 4.0</td>
<td>n.m.</td>
</tr>
<tr>
<td>soluble phosphate (P₂O₅)</td>
<td>mg/kg</td>
<td>≤ 100</td>
<td>n.m.</td>
</tr>
<tr>
<td>total phosphate (P₂O₅)</td>
<td>% by mass</td>
<td>-</td>
<td>≤ 5.0</td>
</tr>
</tbody>
</table>

1. if the content of free lime is greater than 1.0 % by mass, soundness have to be tested
2. if the content of free lime is greater than 1.5 % by mass, soundness have to be tested
3. n.m. = not modified
4. tests for initial type testing only
Environmental compatibility in European standards (e.g. EN 450-1)

4.3 Environmental compatibility

Should there be any additional requirements resulting from national laws, regulations and administrative provisions in the place of use of the fly ash regarding e.g.

- the fly ash,
- the leachate of concrete produced with fly ash,
- the co-combustion material,

these are to be considered with respect to environmental compatibility, and conformity to the relevant regulations has, where required, to be evaluated before production.
# 4. Revision of European Standards

## TC 351 horizontal approach

<table>
<thead>
<tr>
<th>ETS</th>
<th>GENERIC (horizontal)</th>
<th>ETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product specific</td>
<td>Existing EN/ISO- or new EN-Standard developed under CEN/TC 351</td>
<td>Product specific</td>
</tr>
</tbody>
</table>

**Definition generic product or specific product or a group of specific products [TR 3]**

**Selection of RDS related to relevant scenario (differentiation between trace elements and input in the production process) [TR 3]**

**Release scenario [TR 2]**

**Monolithic material**

<table>
<thead>
<tr>
<th>above ground water (in soil)</th>
<th>within ground water (in soil)</th>
<th>wash off (on soil)</th>
</tr>
</thead>
</table>

**Granular material**

<table>
<thead>
<tr>
<th>Percolation above ground water (in soil)</th>
<th>Percolation within ground water (in soil)</th>
<th>Percolation (on soil)</th>
</tr>
</thead>
</table>

**Hierarchy [TR 3]**

1. direct leaching test
2. indirect leaching test
3. screening tests (e.g. content, pH)

**Elements**

- Test frequency (ETS)
- Specimen preparation (EN/ISO)
- Model composition
- Testing equipment (EN/ISO)
- Test procedure/ performance
- Analysis of extract [TR6] (EN/ISO)
- Evaluation of measurement results (ETS)
- Method of expressing the results and reporting (ETS)

**CE-marking [TR 3]**

- NPD
- Classes (e.g. A, B, ...)
- Declared value
- Pass/fail

**Example class A:**

\[ E_t = xx \text{ days} \leq XX \text{ mg/m}^2 \]

for Nickel
### 4. Revision of European Standards

#### TC 351 horizontal approach – leaching scenarios

<table>
<thead>
<tr>
<th>General scenario</th>
<th>Test Method to be developed related to scenario</th>
<th>Products (examples)</th>
<th>Boundary conditions in test and/or scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I.</strong>&lt;br&gt;Non permeable product. Water is flowing over the surface of the product</td>
<td>Dynamic surface leaching test (DSLT) for conformity testing (&lt;code&gt;TS351WG1XXX-2&lt;/code&gt;)&lt;br&gt;<strong>Source</strong>: existing draft of CEN/TC 292/WG6</td>
<td>Metal sheets and strips, coatings, ceramic tiles, glass, bituminous products…</td>
<td><strong>Test</strong>&lt;br&gt;<strong>Scenario</strong></td>
</tr>
<tr>
<td><strong>II.</strong>&lt;br&gt;Low permeable product. Water is transported into the matrix by capillary forces; contribution of core to surface</td>
<td>Dynamic surface leaching test (DSLT) (&lt;code&gt;TS351WG1XXX-2&lt;/code&gt;) (including procedure for granular products)&lt;br&gt;<strong>Source</strong>: guidance paper or TR</td>
<td>Structural concrete, bricks, treated wood, cement mortar, coatings, road materials, …</td>
<td>Leachant (e.g. pH), Particle size, L/S ratio, Volume/Surface ratio, Contact time…&lt;br&gt;pH (also carbonation), Salinity, DOC, Redox, Dry/wet cycles…</td>
</tr>
<tr>
<td><strong>III.</strong>&lt;br&gt;Permeable product. Water may infiltrate into the matrix driven by gravity</td>
<td>Percolation (column) test for conformity testing (&lt;code&gt;TS351WG1XXX-3&lt;/code&gt;)&lt;br&gt;(short test, first eluates or alternatively batch EN 12457-1 to -4)&lt;br&gt;<strong>Source</strong> percolation test: CEN/TS 14405</td>
<td>Unbound aggregate, drain concrete, …</td>
<td><strong>Test</strong>&lt;br&gt;<strong>Scenario</strong></td>
</tr>
</tbody>
</table>
4. Revision of European Standards

WT/WFT approach

WT - without testing
WFT - without further testing
FT - further testing
ITA - initial type assessment
ITT - initial type testing
4. Revision of European Standards

**DSLT (Tank Leaching Test)**

**Standtest (Labor)**

Prüfkörper (a = 100 mm)

Eluent

Ergebnis, z. B.:

\[ E_t = 56 \text{ days} \]

= XX mg/m² für Nickel

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**Up-flow Percolation Test**

Based on NEN 7343

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CEN/TC 351/WG1 AHG "Working plan" N 0122 fourth draft TS-2 (rev1) - 2009-10-26

Generic horizontal dynamic surface leaching test (DSLT) for determination of surface dependent release of substances from monolithic or plate-like or sheet-like construction products

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CEN/TC 351/WG1 AHG "Working plan" N0120 TS XXX-3 – 2009-10-01

Generic horizontal up-flow percolation for determination of the release of substances from granular construction products
4. Revision of European Standards

Guidance standard for CEN Product TC’s for selection of leaching tests appropriate for their product(s) – General principles

Scheme for the selection of a test to assess release from a construction product.
4. Revision of European Standards

CEN/TC 351 Workshop on Radiation from Construction Products on October 30, 2009

Recommendation 1
Develop (in CEN/TC 351) a standardised measurement method for activity concentrations of radioactivity (gamma radiation).

Recommendation 2
If it is necessary to develop a harmonised method for the calculation of the dose caused by gamma radiation, this should be covered in a separate standard.

Recommendation 3
There is a need for a European standardised method for the measurement of indoor radon concentration. However, this method is not specific for construction products and thus not covered by the scope of CEN/TC 351.
4. Revision of European Standards

CEN/TC 351 Workshop on Radiation from Construction Products on October 30, 2009

Recommendation 4
Radon exhalation is covered by the Austrian regulation, but not by the Finnish nor Polish or the revised BSS. As pre-normative research seems necessary, CEN/TC 351 shall not start developing a radon exhalation measurement and dose assessment method now, but CEN/TC 351/TG 6 shall deliver a state of the art report regarding radon exhalation measurement and dose assessment methods.

Recommendation 5
Development of an assessment method for thoron (220Rn) shall be postponed.

Recommendation 6
Involvement of DG TREN in this work is highly appreciated and shall be continued.
6. Concluding remarks

► Every year more than 100 million tonnes of CCPs are produced in Europe (EU-27).

► 61 million tonnes of Coal Combustion Products (CCPs) were produced in Europe (EU-15) in 2007.

► CCPs may be redefined as by-products according the revised Waste Directive.

► By-products and end-of-waste-substances are subject to REACH. Consortia are currently formed for registration of calcium sulphate and different types of ashes.

► The technical and environmental requirements for products are addressed in European and national product standards which are subject to regular revision. The future revision will include ER 3 in the CE-marking of products.
EUROCOALASH 2010

International Conference
May 27/28, 2010
Ingeniørforeningen in Copenhagen/Denmark

Organizer: IDA-Energie
Co-Organizers: ECOBA, Eminimal A / S

www.eocoalash.org
Thank you for your attention!