

POLICY BRIEF JANUARY 2020

Bauxite Residue (BR) produced by Alumina refineries in Europe

Scope of Document:

The present document was drafted under the RemovAl H2020 research project by Efthymios Balomenos (Mytilineos S.A.), Stephan Beaulieu (Aughinish Alumina), Ken Evans, Christian Leroy (European Aluminium), Diego Rosani, George Tentis (Green2Sustain), Eva Tormo (European Aluminium).

The purpose is to outline the current state of Bauxite Residue production and handling in Europe and highlight the legislative challenges faced in its recycling. The authors thankfully acknowledge the contributions of Iliev Sorin (ALUM), Carlos Gago Rodriguez (Alcoa - San Ciprian), Amiel Boullemant (Rio Tinto), David Cochrane (South 32), Benoit Cristol (Rusal) and Gökhan Kürşat Demir (ETI ALUMINYUM) and Hydro Alunorte in reviewing and editing the document.

At this stage it is intended as a draft technical document without consideration of legal issues.





1. BR production process description

Bauxite Residue refers to the insoluble solid material, generated during the extraction of alumina (Al_2O_3) from Bauxite ore using the Bayer process. When bauxite ore is treated with caustic soda, the aluminium hydroxides/oxides contained within are solubilised, with approximately 50% of the bauxite mass being transferred to the liquid phase, while the remaining solid fraction constitutes the residue. The Bayer process applied worldwide for alumina production is represented schematically in Figure 1.

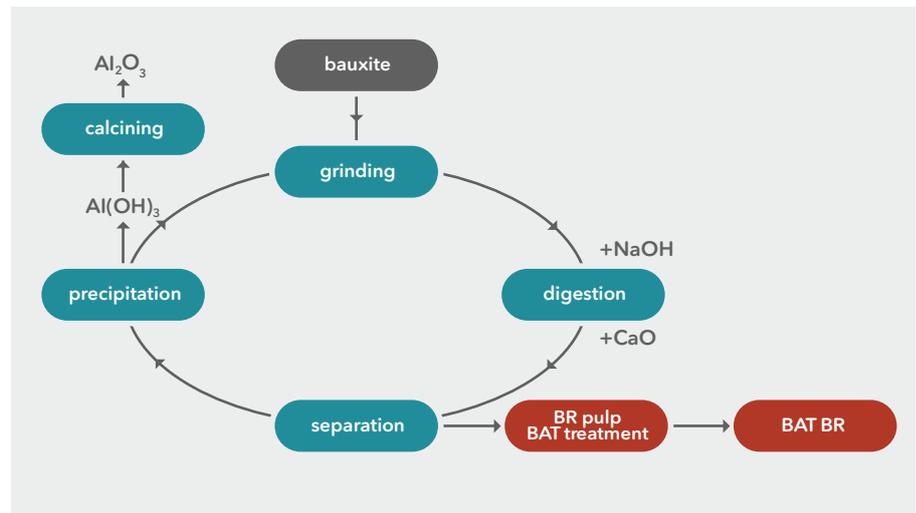


Figure 1: Typical Bayer process (Residue Treatment not included in Bayer Cycle)

The Bayer process typically consists of the following stages:

1. Preparation of bauxite (bauxite crushing & grinding)
2. Digestion under pressure (leaching)
3. Solid-liquid separation
4. Precipitation and crystallisation of aluminium hydroxide
5. Sale of aluminium hydroxide or calcination to produce chemical grade or metallurgical alumina

The preparation of bauxite ore ensures uniformity of supply to the Bayer circuit and consists of the stages of crushing and grinding. In order to achieve a satisfactory input, the feed should have a stable chemical composition and a desired particle size. Subsequently, the prepared bauxite is leached with alkaline solution (NaOH) at high temperature and pressure depending on the ore characteristics. This chemical step dissolves the aluminium hydroxides/oxides in the alkaline solution. Equations (1) and (2) describe the chemical reactions of the of the aluminium containing species present in bauxite, these may be Gibbsite ($\text{Al}(\text{OH})_3$), Boehmite (AlOOH) or Diaspore (AlOOH):



Active lime (CaO) is added to control and reduce caustic soda and alumina losses during digestion occurring with the formation of the desilication products. After the digestion stage, the slurry consists of the liquid phase (aluminate solution) and the solid phase (bauxite residue). The solid-liquid separation after digestion takes place in thickeners. The resulting sodium aluminate solution is cooled down, aluminium hydroxide seed crystals are added, with the resulting precipitation/crystallization of aluminium hydroxide $\text{Al}(\text{OH})_3$; some



of this is washed and sold as a moist filter cake, some is dried and subsequently ground and some is calcined to produce metallurgical or chemical grade alumina (Al_2O_3) (Figure 2).

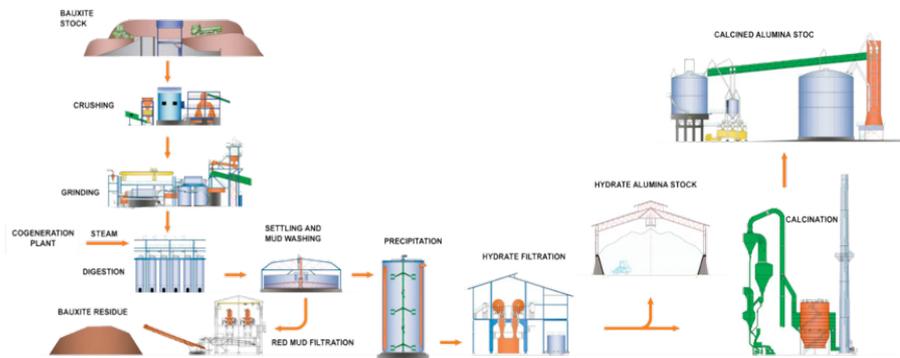


Figure 2: Flowsheet of the Bayer process in the Mytilineos (formerly Aluminium of Greece) alumina plant.

During solid-liquid separation using thickeners (Figure 3), the undissolved residue settles to the bottom of the thickener and then washed in multiple washers using condensates of the Bayer process and fresh water. In each washer, the underflow solid from the previous washer is mixed counter-current with the overflow from the subsequent washer. In each stage of washing, the alkali concentration of the residue is gradually reduced, leaving at the exit of the last washer the final slurry, while at the overflow of the first washer the water solution is re-introduced to the Bayer process.

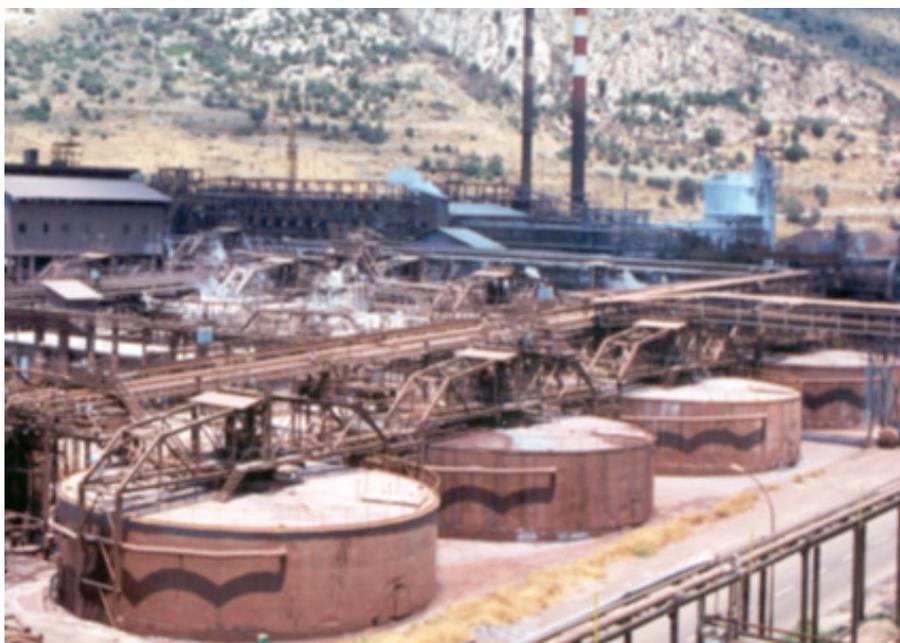


Figure 3: Thickeners for bauxite residue slurry (red mud) washing and settling.

Since caustic soda is a key input and cost within the extraction process, plants are always concerned to recover as much as possible for reuse within the Bayer process. Therefore, the desire for both an easily manageable by-product as well as the need to minimise soda/aluminate solution losses has pushed the industry to develop technologies for 'dewatering' the bauxite residue slurry.



2. Use of Best Available Technique (BAT) technology in BR handling

Nowadays many alumina refineries use a final step to produce bauxite residue using the Best Available Technology (BAT) as defined in EU Directive 2010/75/EU (i.e. the Industrial Emissions Directive)¹. Two of the recommended technologies are being used in Europe: use of high pressure filtration prior to disposal to reduce moisture to 25-32% and use of bauxite residue farming carried out on the residue disposal site to reduce pH below 11.5 and to reduce moisture to 25-28%.

BAT - High Pressure Filtration

Many alumina refineries use as a final step of slurry treatment high pressure filtration (a very efficient way to achieve alkali recovery), in which the slurry is pressed (Figure 4) to remove the maximum amount of remaining liquor to produce a compact filter cake with a moisture content of 25-32%. The filtration method of mechanical compression is Best Available Technique (BAT) for bauxite residue BAT 57 as detailed in the Commission implementing decision 2016/1032 of 13 June 2016 establishing Best Available Techniques (BAT) conclusions under EU Directive 2010/75/EU (i.e. the Industrial Emissions Directive)¹ published by the Joint Research Centre, European Commission. Further information can be retrieved in the Best Available Techniques (BAT) Reference Document for the Non-Ferrous Metals Industries² under section 4.3.1.3 Techniques to prevent and minimise bauxite residue from alumina production, published by the Joint Research Centre, European Commission.

Additional information on the use of filter presses for bauxite residue and mud farming (sometimes called AMC - Accelerated Mechanical Consolidation) on bauxite residue are described in sections 4.1.3.3.3, 4.2.2.1.1.4 and 4.2.2.1.4.4 of the document Best Available Techniques (BAT) Reference Document for the Management of Waste from Extractive Industries³, published by the Joint Research Centre, European Commission.

BAT 57 is explained as follows:

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in order to reduce the quantities of waste sent for disposal and to improve the disposal of bauxite residues from alumina production, one or both of the following techniques can be applied:

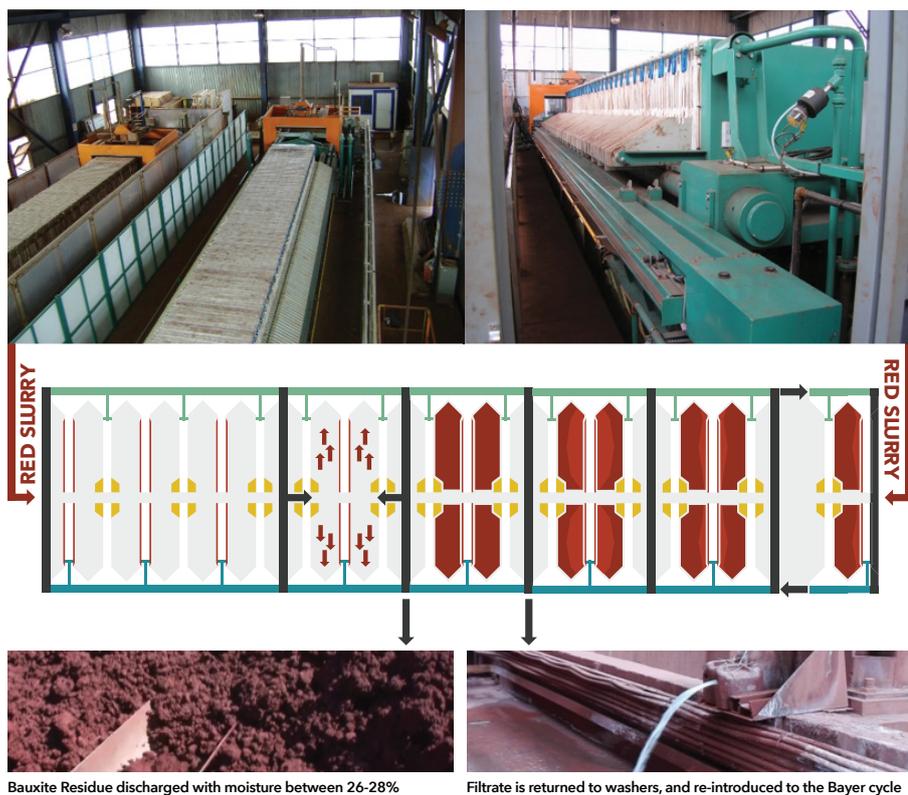
- a. **Reduce the volume of bauxite residue by compacting in order to minimise the moisture content, e.g. using vacuum or high-pressure filters to form a semi-dry cake.**
- b. **Reduce/minimise the alkalinity remaining in the bauxite residues in order to allow disposal of the residue in a landfill.**

”

¹ Commission implementing decision 2016/1032 of 13 June 2016 establishing Best Available Techniques (BAT) conclusions under Directive 2010/75/EU. Retrieved from: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016D1032&from=EN>

² Cusano, G., Rodrigo Gonzalo, M., Farrell, F., Remus, R., Roudier, S., Delgado Sancho, L. (2017). Best Available Techniques (BAT) Reference Document for the Non-Ferrous Metals Industries. Joint Research Centre, European Commission. Retrieved from: http://eippcb.jrc.ec.europa.eu/reference/BREF/NFM/JRC107041_NFM_bref2017.pdf

³ L. Elena Garbarino, Glenn Orveillon, Hans G. M. Saveyn, Pascal Barthe, Peter Eder (2018). Best Available Techniques (BAT) Reference Document for the Management of Waste from Extractive Industries. Joint Research Centre, European Commission. Retrieved from: https://susproc.jrc.ec.europa.eu/activities/MWEI/documents/jrc109657_mwei_bref_-_for_pubsy_online.pdf.



Bauxite Residue discharged with moisture between 26-28%

Filtrate is returned to washers, and re-introduced to the Bayer cycle

Figure 4: Plate and frame filter press installed in Mytilineos Alumina plant (formerly Aluminium of Greece) for the Bauxite Residue treatment.

After high pressure filtration of the bauxite residue slurry the resulting filter cake, herein called “Filtered Bauxite Residue” (BR) (or ferroalumina or other commercial names such as Bauxaline®) has a solid content of about 75 %wt. constituting a moist material, which can be trucked or put on a conveyor belt (Figure 5). A typical chemical analysis of filtered bauxite residue from Mytilineos obtained from filter presses in filter cake form is presented in table 1. The liquid filtrate from the filter press, containing a small amount of caustic soda, is recycled to the washing lines, effectively re-entering the Bayer cycle or discarded after treatment to a recipient, following the environmental legislation.

Element	Fe ₂ O ₃	Al ₂ O ₃	CaO	SiO ₂	TiO ₂	Na ₂ O	LOI
Content % wt.	30-45%	10-20%	8-10%	5-8%	5-8%	1-3%	8-10%

Table 1: Typical metal concentration in Mytilineos’s Bauxite residue from filter presses.

Filtration using drum or plate and frame filter presses to recover caustic soda, thereby producing a lower moisture and more handle-able bauxite residue, has been employed for many years but is now growing in usage. In addition to recovering caustic soda, this trend provides considerable benefits in terms of residue use as the material is normally produced as a friable cake, with typically less than 25% moisture, thereby dramatically reducing transport issues and costs. It should be further noted that in the case of filtered bauxite from Mytilineos, natural weathering of the filter cake for a period of 30 days results in a final moisture between 18-22% (depending on weather conditions).



Figure 5: Bauxite Residue filter cake storage at Mytilineos

Some of the most significant differences between bauxite residue as an un-processed slurry and bauxite residue as a filter cake relate to water and soda content in the final residue for disposal. The characteristics of filtered (and weathered) bauxite residue (82-77% wt. solids, 1-3% wt. Na_2O) instead of bauxite residue slurry (30-50% wt. solids, 4-6 % wt. Na_2O) are adequate to drastically enhance its properties and its transportation either for disposal or for use (e.g. in the cement industry). To some degree, the solids content achieved after filtration is dictated by the particle size distribution of the bauxite residue. It should be noted that when measuring and considering the Na_2O content of bauxite residue, it is very important to understand the difference between the 'soluble' or 'leachable' Na_2O and that combined with other elements to form relatively insoluble species, de-silication products such as sodium aluminium silicate. The sparingly soluble sodium compounds are often less deleterious in different applications compared to soluble sodium compounds. The Na_2O figures quoted above relate to readily soluble soda and not that bound within sparingly soluble desilication products.

It should be noted that in some alumina refineries, for example AOS-Stade, the red mud slurry is filtered and much of the soda is recovered, and water is then added to allow the filtered material to be pumped more readily. The deposited red mud slurry will therefore have a relatively low sodium content, thereby reducing its hazardous nature.

This is also identified in the BREF for Non-Ferrous Metal Industries, where in the description of the alumina production process it is stated: "When a high-pressure filtration is used, the solid residue produced has a very low water content and can be stored as a solid or economically transported to be used in various other applications".

BAT - Bauxite Residue Farming

The bauxite residue farming technique is also a Best Available Technique (BAT#29)⁴ for bauxite residue. Similar soda and moisture level reduction of bauxite residue slurry can also be achieved using bauxite residue farming. The objectives of this technology is to achieve both a low moisture level and pH of less than 11.5, which makes the farmed bauxite residue (farmed BR) non-hazardous. The technology consists of using specific residue farming equipment that can work on wet and dry bauxite residue.

The wet farming equipment, called "amphirol", travels using scrolls, to allow the vehicle to move through the bauxite residue. As the amphirol travels, it compresses the residue and creates tracks or furrows. These furrows allow the

⁴ JRC, Best Available Techniques (BAT) Reference Document for the Management of Waste from Extractive Industries 2018, page 534. <https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/best-available-techniques-bat-reference-document-management-waste-extractive-industries>



water, which has been “squeezed” from the residue to drain along the sloping stack towards the perimeter wall of the cell and into the perimeter channel. Once the residue has compacted to 72-75% solids by multiple passes of the amphirolo, the surface is then graded by a bulldozer to level the surface and generate a constant gradient from the discharge (high point) to the perimeter wall (low point). This makes the residue suitable for conventional agricultural machinery to travel and operate on its surface. The use of agricultural equipment encourages exposure of the bauxite residue to atmospheric carbon dioxide thereby promoting carbonation of some of the sodium compounds. Sufficient exposure and carbonation reduces the causticity below 30% and reduces the residue pH to below 11.5. Once carbonation is completed as evidenced by pH measurements of samples from the cell, the area is then re-graded using a bulldozer to remove any depressions. The cell is then ready for the subsequent layer of bauxite residue.

As such, bauxite residue farming also complies with the BAT criteria mentioned earlier and Farmed BR can be transferred and re-used in a similar fashion to Filtered BR.

Bauxite residue farming practised at the Aughinish refinery in Ireland can achieve a final ‘Farmed BR’ with a moisture content of 25-28% and pH of less than 11.5.



Figure 6: Bauxite Residue Farming and Carbonation at Aughinish

A variant of Bauxite residue farming, using sea water neutralisation, is implemented in Eastern Australia. The residual moisture after mud farming with an amphirolo is between 20 to 30% and the pH is <10.

In 2014 ALUM in Romania, performed in pilot scale similar Mud Farming operation (drying and carbonation through mechanical mixing and homogenisation) of the BR slurry deposited in “Valea lui Flam” and submitted a relative environmental study to the Romanian authorities for the reuse of the produced Farmed BR. The Romanian authorities recognise that this process as a recovery process, effectively allowing its re-use in other industries and defining it as **“no longer as waste”**.

One of the major producers in Europe, AOS in Stade, Germany, filters their residue using drum filters, washes it using condensates and then pumps the material in a slurry form to holding ponds. Whilst this residue has a higher water content than BAT farmed or press filtered bauxite residue, it has a low soda content and consequently a low pH value. A key reason for keeping the material wet, is to avoid the possibility of dust generation which otherwise could be a problem in Northern Germany in winter.



It is noted that in Brazil, leaching tests governed by NBR 10004 are applied to determine if any waste is hazardous or non-hazardous. Brazilian National Policies of Solid Waste (Law number 9.605/2010) states that the waste generator has as co-responsibility (Art. 30): II - promote the utilisation of solid waste by its incorporation of its process or on others productive chain; V - stimulate the market development, production and consumption of products derived from waste solids. (www.planalto.gov.br/ccivil_03/_ato2007-2010/2010/lei/112305.htm)

3. BR waste classification

In the EU categorisation of waste documentation (Commission notice on technical guidance on the classification of waste (2018/C124/08) - published in the Official Journal of the EU 9th April 2018), 'red mud' is listed under two codes: EWC 01 03 09 (MNH - Mirrored Non-Hazardous) code "red mud from alumina production other than the wastes mentioned in 01 03 10"; and a mirror code 01 03 10* (MH - Mirrored Hazardous) "red mud from alumina production containing hazardous substances other than the wastes mentioned in 01 03 07". Code 01 03 07 (MH) refers to "other wastes containing hazardous substances from physical or chemical processing of metalliferous minerals". The MNH or MH classification can only be determined after the necessary test work has been undertaken. Some 15 properties are used to assess whether a waste is hazardous, namely is it: Explosive, Oxidising, Flammable, Irritant to skin or cause eye damage, Specific Target Organ Toxicity (STOT)/Aspiration Toxicity, Acute Toxicity, Carcinogenic, Corrosive, Infectious, Toxic for Reproduction, Mutagenic, Release of an acute toxic gas, Sensitising, Ecotoxic or Waste capable of exhibiting a hazardous property listed above not directly displayed by the original waste. The testing methods to be used are prescribed in Annex 3 of the EU Commission notice on technical guidance on the classification of wastes (2018/C 124/01) published on the 9.4.2018. Prior to any transport from site, the necessary REACH and CLP regulations need to be addressed⁵. Due to the significant differentiation between the different treatment processes for bauxite residue, it is argued that Filtered and or Farmed bauxite residues - or BAT-processed BR is not properly defined by the current classification, in particular:

- BAT BR refers to a solid filter cake/paste obtained after pressure filtration/farming of the red mud slurry, according to BAT;
- BAT BR normally has a significantly lower soda content than the corresponding unprocessed red mud slurry (it should be noted that in some refineries, the red mud slurry is filtered, and water is then added to aid pumpability);
- BAT BR is stored in a completely different way to the red mud slurry (and with significant less risk);
- BAT BR filter pressing using a plate and frame filter press to produce bauxite residue is practiced by more and more alumina refineries in Europe (currently performed in Greece, France and Turkey and planned for in Romania);
- BAT BR transport is feasible by land or sea.

It could therefore be argued that the existing EWC assigned to the bauxite residue slurry that was historically produced by wet disposal methods, does not apply to the BAT BR presented in this document.

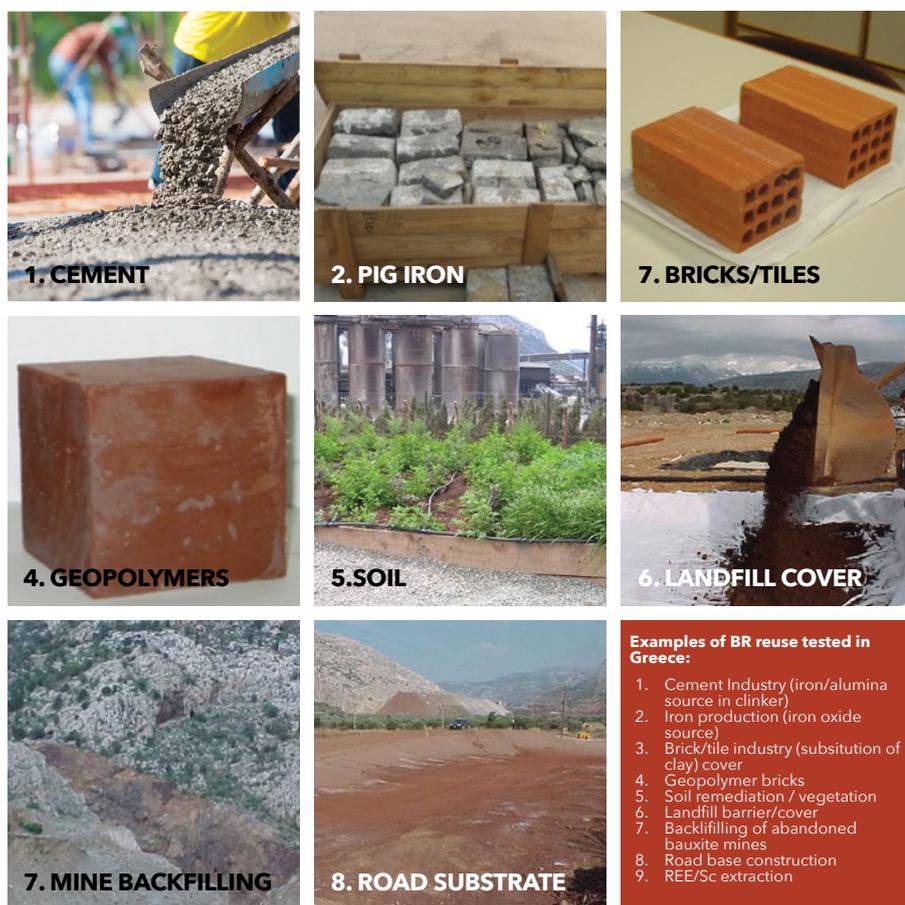
⁵ Before any chemicals, compound or substances are sold in the EU they must comply with REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) regulations. Off J of the EU 1907/2006 published 30.12.2006. CLP (Classification, Labelling and Packaging) regulations 1272/2008.



The vast amount of research and studies on BR utilisation is justified by more than 734 patents from 1964. Possible applications can broadly be broken down into various categories:

- recovery of specific elements present in the bauxite residue, e.g. iron, titanium, aluminium, rare-earth elements (REE) i.e. lanthanides, yttrium and scandium;
- use as a main component in the manufacture of another product, e.g. Portland cement clinker;
- use of the bauxite residue as a constituent in a building or construction material, e.g. road building, dyke construction, concrete, tiles, bricks, mineral wool insulation;
- use for some specific property which might include conversion of the bauxite residue to a useful material by modifying the compounds present, e.g. catalysis, phosphate trapping, soil amelioration, landfill capping, acid mine drainage treatment.

4. BR as a mineral resource



- Examples of BR reuse tested in Greece:**
1. Cement Industry (iron/alumina source in clinker)
 2. Iron production (iron oxide source)
 3. Brick/tile industry (substitution of clay) cover
 4. Geopolymer bricks
 5. Soil remediation / vegetation
 6. Landfill barrier/cover
 7. Backfilling of abandoned bauxite mines
 8. Road base construction
 9. REE/Sc extraction

Figure 7: Greek BR applications studied in Mytilineos

In Europe the total amount of Filtered /Farmed Bauxite Residue and Red Mud produced from the alumina industry is stockpiled at a rate of 7 million tonnes on a dry basis per year. More than 3.5 million tonnes out of those 7 are produced as BAT BR (Mytilineos/Greece, ALTEO/France and ETI/Turkey are using plate and frame filter presses and AAL, Ireland are using mud farming). This is seen as a potential mineral resource for use, the overall 7 million tonnes translates to:

- With an average iron oxide content of 40 wt%, it can be considered as an equivalent of 3.4 Mt of iron ore available in Europe. This results in a 4%





decrease in iron ore imports equivalent to an 18% increase in European iron ore production.

- With an average alumina content of 20 wt% and an inherent clay-like behaviour BR is a valuable raw material for various building applications.
- Recycling the alumina and soda (2-3 wt%) of the BAT BR back to the alumina refinery will lead to practically 100 % extraction efficiency of alumina from bauxite ore.
- BAT BR is a considerable resource for REE/Sc. Extracting the REE from Mytilineos' annual Filtered BR production can meet the needs of approximately 10% of the European REE import demand.
- Gallium is found in bauxite ores at levels of 30-80 g/t and is distributed between the Bayer and BR streams; extracting gallium from both the BAT BR and Bayer liquor from a single European alumina refinery would amount to global levels of gallium production (annual world production 284 t in 2012).



The combination of an easily transportable dry matter with a low soda content enables BAT BR to be accepted as alternative raw material in nearby cement plants.



Figure 8: Left: Transportation and storage of Filtered bauxite residue as filter cake at storage site in Mytilineos, Right: Loading on a ship for use in a cement plant.

In fact, the Mytilineos refinery which has adopted filter pressing for its entire bauxite residue output since 2012 and has reached in 2018 a level of nearly 15% (110,000 t) use of its annual Filtered BR, in 2 Greek and 1 Cyprian cement plants. The amount used, however, is expected to increase. The Filtered BR is used in these plants as a clinker raw meal substitute in levels between 1.5-3.0 %wt for Portland cement clinker production.

Internationally, similar bauxite residue which is produced in a similar way to the European BAT BR, is used in China, India, Ukraine, Russia, and Brazil, as a raw meal substitute in Portland cement clinker production. Extensive research is being undertaken using bauxite residue as supplementary cementitious materials in blended cement production. Also bauxite residue which is produced in a similar way to the European BAT BR is used as a raw material in blast furnace pig-iron production has been reported in China and India.

Based on the EC COM(2007) 59/21.2.2007 - Annex II, the BAT BR can be considered **a non-waste by-product as:**

- The intended use in cement, iron and other industries **is lawful**.
- BR is not deliberately produced during alumina production; it is -as its name implies- **a production residue**.
- BAT BR (after filter pressing or residue farming) production has become an integral part for some alumina refineries, especially when offsite use is planned.
- BAT BR's demand ⁶ as an alternative mineral source **is certain** (it has been taking place with increasing rate over the last 5 years in Greece and internationally).
- BAT BR is ready for use without further processing (it enters directly in the cement mills or blast furnace).

Furthermore, according to directive 2008/98/EC article 6, BAT BR can receive the **end-of-waste** status as it complies with the following criteria:

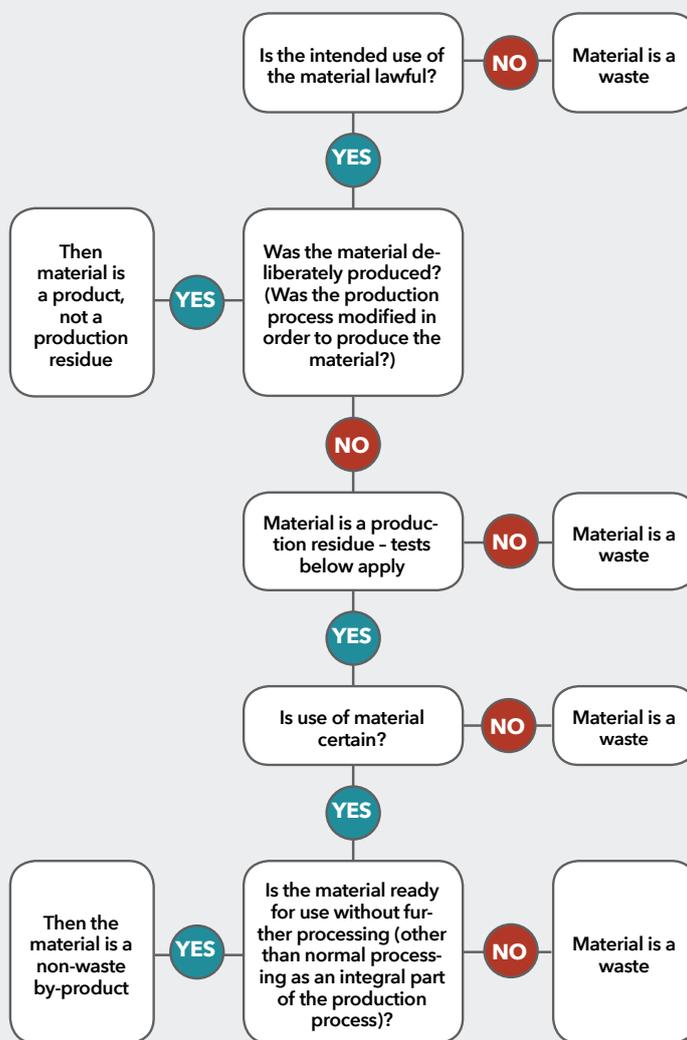
- *The substance is commonly used for specific purposes*, as already seen in the cases of the Greek and Cyprian cement industries
- *A market or demand exists for such a substance*; in the example of Greek BAT BR, the market demand for use in cement plants, not only exists but it is increasing yearly; in the last four years the amount has increased by a factor of 10.

5. BAT BR end-of-waste



- *The substance fulfills the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products;* this has been studied and proven extensively in the case of cement clinker production.
- *The use of the substance or object will not lead to overall adverse environmental or human health impacts;* BAT BR examined in this document, have all been classified as a non-hazardous waste, following detailed characterisation and testing and according to the Regulation (EU) 1357/2014; furthermore reusing BAT BR will lighten environmental impacts by reducing the BAT BR landfilled amounts and reducing other virgin raw material mining, such as iron and clay minerals.

ANNEX II - a decision tree for waste versus by-product decisions



The proven utilisation of BAT bauxite residue as an alternative raw material in cement and the steel industry, highlights the position of BAT bauxite residue as a non-waste by-product for which specific end-of-waste regulations should be applied.



5. BR as a product

Following discussions at the policy review on the 6th November, it was agreed that consideration should also be given to classifying BAT BR as a 'product' and seeking registration under REACH regulations. A particular issue that would need to be addressed, however, would be the variability of compositions of BRs from different sources due to the use of different bauxites and process conditions. Prior to any testing of samples, discussion with ECHA (the European Chemical Agency) would be essential. At the Policy discussions held in Brussels on the 6th November 2019, a representative of EU DG ENV clearly thought the industry should treat bauxite residue as a product and seek REACH registration. He also saw no problem in bauxite residue being regarded as both a waste and a product. In view of the variability of composition of BRs from different sites it would be necessary to treat the material either as a Substance (or a mixture of substances), a MCS (Multi Component Substance) or as an UVCB (Unknown or Variable Composition, complex reaction products or of Biological materials. A UVCB substance may have many different constituents, some of which may be unknown; the composition can be variable or difficult to predict. These different options will be reviewed.



APPENDIX



Legislation review for by-products and End-Of-Waste criteria

The scope of this section is to provide the differences between by-products and end-of-waste according to the EU legislation.

The responsible body for waste legislation in the EU is DG Environment (Directorate-General for Environment), through its Unit B (Circular Economy & Green Growth), and division B.3 (Waste Management & Secondary Materials).

Today, the law in power is the Waste Framework Directive (WFD) 2008/98/EC, as amended by Directive (EU) 2018/851 (30 May 2018).

The WFD is supplemented by various directives related to waste management and activities regulation:

- Waste framework and waste shipment
- General waste management operations
- Management of specific waste streams

According to WFD 2008/98/EC, End-of-waste status can only be achieved if substances or objects comply with relevant requirements applicable to products. End-of-waste rules can be established in product-specific legislation.

The four prerequisites for End-Of-Waste status have been amended in 2018 as follows:

- a. the substance or object is to be 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.

Therefore, the market existence is no longer a go/no-go criterion for End-Of-Waste, since it can be substituted by 'demand'. Hence, the non-existence of willingness to pay for a certain material does not preclude the fact that there is actually a demand for the material, even at a symbolic price.

In addition, End-Of-Waste can be defined in the following levels:

- Union level
- National level
- Case-by-case basis

At EU level, the criteria¹ should be set by the Commission (responsible monitoring body) and should include the following:

- permissible waste input material for the recovery operation;
- allowed treatment processes and techniques;
- quality criteria for end-of-waste materials resulting from the recovery op-

¹ The detailed criteria "shall ensure a high level of protection of the environment and human health and facilitate the prudent and rational utilisation of natural resources".



eration in line with the applicable product standards, including limit values for pollutants where necessary;

- requirements for management systems to demonstrate compliance with the end-of-waste criteria, including for quality control and self-monitoring, and accreditation, where appropriate; and
- a requirement for a statement of conformity.

On a national level, member states can establish their own detailed criteria, which should:

- take into account any possible adverse environmental and human health impacts of the substance or object
- satisfy the same requirements of EU-wide level
- report to the Commission in accordance with Directive (EU) 2015/1535.

On a case-by-case basis, a member state may provide decisions or take appropriate measures to verify, that certain waste has ceased to be waste on the basis of the four prerequisites. The requirements that are laid at the EU-wide level **should be reflected where necessary**. Limit values for pollutants and any possible adverse environmental and human health impacts should be taken into account. Such case-by-case decisions are not required to be notified to the Commission in accordance with Directive (EU) 2015/1535.

According to the amended WDF, there is an amount of responsibility falling on the natural or legal person who:

- uses, for the first time, a material that has ceased to be waste and that has not been placed on the market; or
- places a material on the market for the first time after it has ceased to be waste,

This person shall ensure that the material meets relevant requirements under the applicable chemical and product related legislation, provided that the four prerequisites have been met first.

According to the WDF, when substances/objects originating from a production process not primarily aimed at producing such substances or objects are by-products and not waste.

According to standard permitting practice, an object or substance should be regarded as being a by-product only when certain conditions are met. Normally, the existence of an environmental licence or general environmental rule that allows the use of a by-product, is a valid indicator that no overall adverse environmental or human health impacts are expected to occur. Since by-products fall into the category of products, exports of by-products should meet the requirements of the relevant community legislation.

According to the WDF, by-products are not waste, and they are not subject to the waste management legislation. The By-Product definition is clearly set in Article 5 of the WDF as follows

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;
- a. the substance or object can be used directly without any further process-





- ing other than normal industrial practice;
- a. the substance or object is produced as an integral part of a production process; and
 - a. further use is lawful, i.e. the substance or object fulfills all relevant product, environmental and health protection requirements for the specific use and will not lead to overall adverse environmental or human health impacts.

According to the EC document, which targets to clarify the interpretation of the WDF, there is a decision tree (based on decisions of the European Court of Justice - ECJ), which provides the reasoning for considering the by-product status:

- If a material produced is the result of technical choice of the industry, then the material is not a residue or waste
- If a material is produced unintentionally (in an automated way) and it is certain it would be used in its entirety, mainly for the same purposes as other substances, then it is not a residue;
- Even where a material is considered to be a production residue, the ECJ has indicated that it is not necessarily a waste. The characteristics of the material in terms of its readiness for further use in the economy can mean that it should not be considered to be a waste;
- To the extent that treatment tasks are an integral part of the production process (on the production site, on the site of the next user, or by intermediaries), they do not prevent the material from being considered as a by-product;
- A high price, in line with or above current market prices for the material, may indicate that the material is not waste;

According to EC document the status of waste must be attributed to an industrially produced material in the following cases:

- Even where a material is considered to be a production residue, the ECJ has indicated that it is not necessarily a waste. If the readiness for further use in the economy is low may mean that it should be considered to be a waste;
- If there is a possibility that the material is in fact not useable, or it does not meet the technical specifications that would be required for it to be useable, or there is no market for that material, then it should be considered as a waste;
- The lack of long term contracts between the material holder and its subsequent users can be an indication that the material is not ready to be used, certainty of use is absent and therefore it is waste;
- if the material is going to be stored for an indefinite amount of time, prior to a potential but not certain re-use, then it should be considered as a waste while it is being stored;
- if further use of the material is prohibited, or the material must be disposed of or recovered as a waste, owing to environmental protection legislation (e.g. PCBs/PCTs directive) then they should remain waste; and
- Even if waste production residues are composed of exactly the same material as the primary product, if they are destined to be discarded, then they will still be waste

It is important to emphasize the criterion of long-term or indefinite storage, which, by itself, is an indication of a material been waste.

The Commission is not obliged but it is free to adopt (“may adopt”) imple-



menting acts in order to establish detailed criteria on the uniform application of the conditions to specific substances or objects. Nevertheless, where criteria have not been set at Union level, Member States may establish detailed criteria on the application.

EU legislation framework on waste	Waste management operations	Specific waste streams
Waste Framework Directive 2008/98/EC	Industrial Emissions Directive 2010/75/EC	Sewage Sludge Directive 86/278/EEC
Waste Shipment Regulation EC No. 1013/2006	Landfill Directive 199/31/EC	Batteries & Accumulators Directive 2006/66/EC
Regulations on EoW criteria: glass cullet (Reg. 1179/2012), copper scrap (Reg 715/2013), scrap metal	Waste Incineration Directive 2000/76/EC	Packaging & Packaging Waste Directive 94/62/EC
	Acceptance at Landfills - Decision 2003/33/EU	End-of-life Vehicles Directive 2000/53/EC
		Restriction of Use of Hazardous Substances Directive 2011/65/EU
		Electrical & Electronic Equipment Directive 2012/19/EU
		Waste from Extractive Industries Directive 2006/21/EE

EU waste legislation framework (adapted from KU Leuven & Green2Sustain, 2017)





Removing the waste streams from the primary Aluminum production in Europe

The RemovAL project will combine, optimise and scale-up developed processing technologies for extracting base and critical metals from such industrial residues and valorising the remaining processing residues in the construction sector.

The ambition of RemovAL is straightforward: to overcome environmental issues and technological barriers related to aluminium industry, by combining and advancing existing technologies for the sustainable processing of BR, SPL and other by-products, generating revenue.

www.removal-project.com

