

**International Workshop on
Environmental Aspects of Coal Ash Utilization**

Tel Aviv, Israel
December 15th – 16th 2009

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

H. J. Feuerborn

European Coal Combustion Products Association e.V.

1. Introduction

Coal ash is produced with the production of electricity in coal-fired power plants. Coal ash is a synonym for the combustion residues boiler slag, bottom ash and especially fly ash from different types of boilers. These ashes form the major part of all coal combustion products (CCPs) which consist also of desulphurisation products like spray dry absorption product and FGD gypsum. In 2007, about 61 million tonnes of CCPs were produced in Europe (EU15). The production in all the European member states is estimated to be about 100 million tonnes. 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.

The use of CCPs has several environmental and technical benefits. It has developed by the years and is mostly based on requirements of standards or other specifications which are subject to regular revision by CEN or national authorities. At present, the most important discussion focus the definition of CCPs. With the revision of the Waste Directive also “by-products” and “end-of-waste” will be defined. By-products will from the beginning be not subject to waste legislation, end-of-waste materials are resulting from the recovery of waste. For non-waste-materials the REACH regulation has to be considered and substances which are not waste are subject to REACH. In addition, some technical standards are under revision. The new generation of harmonised standards will also deal with the essential requirements no 3, which will become part of the CE marking of products.

This paper gives an overview on coal ash utilisation in Europe and will focus the development of environmental legislation (i.a. Waste Directive, REACH Regulation) and the revision of European standards.

2. Utilisation

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. In 2007, about 53% of the total CCPs are used in the construction industry, in civil engineering and as construction materials in underground mining and about 36% for restoration of open cast mines, quarries and pits. About 2.5 % were temporarily

International Workshop on Environmental Aspects of Coal Ash Utilization

Tel Aviv, Israel
December 15th – 16th 2009

stockpiled for future utilisation and about 8 % were disposed off. Figures regarding the specific use of CPPs are given in Annex I.

Fly ash

In 2007, about 20 million tonnes of fly ash were utilised in the construction industry and for production purposes in underground mining. Most of the fly ash produced in 2007 was used as concrete addition, in road construction and as raw material for cement clinker production. Fly ash was also utilised in blended cements, in concrete blocks and for infill (that means filling of voids, mine shafts and subsurface mine workings) (see figure 1 in Annex I).

Bottom ash

Bottom ash is much coarser than fly ash. About 2.5 million tonnes of bottom ash were used in the construction industry. Out of this about 45 % was used as fine aggregate in concrete blocks and in concrete, about 37 % in road construction and filling applications and about 13 % in cement production (see figure 2 in Annex I).

Boiler slag

About 66 % of the boiler slag produced was used as blasting grit, about 10 % for grouting and in drainage layers and about 14 % was used as aggregate in concrete (see figure 3 in Annex I).

Fluidized Bed Combustion (FBC) Ash

In 2007, about 0.2 million tonnes were mainly used for engineering filling applications (40 %), for infill (30 %) and subgrade stabilisation (about 14 %; see figure 4 in Annex I). It has to be noted that the total amount of FBC-ash in EU 15 countries is small compared to the amount produced at least in Poland and the Czech Republic.

3 Revision of European standards

Based on the major fields of application the most important standards which are under revision will be described. All the standards are or will become harmonized standards. Together with the technical requirements the conformity control will be unified and the essential requirements no. 3 health on hygiene will be incorporated in the next or the next but one generation.

Revision of EN 450-1 and EN 450-2

The application as concrete addition constitutes the highest added value for fly ash. By this, the European Standard EN 450 "Fly Ash for Concrete" is particularly important for the marketing of fly ash. The standard was first published in 1994 and the revised standards EN 450-1 und EN 450-2 entered force on January 1, 2007. EN 450-1 deals with definitions, specifications and conformity criteria for siliceous fly ash, which is produced by burning of pulverized coal, with or without co-combustion materials, and collected in a dry state, or which is processed by e.g. classification, selection, sieving, drying, blending, grinding or carbon reduction or by a combination of these processes. This is because in some countries fly ash has been processed according to national regulations for years or, in some cases, decades. EN 450-2 deals with the conformity evaluation of fly

International Workshop on Environmental Aspects of Coal Ash Utilization

Tel Aviv, Israel
December 15th – 16th 2009

ash for concrete produced in power plants and in processing plants. Most important is the documentation of procedures for the production control in a works quality manual.

In EN 450-1 requirements regarding homogeneity, soundness and effectiveness are stipulated. The chemical requirements refer to e.g. the loss on ignition, sulphur-, chloride- and free-lime-content. If fly ash is produced with co-combustion the content of reactive SiO₂, the total oxide content of SiO₂, Al₂O₃, Fe₂O₃, the alkali-, MgO- and phosphate-content have to be tested. The physical parameters stipulate requirements on the fineness, variation of fineness and density, on soundness and activity index. In addition to these requirements, fly ash from co-combustion has to meet the requirement of initial setting time, fly ash of category S those of the water demand. Within the ongoing revision of the standards all parameters are subject to critical review and the amount of co-combustion materials will be increased to incorporate the experience gained with European Technical Approvals (ETA). Proposed changes will be documented in a respective background report.

Revision of EN 13282 Hydraulically bound mixtures

The revision of the European standard for hydraulic road binders (prEN 13282) resulted in the preparation of three parts. Part 1 is dealing with rapid hardening hydraulic road binders. These are cement based binders which follow the requirements as already known from prEN13282. Part 2 is dealing with normal hardening hydraulic road binders. These binders have lower cements contents, the compressive strength has to be tested after 56 days (part 1 at 28 days). A slaking procedure was implemented to guarantee that also lime rich mixtures can be evaluated in the laboratory. Part 3 of the standard deals with the conformity evaluation.

Calcareous fly ash meeting the requirements of EN 197 /8/ as well as FBC ash meeting specific requirements regarding the chemical composition can be used as main constituents for the production of these binders.

Revision of EN 14227 Hydraulically bound mixtures

In June 2009 the revision of the EN 14227-series was decided. EN 14227 part 3 is dealing with fly ash bound mixtures and part 4 with fly ash for these mixtures in which the definition and requirements for siliceous and calcareous fly ash are given. In contrast to the standard referring to the cement standard EN 197-1 for the definition of fly ash in this standard no reference is made. Due to the given definition also FBC-ash is covered and needs to fulfil the same requirements as the ashes from classical dust-fired boilers.

International Workshop on Environmental Aspects of Coal Ash Utilization

Tel Aviv, Israel
December 15th – 16th 2009

Revision of EN 13055 Aggregates

The European Standards EN 13055- Part 1: “Lightweight aggregates for concrete, mortar and grout” and EN 13055-2 Lightweight aggregates - Part 2: “Lightweight aggregates for bituminous mixtures and surface treatments and for unbound and bound applications” will be merged to one standard according the decision of TC 154. The new standard EN 13055 will be entitled “Lightweight aggregates for building, civil engineering and other applications”.

The standard is relevant for CE marking as lightweight aggregates for the intended use in “Concrete, mortar and grout”, “Bituminous mixtures and surface treatments” and now also in “Unbound and hydraulically bound applications”.

Most of the proposed changes are editorial. Ongoing discussion refer to the scope of the standard (only mandated applications (M125) or widening up the standard for other applications, the definitions considering also other aggregate standards (i.e. EN 12620, EN 13242), the test methods described in Annexes and the annex of factory production control and minimum test frequencies. The standard will serve as first example for the implementation of ER 3 “Dangerous substances”.

4 Revision of the Waste Directive

According to the European Waste Framework Directive from 1996 CCPs have legally to be considered as waste. Since the early 90ties of the last century discussions took place on the question if in certain cases a by-product from industrial processes is covered by the definition, i.e. has to be considered as waste or if waste properties could cease at a specific stage of the managing process. A typical example is FGD gypsum, which is on one hand a residue of a pollution abatement process and on the other hand was produced from scrubber sludge by an oxidation, cleaning and drying procedure aiming at a material, which meets technical specifications of the users (gypsum and cement industry). After several years of discussion it is now generally accepted by the authorities that FGD gypsum has ceased the waste properties after the processing in the power plant.

The case is not clear for fly ash as it is argued that no processing takes place in the power plant and that the recovery operation is the final use of the material. That would mean that the material is to be handled (collected, transported, stored) as a waste. By this, a concrete producer would use a waste to produce concrete, i.e. a ready mixed concrete plant becomes a waste handling plant. Even if the restrictions or the additional paper work required by the authorities are not too heavy it is the image problem of the concrete, which might become an additional obstacle for the concrete producer to use fly ash.

Within the revision of the Waste Directive the discussion on the legal definition of by-products and end-of-waste status was restarted at the European institutions and ended with the publication of a revised Waste Directive including definitions for “by-products” and “end-of-waste” status. The Directive entered into force on 12 December 2008. Member States must adopt the measures to comply with the Directive within 24 months, i.e. by 12 December 2010. By-products according article 5 will from the beginning be not subject to waste

International Workshop on Environmental Aspects of Coal Ash Utilization

Tel Aviv, Israel
December 15th – 16th 2009

legislation, end-of-waste materials are resulting from the recovery of waste. For both types of materials criteria must be met (see Annex II). Due to these criteria the CCP producers are of the opinion that CCPs are by-products as the production process is fully controlled to meet the requirements of standards and specifications and as the product is offered to the construction material markets.

In article 6 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.*

The Commission ordered the Institute for Prospective Technological Studies (IPTS) and DG Joint Research Centre (JRC) to develop a general methodology for determining end-of-waste criteria. The developed methodology was evaluated for aggregates, compost and metal scraps. For these materials pilot studies were prepared and discussed at stakeholder workshops. The methodology is assessment based as a wide range of waste materials have to be considered. For aggregates – and by this for bottom ash and boiler slag - the criteria will be based on leaching limit values. In April 2009, the Commission has established a Technical Adaptation Committee (TAC) which should deal with the proposal for end-of-waste criteria.

5 REACH Regulation

On 1st June 2007, the REACH-Regulation (Registration, Evaluation, Authorisation and Restriction of Chemicals) entered into force. REACH requires that chemical substances on their own, in preparations and those which are intentionally released from articles have to be registered to the European Chemicals Agency (ECHA).

The overriding goal of the regulation is to improve the protection of human health and the environment from the risks of chemicals while enhancing the competitiveness of the EU chemicals industry. By this, all chemicals manufactured in or imported into the EU have to be registered at the European Chemicals Agency (ECHA). The registration requires information on the properties and the potential risks of the substances.

REACH is not specifically made for CCPs. But as CCPs are mainly utilised in the building material industry, in civil engineering and in road construction they are placed on the market and for many applications they are subject to REACH.

Each producer or importer of coal combustion products (CCPs) placed on the market as construction materials has to register its substances. Producers of so-called “phase in” substances had to pre-register from 1. June 2008 to 1. December 2008. The pre-registration required information on the substance identity, the tonnages and the name and address of the producer. The registration requires i.a. comprehensive information about toxicology and ecotoxicology of the substances.

In Europe, non registered substances can not be placed on the market after 1st June 2008 any more! For CCPs, since they are already registered in the European Inventory of the Existing Commercial Chemical Substances (EINECS) the deadline for registration is extended to 1 December 2010. Pre-condition is that the producer/importer has pre-registered before 1. December 2008!

International Workshop on Environmental Aspects of Coal Ash Utilization

Tel Aviv, Israel
December 15th – 16th 2009

By 1st December 2008, the European Chemicals Agency (ECHA) received 2,752,646 submissions, which is much more than the original estimate of 132,292. Due to this, the number of pre-registered parties in Substance Information Exchange Forums (SIEFs) for the different CCPs is extremely high. After identification of the interested parties willing to co-operate consortia for registration of the substances will be formed.

At present consortia for calciumsulfat, ashes (fly ash ,including cenospheres, bottom ash and boiler slag), for FBC-ash and for mixed ash have been formed.

6 Environmental compatibility of the use of CCPs

There are many environmental benefits connected with the use of CCPs as saving of natural resources, saving of energy, saving of emissions of pollutants to the air, saving of CO₂ emissions and saving of disposal space. Nevertheless, the environmental impact of the use of CCPs has to be considered in any application. Fly ash and bottom ash as any natural minerals contain a certain amount of trace element compounds. The concentrations of some of the trace elements may be higher in fly ash than in natural minerals or products used for a certain application. In order to avoid any negative impact on the environment or on human health, regulations have been developed for the different uses of industrial by-products at a national level in the European Member States.

In November 2005, CEN established a new Technical Committee (CEN/TC 351) for "Construction products: Assessment of release of dangerous substances". The TC shall develop horizontal standardised assessment methods for harmonised approaches relating to the release (and/or the content when this is the only practicable or legally required solution) of regulated dangerous substances under the Construction Products Directive (CPD) taking into account the intended conditions of the use of the product. It addresses emissions to indoor air and release to soil, surface water and ground water. For release to soil and ground two standards are under preparation. One for uses of bound material (tank leaching test) and one for unbound materials (upflow percolation test). With the assessment methods information may be given for the CE marking of construction products on the release of dangerous substances in the use phase.

7 Summary

In Europe (EU 15) about 61 million tonnes of Coal Combustion Products (CCPs) were produced in 2007. The annual production in EU 27 is estimated to amount to about 100 million tonnes. The CCPs include combustion residues such as boiler slag, bottom ash and fly ash from different types of boilers as well as desulphurisation products like spray dry absorption product and FGD gypsum.

CCPs are mainly utilised in the building materials 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 mining. They are used as a replacement of natural resources. Their utilisation helps to save natural resources and to reduce the energy demand and greenhouse gas emissions to the atmosphere caused by mining and generation of products which are replaced by CCPs.

International Workshop on Environmental Aspects of Coal Ash Utilization

Tel Aviv, Israel
December 15th – 16th 2009

The use of CCPs has several environmental and technical benefits. It has developed by the years and is mostly based on requirements of standards or other specifications which are subject to regular revision by CEN or national authorities. At present, the European standards EN 450-1 and EN 450-2 are under revision. Within the ongoing revision of the standards all parameters are subject to critical review. Proposed changes will be documented in a respective background report. Furthermore, the European standard for hydraulic road binders with basic definitions also for FBC ash as a main constituent will be published in an updated version with three parts.

The utilisation is becoming more and more restricted by environmental regulations. A European Technical Committee is working on horizontal standardised assessment methods for the release of dangerous substances from construction materials. In addition, the legal definition of CCPs as waste causes hurdles, which are unnecessarily impeding the utilisation markets, which have been developed in the last decades. With the revision of the Waste Directive a definition of by-products will be introduced for materials which are from the beginning not a waste. Materials may also leave the waste regime after a recovery operation and meeting of waste stream specific end-of-waste criteria. For coal ash as aggregates these may be based on leaching limits.

Materials not being waste are subject to REACH and have to be registered before being placed on the market from June 1, 2008. For CCPs, a special regulation could be used since they are already registered in the European Inventory of the Existing Commercial Chemical Substances (EINECS). By this, the deadline for registration is extended to 1 December 2010 if the producer pre-registered by 1 December 2008! The pre-registered parties have to agree on the sameness of their substances. At present, consortia for the joint registration of calcium sulphate and ash (from dry and wet bottom boilers as well as from FBC-boilers) are formed. Further consortia will be installed to register other types of ashes and other CCPs.

International Workshop on Environmental Aspects of Coal Ash Utilization

Tel Aviv, Israel
December 15th – 16th 2009

Annex I

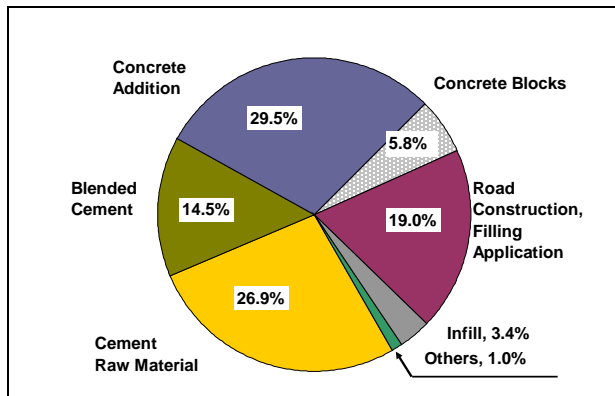


Figure 1:
Utilisation of Fly Ash in the Construction Industry and Underground Mining in Europe (EU 15) in 2007.
Total utilisation 20.0 million tonnes.

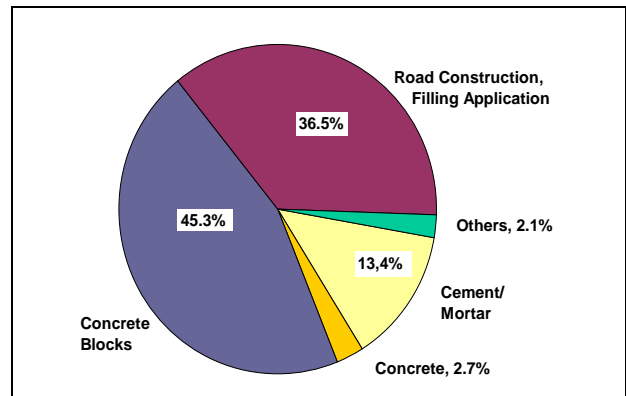


Figure 2:
Utilisation of Bottom Ash in the Construction Industry and Underground Mining in Europe (EU 15) in 2007.
Total utilisation 2.5 million tonnes.

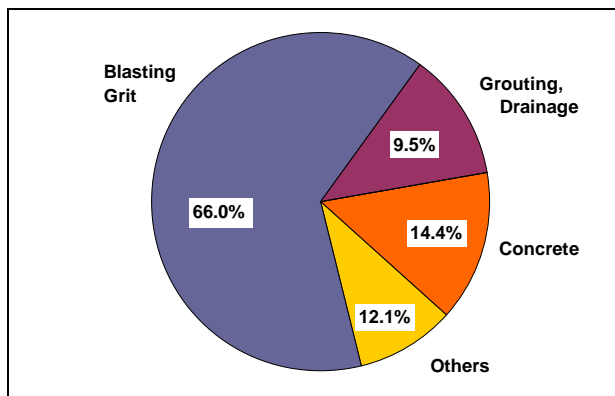


Figure 3:
Utilisation of Boiler Slag in the Construction Industry and as Blasting Grid in Europe (EU 15) in 2007.
Total utilisation 1.3 million tonnes.

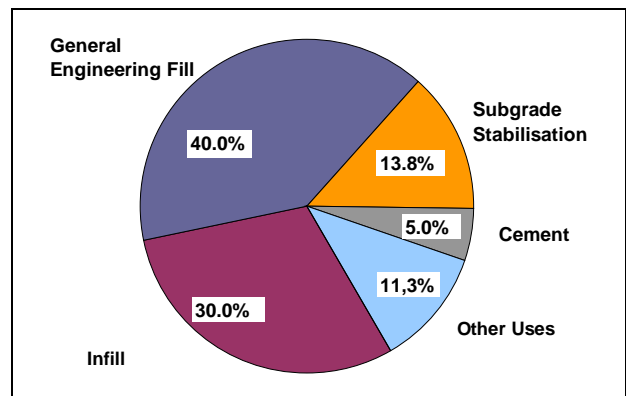


Figure 4:
Utilisation of FBC Ash in the Construction Industry and Underground Mining in Europe (EU 15) in 2007.
Total utilisation 0.2 million tonnes.

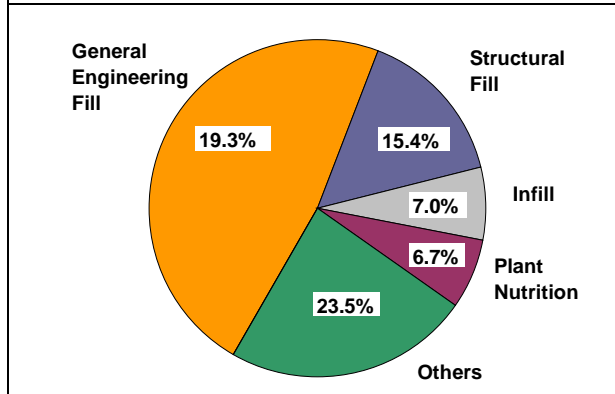


Figure 5:
Utilisation of SDA- Product in the Construction Industry and Underground Mining in Europe (EU 15) in 2007.
Total utilisation 0.3 million tonnes.

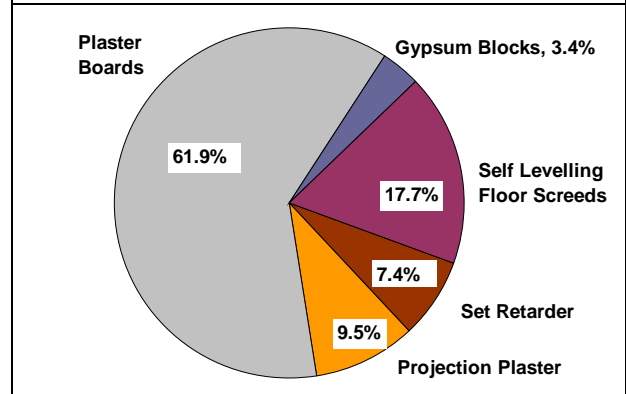


Figure 6:
Utilisation of FGD gypsum in the Construction Industry in Europe (EU 15) in 2007.
Total utilisation 8.8 million tonnes.

**International Workshop on
Environmental Aspects of Coal Ash Utilization**

Tel Aviv, Israel
December 15th – 16th 2009

Annex II

The revised Waste Directive¹ contains a proposal for a definition of by-products in article 5 as well as for end of waste status in article 6.

**Article 5
By-products**

1. *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:*
 - (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.*
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, 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).*

**Article 6
End-of-waste status**

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:*

¹ Waste Directive (2008/98/EC) of the European Parliament and the Council of 19 November 2008 on waste and repealing certain Directives, Official Journal of the European Union (L312/3), 22.11.2008

**International Workshop on
Environmental Aspects of Coal Ash Utilization**

Tel Aviv, Israel

December 15th – 16th 2009

- (a) *the substance or object is commonly used for specific purposes;*
- (b) *a market or demand exists for such a substance or object;*
- (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.

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.*
3. *Waste which ceases to be waste in accordance with paragraphs 1 and 2, shall also cease to be waste for the purpose of the recovery and recycling targets set out in Directives 94/62/EC, 2000/53/EC, 2002/96/EC and 2006/66/EC and other relevant Community legislation when the recycling or recovery requirements of that legislation are met.*
4. *Where criteria have not been set at Community level under the procedure set out in paragraphs 1 and 2, Member States may decide case by case whether certain waste has ceased to be waste taking into account the applicable case law. They shall notify the Commission of such decisions in accordance with Directive 98/34/EC of the European Parliament and of the Council of 22 June 1998 laying down a procedure for the provision of information in the field of technical standards and regulations and of rules on Information Society servicesⁱ where so required by that Directive.*

ⁱ OJ L 204, 21.7.1998, p. 37.