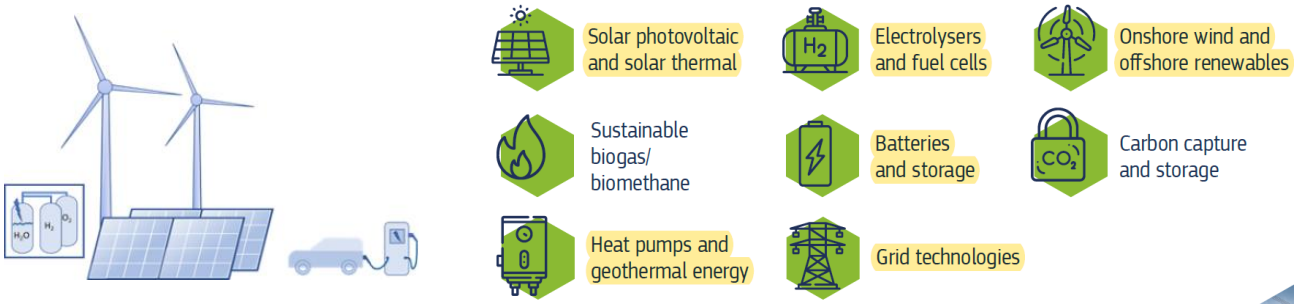
Annex 1: Specialty alumina applications

Supporting strategic net-zero technologies



https://ec.europa.eu/commission/presscorner/detail/en/FS_23_1667

Specialty alumina actively supports the advancement of six out of the eight strategic net-zero technologies outlined in the Net Zero Industry Act, with significant potential to contribute to the EU's decarbonization.

Solar panels

The expansion of solar power plants depend on the availability of high-voltage insulators, made from special aluminium oxides provided by European producers. Besides, specialty alumina also enhance light absorption in photovoltaic cells.

Wind turbines

In the generation of wind power, specialty alumina is essential in

- specialty alumina-based brake pads to ensure safe and reliable operation of the windmills
- high-voltage insulators
- the glass fibres that make wind turbines blades strong, lightweight, and durable.

Power grid market

Alumina's electrical insulation, thermal stability, and mechanical strength properties make it a valuable material for the power generation, transmission, and distribution sectors. It plays a crucial role in ensuring the reliability, safety, and efficiency of the power grid by being used in various electrical components and insulating materials, such as

- insulators: alumina is commonly used to manufacture insulators for power lines and electrical substations. These insulators provide electrical insulation and support for overhead power lines and help prevent electrical arcing and power loss.

EPSA
European Producers of Specialty Aluminas
A sector group of Cefic
European Chemical Industry Council - Cefic aisbl
Rue Belliard 40, b15, B-1040 Brussels, Belgium
Tel. +32.2.436.93.00 - info@cefic.be - www.cefic.org
EU Transparency Register: 64879142323-90

- high-voltage equipment: alumina ceramics are used in high-voltage electrical equipment such as circuit breakers, switchgear, and transformers. These components require the unique electrical insulation properties of alumina.
- surge arresters: surge arresters are crucial for protecting electrical equipment and power lines from voltage spikes or surges. Alumina-based materials are often used in the insulating components of surge arresters to ensure their reliability.
- substation components: alumina components are used in various parts of electrical substations, including bushings, insulators, and insulating support structures. These components help maintain the integrity of the power grid and ensure safe and efficient electrical transmission and distribution.
- power electronics: alumina substrates and ceramics are used in power electronic modules, such as insulated gate bipolar transistor (IGBT) modules and diode modules. These modules are essential for converting and controlling electrical power efficiently in various grid-related applications.
- high-temperature connectors: in some high-temperature power grid applications, alumina is used to manufacture connectors and insulating components that can withstand elevated temperatures without degrading or losing their electrical properties.
- power grid sensors: alumina-based sensors are used for measuring various parameters within the power grid, such as temperature, voltage, and current. These sensors help monitor and control the grid's performance and ensure its reliability.

Batteries and storage

Specialty alumina is essential for the thermal and safety management of the lithium-ion batteries for electric vehicles and stationary energy storage systems.

Specialty alumina-based coatings are used in lithium-ion batteries to protect them against explosion risks (thermal runaways). These coatings prevent the risk of an explosion driven by a short-circuit in case of an overheating of the battery.

Alumina is also used in high voltage insulators (glass, porcelain, silicon based) of different kinds of energy storage systems and fast charging stations.

Heat pumps

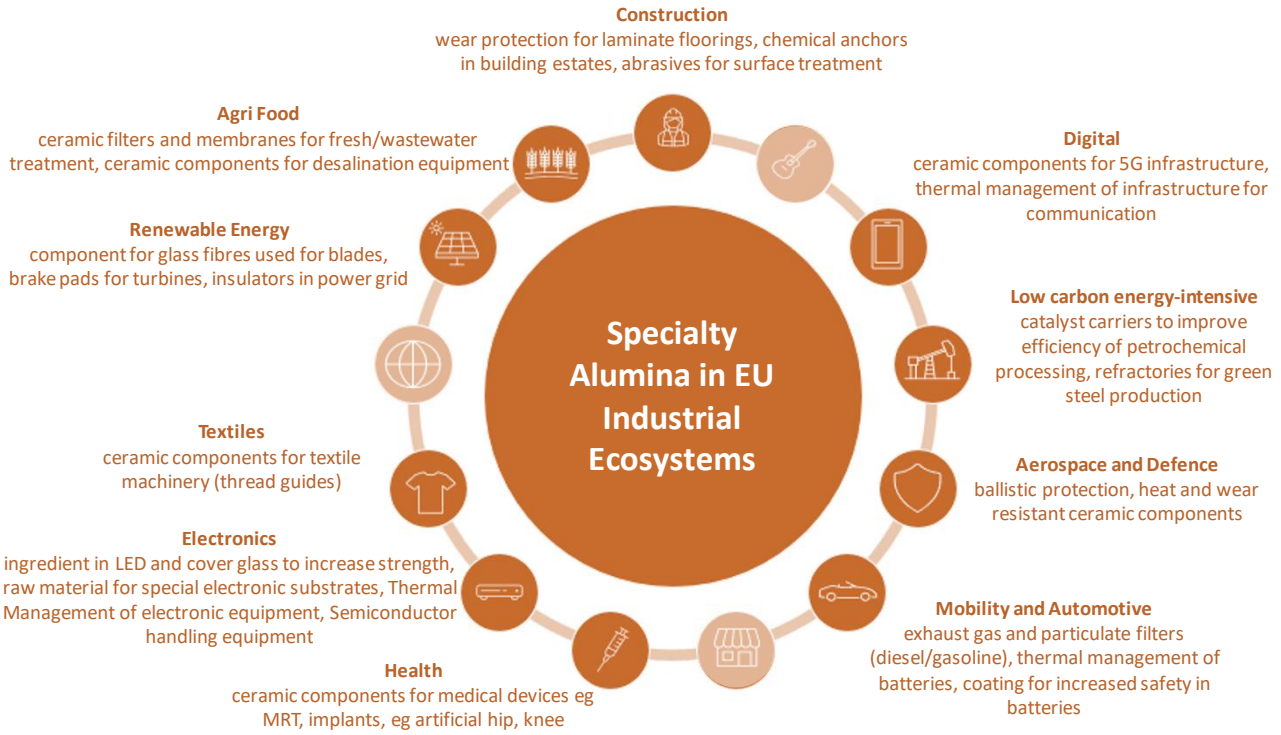
The specific properties of the specialty alumina, such as their resistance to high temperatures, excellent thermal conductivity and insulation properties, are valuable in various heating and cooling applications, like heat pumps. They are used in components like ceramic insulators, heating elements, and as a part of the insulation systems in heat pump assemblies. These properties help improve the efficiency and durability of heat pumps, which are used for both heating and cooling in residential, commercial, and industrial settings.

Fuel cells

Fuel cells are advanced and environmentally friendly devices for generating electricity efficiently with minimal emissions. Specialty alumina is used in solid oxide and certain proton-exchange membrane fuel cells. Its properties, including high ionic conductivity, thermal stability, corrosion resistance, and electrical insulation, make it an ideal choice for various components within fuel cell stacks. This helps to ensure efficient and reliable operation of the fuel cells.

Industrial ecosystems of the European Industrial Strategy

Specialty alumina are used in 10 of the 14 industrial ecosystems of the European Industrial Strategy. Here below a non-exhaustive list of applications, where specialty alumina play a crucial role.



Construction: wear protection

Fine grits of fused alumina are used in the topcoat of floorings to improve the wear resistance. The lifetime of such floorings is 3-5 times higher compared to floorings with unfilled coatings.

Many industries: abrasives

Fused alumina based abrasive grains are irreplaceable raw materials for grinding tools, which are used in nearly all industries. Grinding and furthermore polishing is the last step before assembly of machines. High developed manufacturing processes require abrasive grains having a constant and high quality. Due to high developed abrasives and grinding machines, gear wheels are showing nowadays low wear losses and very long lifetimes.

Digital: thermal and safety management for electronics and telecommunication

Specialty alumina is used in adhesives and gap fillers (Thermal Interface Materials) in batteries, electronics and telecommunication (e.g., 5G, 6G antenna) to support the thermal management of the battery cell.

Low carbon energy-intensive

- Catalyst carriers: Alumina-based carriers are designed to support catalysts that facilitate various chemical reactions in the petrochemical sector. By providing a stable and high-surface-area platform for catalysts, specialty alumina enhances the efficiency of critical processes like hydrocracking, catalytic cracking, and reforming. This results in improved

yields, reduced energy consumption, and lower greenhouse gas emissions. The use of specialty alumina as a catalyst carrier is a significant contributor to making petrochemical processing more energy-efficient and environmentally friendly.

- Specialty alumina for green steel production: Fused alumina is an essential raw material for high value refractories in blast furnaces for the steel production. For example, heat exchanger stones made of fused alumina improve the energy efficiency of blast furnaces significantly. This is by far the biggest specialty alumina-consuming market. As high-alumina refractory solutions have a lower CO_2 footprint than alternative solutions, they are essential to steel manufacturers for succeeding in green steel production.

Defence: armour

The conflict in Ukraine has underscored the importance of robust military defence capabilities for democratic nations. Safeguarding our military forces remains paramount, and specialty alumina play a pivotal role in cutting-edge ballistic protection systems. In defence applications, specialty alumina-based ceramics are used in Defensive Armour Protection solutions that are used for the protection of armed vehicles, semi-stationary security installation, as well as individual protections. Ceramic tiles, incorporated in protective structures, absorb the impact of bullets while dissipating the energy in a controlled way.

Automotive and mobility: fused alumina in refractories

Specialty alumina-based coatings are used in lithium-ion batteries to prevent thermal runaways. These coatings prevent the risk of an explosion driven by a short-circuit in case of an overheating of the battery.

Fused alumina is also characterized by high compactness, used, for example, in kilns for making carbon black, which plays an important role for the effectiveness of the lithium-ion batteries' electrodes.

Health

Alumina plays a vital role in health-related applications, particularly in the production of ceramic electronic substrates used in medical devices. Additionally, specialty alumina serves as a crucial raw material for medical prosthetics, contributing to advancements in healthcare technology.

Electronics: alumina ceramics for semiconductor market

Alumina based ceramic parts that can withstand the harsh conditions in the production of silicon wafers, are crucial for the semiconductor industry, aligning with the growing demand for innovative and eco-friendly solutions in sectors such as electric vehicles, smart grids, and energy storage systems.

Textiles

Specialty alumina plays a crucial role in the textile industry as it is used for ceramic components in textile machinery, such as thread guides. These components are essential for guiding and controlling threads during weaving or knitting processes. Alumina ceramics are favoured for this application due to their exceptional mechanical properties, including high hardness and wear resistance. They provide a smooth surface that minimizes thread abrasion and breakage, ensuring the efficiency and reliability of textile machinery, even in high-temperature operating conditions.

Renewable energy: wind turbines

Specialty alumina plays a crucial role in the renewable energy sector, as component in the production of the glass fibres used in wind turbine blades. Alumina's high strength and durability enhance the structural integrity of these blades, contributing to the efficiency and reliability of wind turbines. Additionally, specialty alumina-based brake pads are employed in turbines, ensuring safe and controlled braking, which is essential for the smooth operation of wind turbines.

Agri-food: ceramic filters, membranes and components for fresh/waste water treatment and desalination equipment

Specialty alumina plays a vital role in the agri-food sector through its applications in water treatment and desalination equipment. In the context of fresh and wastewater treatment, ceramic filters and membranes made from specialty alumina are employed to purify water used in agricultural processes. These filters effectively remove contaminants and impurities, ensuring that the water used for irrigation and other agricultural activities is of high quality. Additionally, in desalination equipment, ceramic components made from specialty alumina are utilised to withstand the harsh conditions of the desalination process, where seawater is converted into freshwater. Alumina's durability, corrosion resistance, and ability to maintain structural integrity in challenging environments make it a valuable material in ensuring a sustainable and reliable water supply for agriculture, a critical component of food production.

Annex 2: Production processes

Products from Bayer Process

Bauxite*
Bayer Process
High demand on energy (carbon or gas)

90% (estimated)
Smelter Grade Alumina

for
Aluminium Metal

10% (estimated)
Chemical Grade Alumina

High electrical energy
High-tech processing

- Abrasives
  - Grinding wheels
  - Cut-off grinding wheels
  - Grinding belts
- Refractories
  - Petro chemistry
  - High temperature kilns
  - Steel mills
- Wear protection
  - Laminate floorings

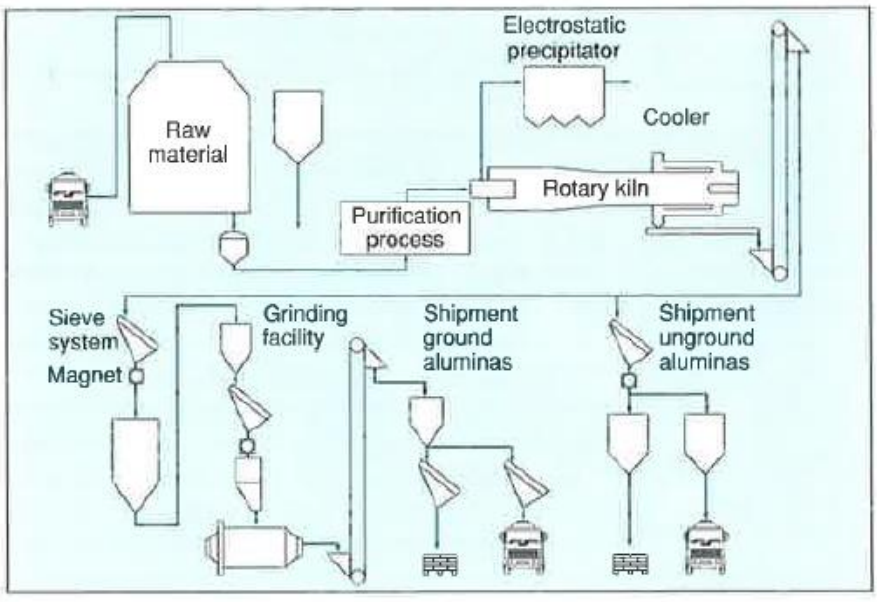
High gas demand
High-tech processing

- Batteries
  - Interfaces to ensure safety
- Steel production
  - Numerous high temperature applications
- Semiconductor production
- Power grits
- Armour
- Brake pads in wind turbines

Specialty alumina production routes

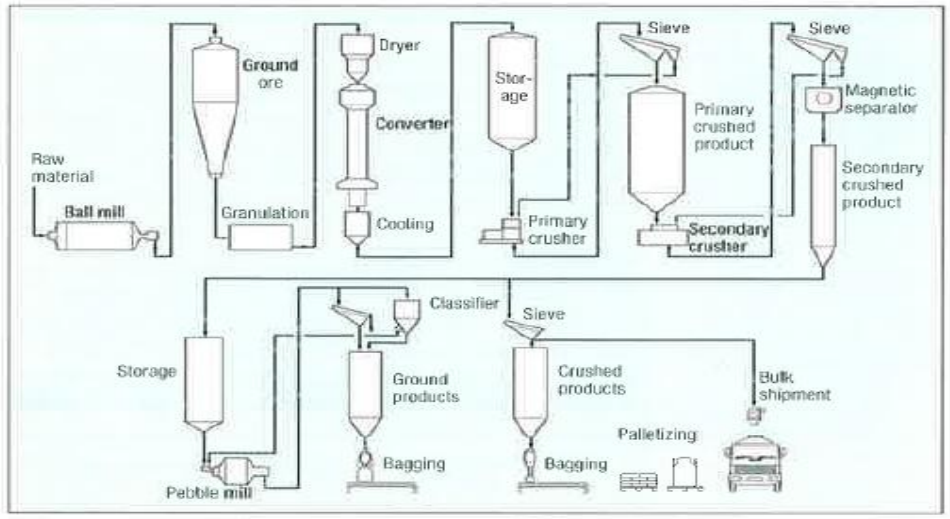
Calcined alumina

The rotary kiln is fired with natural gas and consumes up to 800m³ gas/h to dry the material and heat it up to >1200°C. The ball and jet mills used for grinding are also highly energy-intensive.



Source: "Aluminium Oxide – Production, properties, applications", verlag modern industrie, 1999

Sintered alumina / tabular alumina

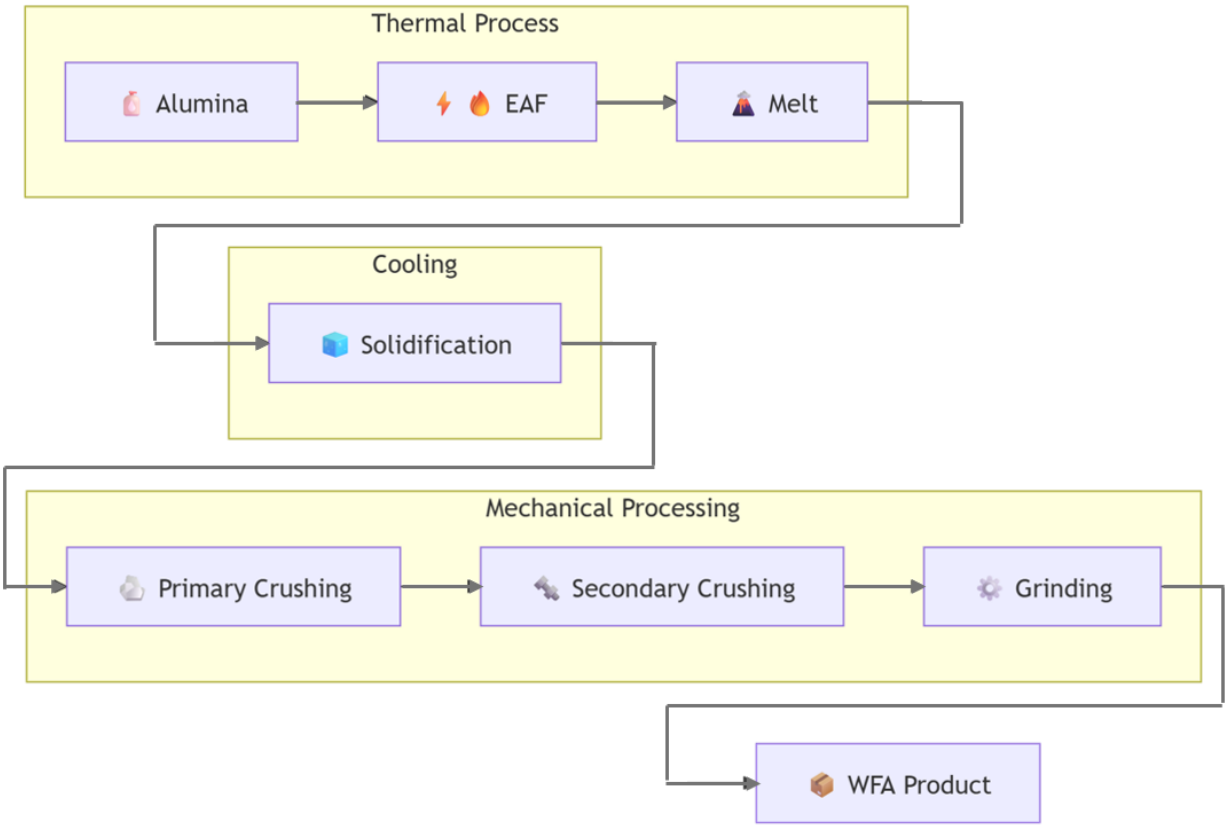


The converter used for the sintering process in Tabular alumina production is fired with natural gas in order to achieve temperatures >1800°C. The crushing and sizing facilities have high consumption of energy.

Source: "Aluminium Oxide – Production, properties, applications", verlag modern industrie, 1999

Fused Alumina

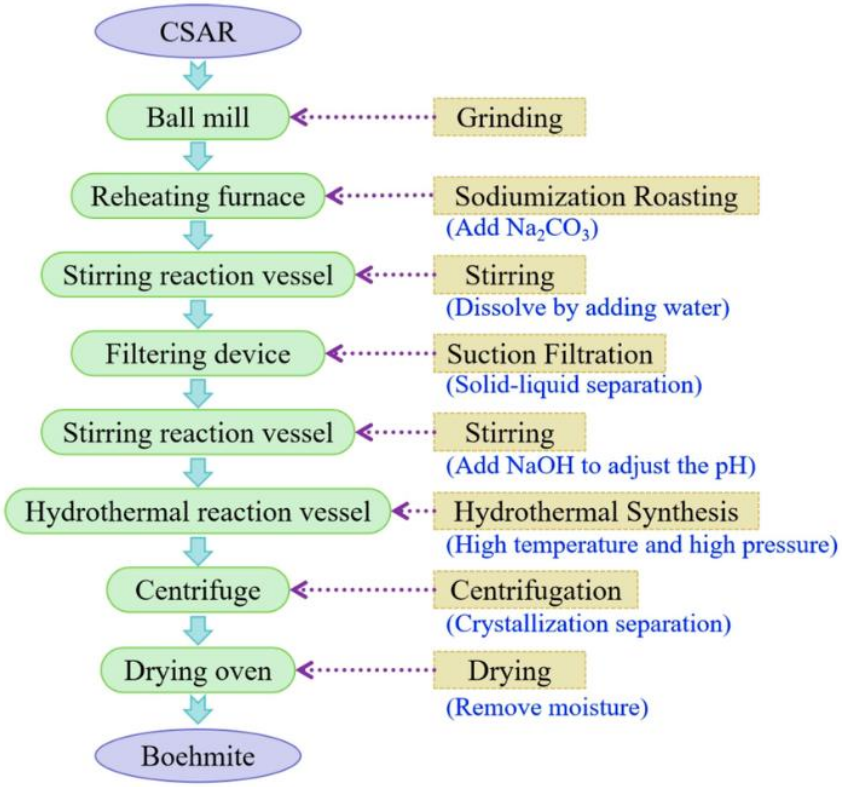
The fusing process in the Electric Arc Furnace is highly energy-intensive, achieving temperatures >2000°C.



Production of White Fused Alumina

Boehmite production process

In the production of fine precipitated hydrate and boehmite, the hydrothermal reaction is the most energy-intensive step.



Source: Process flow diagram for preparing boehmite using the CSAR. | Download Scientific Diagram

Annex 3: Energy needs and costs

Energy use, smelter grade alumina

The table below illustrates the energy necessary for the production of smelter grade alumina.

Table 2-1 Energy consumption per tonne of sawn aluminium ingot production (EAA, 2013)

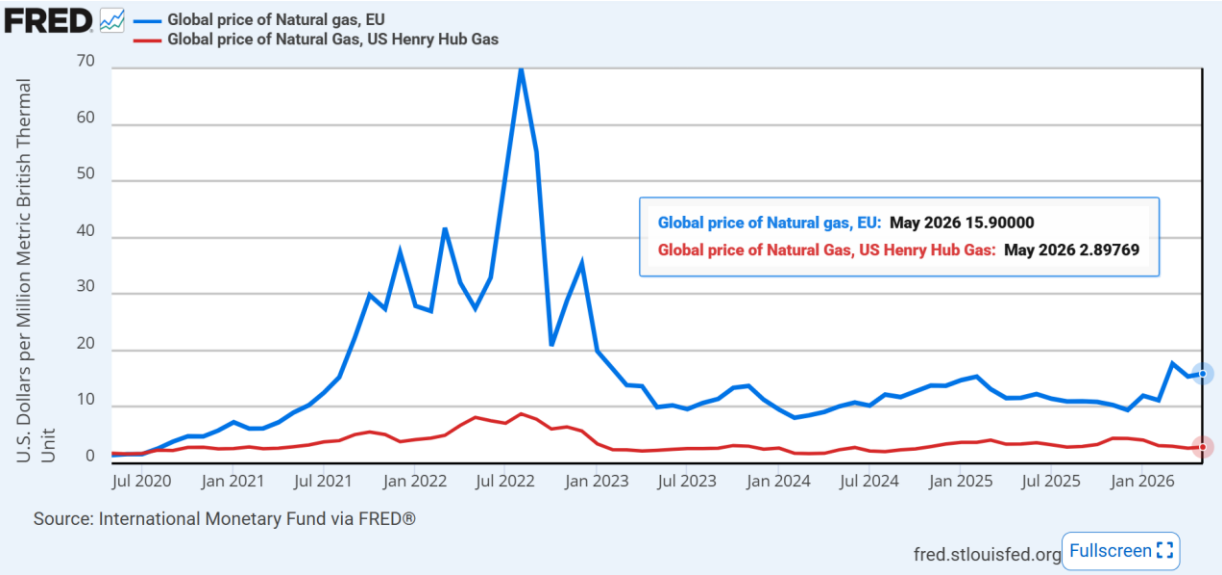
Process	Relative amount of product used	Specific energy requirement (GJ/t product)		Total energy requirement (GJ)		
		Thermal Energy	Electricity	Thermal Energy	Electricity	Total
Bauxite mining	4.5	0.02	0.003	0.089	0.013	0.10
Alumina refining	1.9	10	0.65	19	1.3	21
Anode production	0.56	2.8	0.4	1.6	0.22	1.8
Electrolysis	1.0	14(*)	55	14(*)	56	70
Ingot casting	1.0	1.6	0.4	1.6	0.40	2.0
Total	-	-	-	**37**	**58**	**95**

(*) When anode carbon is regarded as a fuel

Source: JRC report « Energy Efficiency and GHG Emissions: Prospective Scenarios for the Aluminium Industry », p.9: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC96680/ldna27335enn.pdf

Gas price

While average gas prices in the EU were about 1,6 times higher than in the US before the crises, they currently remain around 5 times higher today.

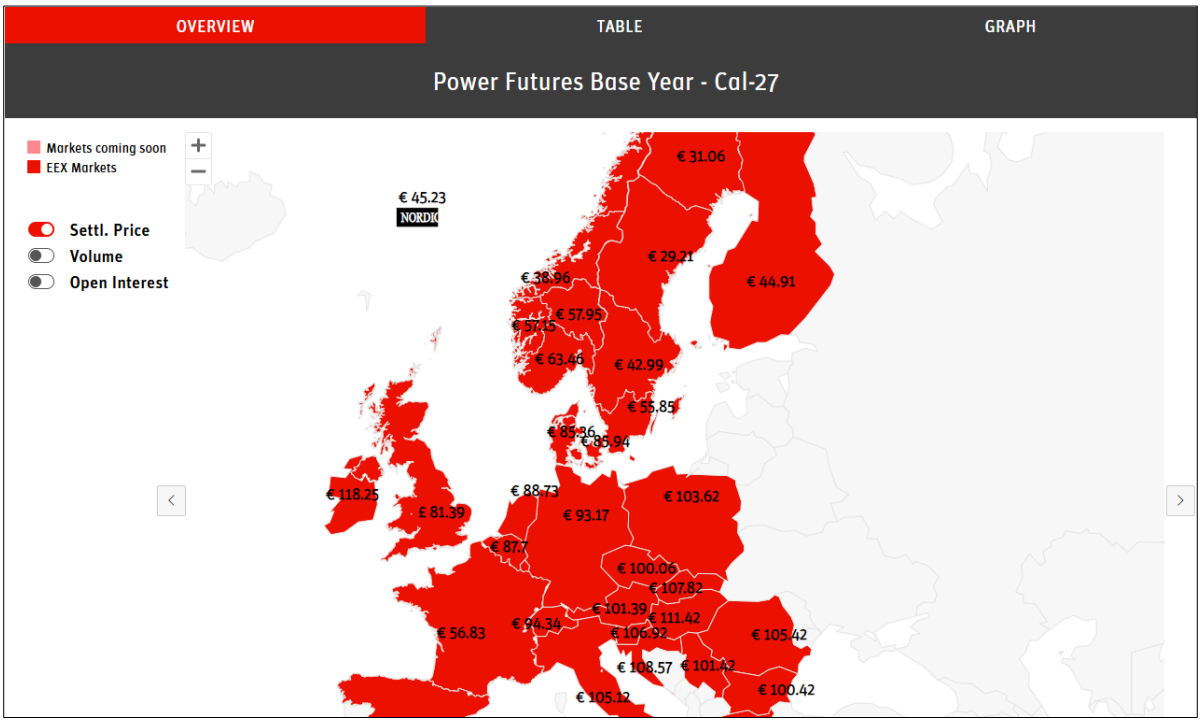


International Monetary Fund, Global price of Natural Gas, EU [PNGASEUUSDM] and US Henry Hub Gas [PNGASUSUSDM], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/PNGASEUUSDM and https://fred.stlouisfed.org/series/PNGASUSUSDM.

Electricity price (per MWh)

In 2022, a spike in electricity and gas prices increased the share of energy in production costs from under 10% to 25%. Despite decreases in gas and electricity prices since late 2022, significant disparities with other regions persist, with Europe's electricity prices (futures) exceeding €100/MWh in many Member States.

Futures



Source: https://www.eex.com/en/market-data/market-data-hub

Annex 4: Plants closures

Closure of Almatis plant in Ludwigshafen, Germany, March 2024

The global specialty alumina market has been under significant pressure due to increased production and exports from Chinese companies. China's capacity to produce and export alumina at lower costs, partly due to less stringent environmental regulations, has led to a global oversupply. This oversupply has driven prices down, making it increasingly difficult for European producers to compete. This competitive disadvantage has contributed to the economic challenges faced by the European specialty alumina sector, leading to plant closures and job losses across Europe. The ongoing struggle undermines the viability of domestic production and threatens the stability of the industry within the region.



Almatis: 55 Mitarbeiter verlieren ihre Arbeit

Geschäftsführung und Betriebsrat vereinbaren geringeren Stellenabbau – Produktionsanlage wird geschlossen

Beim Mundenheimer Aluminiumhersteller Almatis wird fast jeder fünfte Arbeitsplatz abgebaut. Darauf haben sich Geschäftsführung und Betriebsrat verständigt. Zunächst stand im Raum, dass über 70 der rund 250 Stellen bereits zum Jahresende wegfallen.

Diese Ad-hoc-Mitteilung im Herbst hatte massiven Widerspruch von Politik und der Gewerkschaft ausgelöst. Nach „zähen Verhandlungen" sei es gelungen, die Anzahl der betroffenen Mitarbeiter auf 55 zu reduzieren, erklärte IG BCE-Sekretär Fabian Haag. Etwa zehn der 55 betroffenen Mitarbeiter hätten realistische Aussicht auf Übernahme in einem Unternehmen in der Branche. Bewerbungsverfahren bei Renolit und Wöllner verliefen aussichtsreich. Etwa 45 Almatis-Mitarbeiter würden abgefunden, sie müssten sich arbeitslos melden. Der Gewerkschaftsvertreter rechnet damit, dass die laufenden Sozialplanverhandlungen mit dem Betriebsrat um Ostern abgeschlossen sind. Er hat keine Hinweise darauf, dass Almatis weitere Stellenstreichungen plant.

Die Geschäftsführung hatte sie mit der schwierigen globalen Wirtschaftslage begründet. Auf Nachfrage äußerte sich ein Almatis-Sprecher am Montagabend nicht zur weiteren Personalplanung. Am Ende von „harten, aber fairen Verhandlungen" sei insgesamt eine gute Grundlage geschaffen, um „für den Standort Ludwigshafen eine langfristige Perspektive zu entwickeln", hatte „Operations Director" Rüdiger Bastian nach Abschluss der Gespräche erklärt. In der Folge ist zum Jahresende die Sinter-Anlage geschlossen worden, in der ein Produkt zur Herstellung von Feuerfestmaterial produziert worden ist.

Ludwigshafen ist einer von sieben Almatis-Standorten in sechs Ländern. Das Chemieunternehmen ist seit 2015 im Besitz des türkischen Pensionsfonds Oyak und war 2004 vom Aluminiumhersteller Alcoa abgespaltet und verkauft worden. ala

Almatis ist im Mundenheimer Industriepark angesiedelt. FOTO: ALA

Source: https://www.rheinpfalz.de/lokal/ludwigshafen_artikel,-bei-almatis-f%C3%A4llt-jeder-f%C3%BCnfte-arbeitsplatz-weg-_arid,5620090.html

Closure of Imerys, Slovenia, 2026

Imerys halts production at its fused alumina plant in Ruše, Slovenia, by the end of 2026. The plant produces high-quality abrasive minerals used in grinding, cutting, polishing, surface preparation, sandblasting, and refractory applications, including furnace linings and other heat-resistant industrial materials. The closure reflects strong pressure on the European fused alumina sector, mainly from difficult market conditions and intense international competition. It will lead to a gradual shutdown of the site and the loss of several dozen jobs.

Source: https://www.24ur.com/novice/gospodarstvo/imerys-ustavlja-proizvodnjo-v-rusah-brez-dela.html

Long-term temporary discontinuation of operations at Imerys, Germany, 2024

Since 1 June 2024, Imerys has discontinued production of tabular alumina at its Teutschenthal site in Germany on a long-term temporary basis.

IMERYS

February 2024 the 28th

Dear Customer,

Since the middle of 2022, we have experienced significant headwinds; starting with soaring energy costs followed by a significant drop in demand - and therefore volumes - notably on our fused and tabular alumina products due to the competition from China.

Unfortunately we see no improvement and we expect these strong headwinds to continue, which has led to the decision to restructure our tabular alumina production in Europe.

As a consequence, you will be impacted directly. As of June 1st 2024 the production of our tabular Alumina from our site in Teutschenthal will be discontinued temporarily but for the longer term.

Your commercial contact will be in touch in the next days to discuss and coordinate the necessary steps to support you during this transition.

Best regards,

Vincent COUTY
Imerys Refractory Producers Vice President



Source: Imerys letter to customers

Partial relocation of Imerys corundum production from Germany to Austria and Bahrain, 2023

Imerys has transferred production of its white high-purity corundum products from Zschornewitz, Germany, to Villach, Austria, and to Hidd, Bahrain, due to high energy costs, weaker demand, and stronger competition from Chinese producers.

IMERYS

DATE

Sehr geehrte Damen und Herren,

Seit Mitte des Jahres 2022 befinden wir uns in einem sehr turbulenten wirtschaftlichen Umfeld. Die Vervielfachung der Energiekosten als Folge des militärischen Konfliktes in der Ukraine haben zu einer maßgeblich gesunkenen Nachfragesituation und Wettbewerbsnachteil insbesondere bei unseren energieintensiven, synthetisch geschmolzenen Korunden gegenüber Chinesischen Mitbewerbern geführt.

Bedauerlicherweise ist keine Verbesserung dieser Situation in Sicht, was zu der notwendigen Entscheidung geführt hat, unsere Korund Produktion in Europa zu restrukturieren.

Wir möchten Sie mit diesem Schreiben über die folgende Restrukturierung und Änderung informieren. Mit 1. November 2023 wird die Produktion unserer Alodur® Edelkorund Weiß Produkte von unserem Werk Zschornewitz (Deutschland) schrittweise in unsere Werke Villach (Österreich) und Hidd (Bahrain) verlagert. Die Produktion unserer anderen Alodur® Spezialprodukte (EDR, ZPSK, KKW, ZPMX) wird am Standort weitergeführt. Lieferungen dieser Produkte erfolgen weiter wie gewohnt von Zschornewitz.

Im Laufe der nächsten Wochen wird sich unser Verkaufsteam bei Ihnen melden, um die notwendigen Schritte dieser Umstellung im Detail zu besprechen und zu koordinieren.

Mit freundlichen Grüßen

Vincent COUTY
Imerys Refractory Producers Vice President

Source: Imerys letter to customers

Closure of the Imerys Technology Centre, Austria, 2026

The Imerys Technology Centre Austria in Villach, Austria, closes after 22 years of research and development activity. The centre was specialised in fused oxide raw materials and was a key hub for developing fused corundum solutions for industrial applications. These materials are used in abrasives, grinding, cutting, blasting, refractory products, advanced ceramics, investment casting, and high-temperature industrial processes. They support end uses such as metalworking, steel and foundry operations, electronics, energy-related materials, and other advanced manufacturing applications. The closure is driven by rising costs at the Austrian site, changing market conditions, and strong international price pressure, particularly from China in the fused corundum sector. Around 40 engineers and technicians were working at the centre, and part of the workforce is expected to be affected by redundancies.

Source : https://www.kleinezeitung.at/artikel/20772586/internationales-unternehmen-schliesst-forschungsabteilung-in-villach

Closure of Alum Tulcea, Romania, August 2022

“Alum Tulcea, a Romanian alumina plant, controlled by aluminium producer Alro Slatina, will shut down production from 1 August 2022 and 441 employees will lose their jobs. The closure is due to increasing electricity and gas prices, which have made much cheaper to import alumina than to produce it.”

Source: Eurofound (2022), Alum Tulcea, Closure in Romania, factsheet number 107111, European Restructuring Monitor. Dublin, https://apps.eurofound.europa.eu/restructuring-events/detail/107111.

Job losses at Huber Martinswerke, Germany, Jul 2024

The company is facing a decline in demand for around two years and is struggling with inflation and high energy prices. To remain competitive, the plant must reorganize and cut jobs.

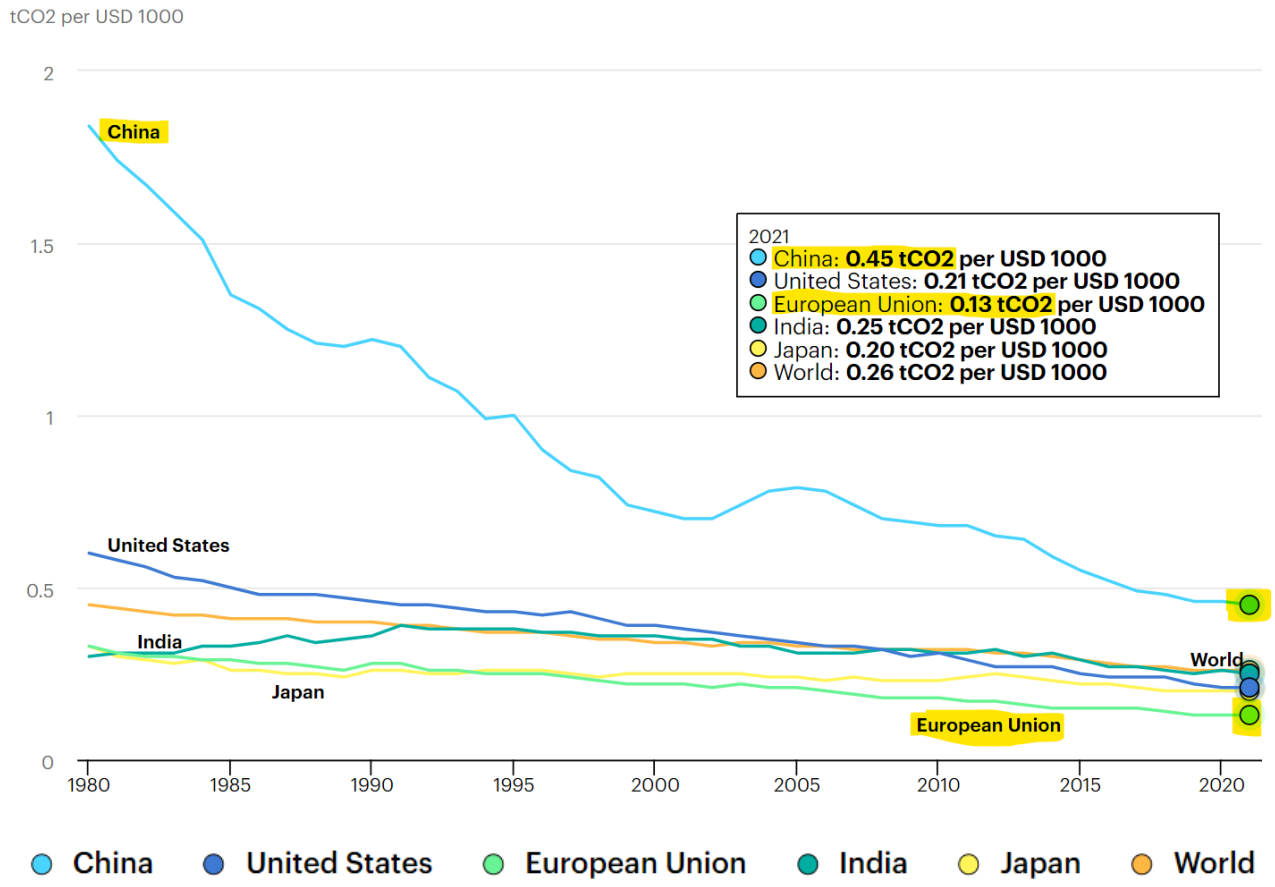
Source: https://www.radioerft.de/artikel/bergheim-einigung-beim-martinswerk-2060189

Annex 5: CO_2 emissions

CO_2 emissions intensity of GDP

According to the Global Energy Review of the International Energy Agency, the CO_2 Emissions intensity of GDP in 2021 is approximately 3.5 times higher in China than in the European Union. Relocation of production capacity from EU to China may increase CO_2 emissions by a factor of 3.5.

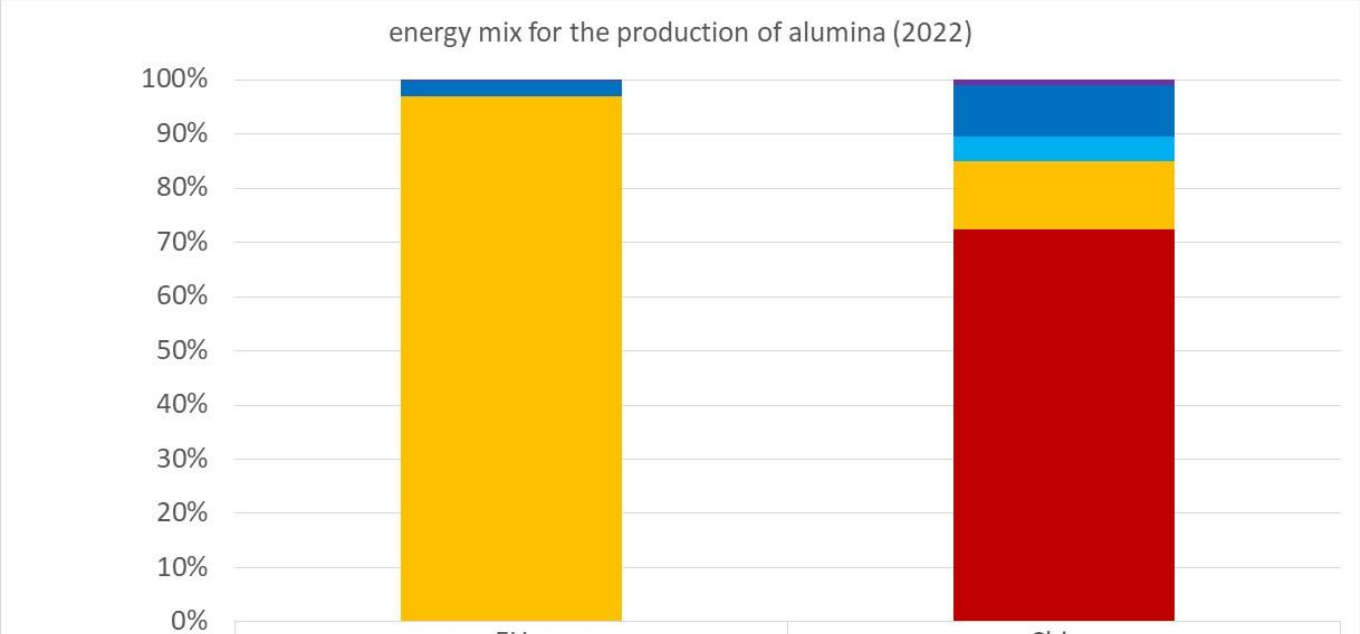
IEA (2022), CO2 emissions intensity of GDP, 1990-2021



Source: IEA, Paris https://www.iea.org/data-and-statistics/charts/co2-emissions-intensity-of-gdp-1990-2021, Licence: CC BY 4.0

Energy mix for the production of alumina (metallurgical grade) in 2022

According to International Aluminium Institute data, alumina production in China relies mainly on coal and heavy oil, unlike production in the EU. Shifting alumina production from Europe to China would therefore significantly increase global CO_2 emissions.



	EU	China
Other [%]	0,1	1
Electricity [%]	2,9	9,4
Oil [%]	0	4,6
Gas [%]	97	12,6
Coal [%]	0	72,4

Source:https://international-aluminium.org/statistics/metallurgical-alumina-refining-fuel-consumption/

Carbon footprint of European specialty alumina

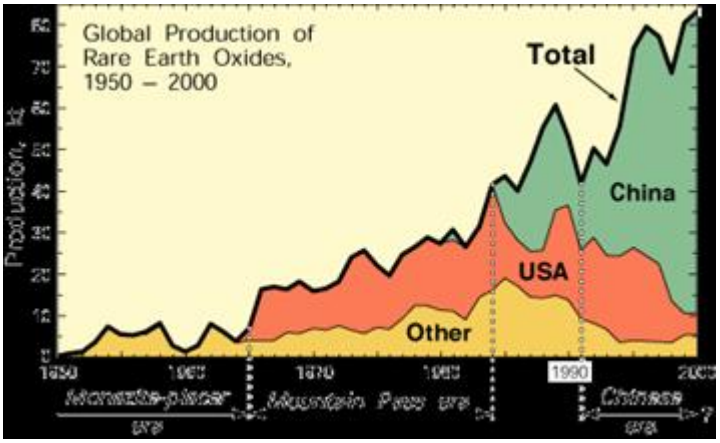
Based on the above sources, we estimate that, where

- European producers' carbon footprint ranges 1 - 1,5t CO_2e/mt produced (scope 1 to scope 3),
- the carbon footprint in China is around 3t CO_2e/mt produced (same scope).

For example, the carbon footprint for Almatis products (scope 1 to scope 3, third-party verified) amounts 1.200 kg CO_2e/mt produced.

Annex 6: Example of disappearance of sector (rare earth elements)

A example for a disappearing of an industry because of unbalanced competition. China is serving over 90 % of the global market for rare earth elements. Since 1990 lower wage- and energy costs, especially the low environmental regulations have caused low product production costs. Until today, Chinese companies can sell rare earth compounds at unbeatable prices. Companies outside China were not anymore competitive with a result of shutting down production capacity. Even though the outstanding importance of rare earth elements, a restart is today very difficult (e.g. loss of know-how) and expensive (e.g. expensive equipment, environmental regulations).



Source: https://pubs.usgs.gov/fs/2002/fs087-02/

Annex 7: Technical comparison between Smelter Grade Alumina (SGA) and specialty alumina – CN code 2818 20 00

This section delves into the technical distinctions between smelter grade alumina and chemical grade alumina (specialty alumina). Both products, despite their significant differences, are currently grouped under the same CN code 2818 20 00. This section aims to illustrate why they deserve separate codes.

Alumina is mainly divided into two different grades: smelter grade alumina (SGA) and chemical grade or specialty alumina (SA). Main differences:

- **Smelter grade alumina (SGA)**: Metallurgical or smelter grade alumina (SGA) is the type of alumina used for producing aluminium metal. Via the Bayer process aluminium ore (Bauxite) is refined to aluminium hydroxide $(AlOH)_3$. This SGA type is mainly calcined in either fluid flash or bed calciners by approx. 800°C. The fluid flash calcining process first removes free and chemically bonded water from aluminium hydroxide (gibbsite). In a temperature range from 180 to 800 °C and further transition/gamma (γ-)alumina is created. It shows a primary crystal size of < 0.02 µm to about 0.5 µm in coarse clusters (agglomerates) between 40 and 100 µm. Typical BET values are about 50 - 80 m²/g.
- **Specialty Alumina (SA)**: Chemical-grade specialty alumina (SA) is essential across a very wide range of technical applications. To obtain the required properties, various additional sophisticated refining steps like high-temperature calcination or fusing steps as well as different milling and classifying steps are crucial. Thanks to these additional production steps it is possible to manufacture a broad spectrum of different specialty aluminas which can be adjusted for an extremely wide range applications.

  During further calcination, SGA recrystallizes to α-alumina (corundum) by a temperature-dependent stepwise decrease of the BET-value (0.4 – 0.9 m²/g) combined with growing of the single/primary crystal size (3 µm). Hereby alumina undergoes temperatures up to 1350 °C.

	Alumina (SGA)	**Specialty aluminas**
Crystal structure	undefined	Defined
Grain size distribution	undefined, coarse	Defined
Specific surface area [m²/g]	≈ 50 – 80	≈ 0.4 – 0.9
Primary crystal size [µm]	≈ 0.02 µm	≈ 3 µm
Crystal modification	transition/γ-alumina	α-alumina