New technical document on BAT and costs for aluminium production

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Agenda

- New document on BAT for aluminium production
- Production of primary aluminium
  - Alumina production (Bayer Process)
  - Fused-salt electrolysis (Hall-Héroult Process)
- Emission abatement technologies and related costs
- Next steps to further develop the document

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BAT reference document for non-ferrous metals

- ✓ Comprehensive description and specification of emission abatement technologies for major non-ferrous metals
  - ✓ copper and its alloys;
  - ✓ aluminium and its alloys;
  - ✓ lead and tin;
  - ✓ zinc and cadmium;
  - ✓ precious metals;
  - ✓ ferro-alloys (e.g. FeCr, FeSi, FeMn,);
  - ✓ nickel and cobalt;
  - ✓ carbon and graphite electrodes.
- ✓ > 1000 pages of partly site specific data
- ✓ Skipping between different abatement technologies and sections necessary to extract information

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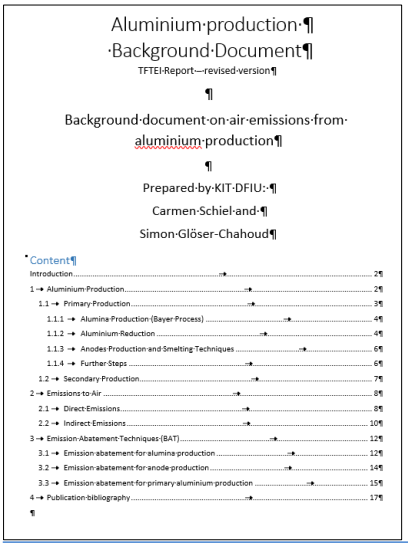
Specific document on aluminium


Aluminium production
Background Document
TFTEI Report — revised version

Background document on air emissions from aluminium production

Prepared by KIT DFIU:
Carmen Schiel and
Simon Glöser-Chahoud

Content

- ✓ Development of a short but comprehensive document on BAT for aluminium production
- ✓ Focus on primary aluminium production in a first step
  - ✓ Secondary aluminium processing strongly depends on properties of scrap
  - ✓ Higher variation in design of processes and related abatement technologies

➡ First feedback from experts received, additional input very welcome

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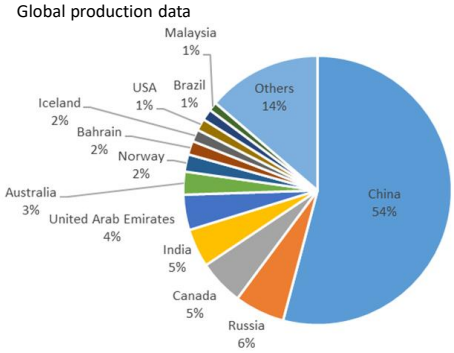
Aluminium production

Global production data



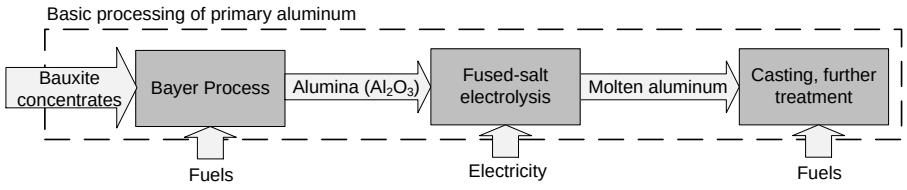
Basic mass and energy balances

Output:		
Aluminium	1	kg
Input:		
Aluminiumfluoride (Cryolite)	0.018	kg
Anodes-C	0.43	kg
Alumina (Al_2O_3)	1.9	kg
Bauxite	4-7	kg
Electricity	48.2	MJ
Process heat	3.83	MJ

- ✓ Global production dominated by China
- ✓ Very high energy (electricity) demand → tendency to move production to sites/locations with low cost energy
- ✓ Many European countries have shut down their primary aluminium production sites

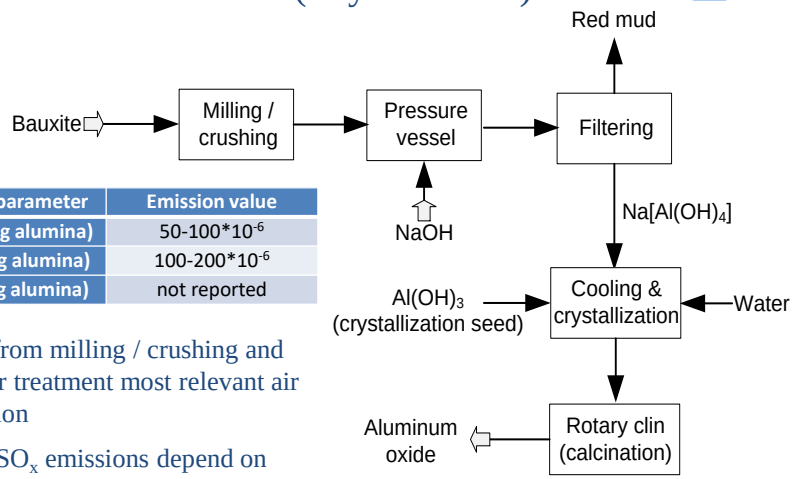
Sources: USGS (2018), German Environmental Agency UBA (2018)

Basic process steps



1. Calcination of Bauxite to produce Alumina (Bayer Process)
2. Production of electrode materials for fused-salt electrolysis
3. Fused-salt electrolysis (Hall-Héroult Process)
    1. Prebake cell
    2. Soderberg cell
4. Casting, further treatment

Alumina production and related emissions (Bayer Process)



Emission parameter	Emission value
Dust (kg/kg alumina)	$50\text{-}100*10^{-6}$
NO_x (kg/kg alumina)	$100\text{-}200*10^{-6}$
CO_2 (kg/kg alumina)	not reported

- ✓ Dust from milling / crushing and further treatment most relevant air emission
- ✓ NO_x, SO_x emissions depend on fuel and combustion technologies

Emission ranges for different plants taken from the BAT document

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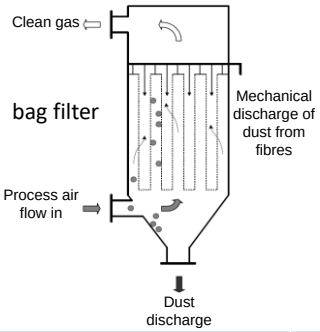
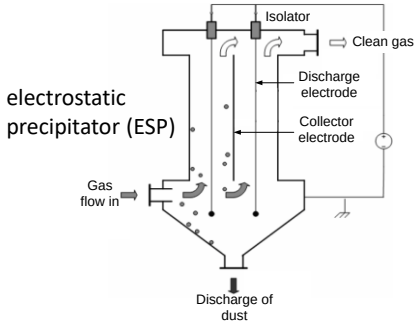
Emission abatement technologies for alumina production





Average flue gas flow (Nm^3/h)	Abatement technology	Average emission value of dust	
		mg/Nm^3	(kg/t alumina)
220 000	ESP	68	0.1
300 000	ESP	23	0.01
107 000	Fabric filter	23	0.07
93 000	Fabric filter	23	0.05

Exemplary values for different plants taken from the BAT document

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Main technologies for aluminium electrolysis

Cell technology	Cell type	Anode configuration	Alumina feed configuration	Acronym	Breakdown in Europe
Prebake cell	Centre worked	Vertical	Bar broken centre feed	CWPB (*)	None
		Vertical	Point centre feed	PFPB	90 %
	Side-worked	Vertical	Manual side feed	SWPB (*)	None
Søderberg cell	Vertical stud	Vertical	Manual side feed	SWVSS (*)	None
			Point feed	PFVSS	10 %
	Horizontal stud	Horizontal	Manual side feed	HSS (*)	None
			Bar broken feed		
			Point feed		
(*): No longer in operation in Europe.					

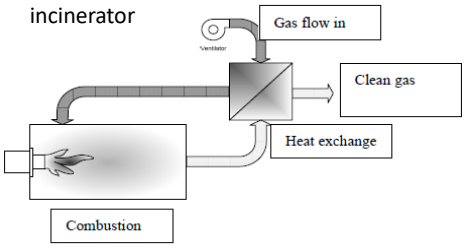
- ✓ The Søderberg technology uses a continuous anode, which is introduced into the cell as a paste and then bakes in the cell itself.
- ✓ The Prebake technology, as the name implies, uses multiple anodes in each cell, which are baked in a separate facility.

Source: USGS (2018), German Environmental Agency UBA (2018)

Anode production

Emission parameter	Emission value
Total fluoride (kg/kg anode)	$10\text{-}100*10^{-6}$
Dust (kg/kg anode)	$10\text{-}1000*10^{-6}$
SO_2 (kg/kg anode)	$100\text{ - }6000*10^{-6}$
NO_x (kg/kg anode)	$100\text{ - }400*10^{-6}$
BaP (kg/kg anode)	$0\text{-}3*10^{-6}$

Concept of a recuperative incinerator



Production process:

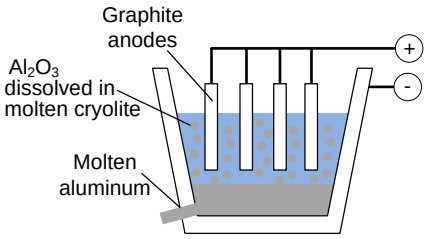
- ✓ Raw materials: petroleum coke, coal tar bits or recycled anode butts
- ✓ Distinction between Prebake and Soderberg anodes
- ✓ Forming and baking at around 1200°C
- ✓ Graphitization

Proposed abatement technologies

- ✓ Bag filters for dust (alternatively ESP with cyclone)
- ✓ Recuperative incinerators for VOC
- ✓ Coke scrubbers for pitch vapors
- ✓ Treatment of fluorides in case of the use of recycled anode butts

Emission ranges for different plants taken from the BAT document

Fused-salt electrolysis (Hall-Héroult Process)



Pollutant	Direct emissions	Unit
CO	0.18	kg/kg Al
CO_2	1.4	kg/kg Al
HF	$40*10^{-6}$	kg/kg Al
Perfluoroethane	$25*10^{-6}$	kg/kg Al
Perfluormethane	$250*10^{-6}$	kg/kg Al
SO_2	0.007	kg/kg Al
PM_{10}	$706*10^{-6}$	kg/kg Al
$PM_{2.5}$	$581*10^{-6}$	kg/kg Al

Key abatement technologies

- ✓ Avoidance of „anode effect“ in which PFCs are formed
  - ✓ Point feeding of anodes and alumina, computer controlled voltage
  - ✓ Efficient gas collection from electrolytic cells
- ✓ Fluoride “scrubbing systems” use alumina to extract gaseous fluoride from pot gases. This “activated” alumina, which contains the residual fluoride, is then used as a feed for the reduction process (alternative scrubbing with crushed limestone or water).

Direct air emissions are average values for Germany reported by the Environmental Agency (UBA)

Conclusions, next steps

- ❑ **Conclusions regarding the document**
- ✓ Draft document completed in May 2019
- ✓ First revisions from experts received
- ✓ Revised version prepared


Aluminium production
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Background document on air emissions from aluminium production

- ❑ **Next steps**
- ✓ Dissemination of revised document among aluminium experts in TFTEI
  - ✓ Preparation of contact list for further work and communication
- ✓ Enhancement of the document in future work
  - ✓ Secondary aluminium production
  - ✓ Level of detail (technical/economical)

Thank you very much for your attention! Questions?

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