4 BERYLLIUM

4.1 Overview

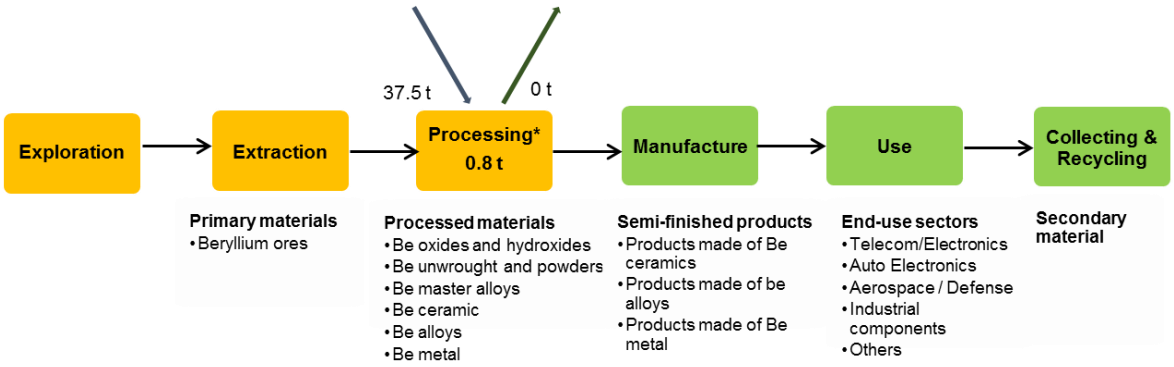

Figure 52: Simplified value chain for beryllium[29] for the EU, averaged over 2012-2016

Beryllium (Be, atomic number 4, formerly also known as glucinium) is a lightweight, dark, silver-grey metal with hexagonal-close-packed structure, with high thermal stability and conductivity, flexural rigidity. Beryllium was on the EU's list of critical raw materials in 2011, 2014 and 2017. For the purpose of this assessment, beryllium was assessed at ores and concentrates and refined stage. The trade code for beryllium ores and concentrates is CN 2617900003. Two trade codes exist for refined beryllium: CN 28259020 "Beryllium oxide and hydroxide" and CN 81121200 "unwrought beryllium; beryllium powders", which however could not be used in the calculations. All quantities are provided in Be content. Approximately 80% of beryllium in commerce exists as an alloy with copper, typically containing 2% or less beryllium.

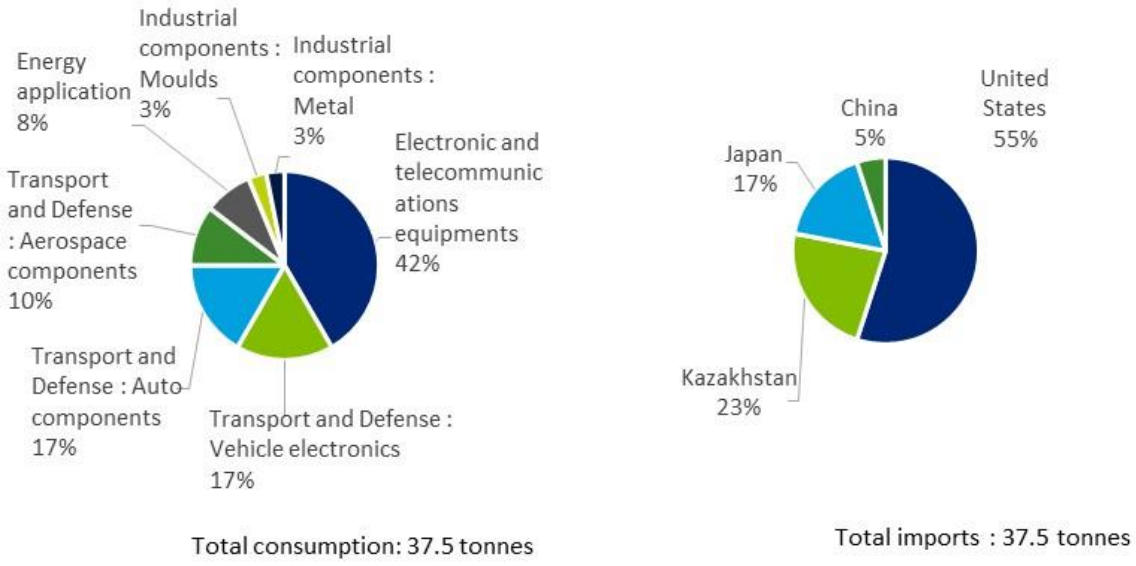

Figure 53: EU consumption and sourcing of refined Beryllium.

[29] JRC elaboration from multiple sources (see next sections). The orange boxes of the production and processing stages suggest that activities are not undertaken within the EU. *The quantity in the Processing stage in the EU refers to criticality assessment 2017.

The annual worldwide production of beryllium in 2014 is estimated at 300 tonnes, expected to increase to more than 425 tonnes per year by 2030 (BeST, 2019b). Beryllium is not traded on any metals exchange. The price of beryllium is dependent on the form. Prices are established by direct contract negotiation between primary producers and refiners or users (European Commission, 2017). USGS publishes an estimated annual average price of beryllium content in beryllium-copper master alloys. In 2018, the price of contained beryllium in beryllium-copper master alloy was USD 500 perkg (USGS, 2019).

The average annual EU consumption of refined beryllium in 2016 was estimated at 37.5 tonnes per year (BeST, 2019a). The EU relied entirely on imports to meet its demand for refined beryllium in 2012-2016. More than half of the refined beryllium supply to the EU came from the United States.

The application of beryllium is indispensable in defence, transportation or energy applications where reliability is essential to ensure safe operation, including the construction of the ITER fusion reactor. Other uses are in electronic and telecommunications equipment and industrial components (European Commission, 2017).

World resources of beryllium are estimated at 100,000 tonnes, of which 60% are located in the United States. In the United States, proven and probable reserves were estimated at about 21,000 tonnes of beryllium content (USGS, 2019). Resources of beryllium in Europe are known to exist in Austria, Czechia, France, Finland, Germany, Italy, Portugal, Spain, Sweden, and Norway. There are no known reserves of beryllium in the EU.

The world annual production capacity of beryllium ores and concentrates in 2016 was estimated at 5,360 tonnes. The two major producers of beryllium ores were the United States (72% of global supply) and China (22% of share) (BeST, 2019a). In the EU, no beryllium is mined in 2016.

Global supply of refined beryllium in 2016 was estimated at 220 tonnes. Refined beryllium was mostly produced in the United States (50% of global supply), followed by Kazakhstan (25%), Japan (17%), and China (8%) (BeST, 2019a). Among these countries, the EU has a free-trade-agreement in place with Japan.

Beryllium is not recycled from end finished products (end-of-life recycling input rate 0%), but between 94% and 100% of new scrap is recycled (between 100 and 135 tonnes in 2013, i.e. about 20% of global demand).

Beryllium-containing dusts are toxic by inhalation causing chronic beryllium disease (CBD), also called chronic berylliosis, a chronic life-threatening lung disease. Therefore, industrial risk mitigation measures are implemented in the EU (European Commission, 2014).

4.2 Market analysis, trade and prices

4.2.1 Global market analysis and outlook

Beryllium annual consumption is expected to grow to 425 tonnes per year by 2020 and to more than 450 tonnes per year by 2030, driven by applications such as the construction of the ITER fusion reactor (BeST, 2019b). It is not possible to split the forecast by major end-market applications, due to the lack of available data. The larger increases are expected in defence and commercial applications such as (non-medical and industrial) X-ray products, semiconductor processing equipment and new types of beryllium alloys.

According to Freeman (2016), the demand for beryllium products will increase for the next 10 years, starting from 2016, as well as for the supply. Forecast on 20 years was not available

Table 23: Qualitative forecast of supply and demand of Beryllium (Data from Freeman, 2016)

Materials	Criticality of the material in 2020		Demand forecast			Supply forecast		
	Yes	No	5 years	10 years	20 years	5 years	10 years	20 years
Beryllium	x		+	+	?	+	+	?

4.2.2 EU trade

The EU does not import any beryllium ores (CN 2617900003) because there are no processing activities undertaken in the EU, also in the period considered for this assessment (2012-2016).

The EU sourced refined beryllium exclusively from import. The EU import of refined beryllium amounted to 37.5 tonnes per year on average for the period 2012-2016 (BeST, 2019a). Approximately 80% of beryllium imported into the EU are beryllium-containing alloys (mainly copper-beryllium alloys $CuBe_2$) and master alloys, 15% in the form of pure metal and the remaining 5% are used in beryllium oxide ceramics. Figure 55 shows the EU imports of refined beryllium. The suppliers of the EU are the United States (55%), Kazakhstan (23%), Japan (17%), with whom the EU has a free-trade-agreement in place, and China (5%) (BeST, 2019a).

Eurostat-Comext reports trade of processed beryllium under two codes: 28259020 "beryllium oxide and hydroxide" and 81121200 "unwrought beryllium; beryllium powders". Unfortunately these data are not sufficient to depict EU imports and exports of all refined beryllium (no codes for several types of refined beryllium, for example copper-beryllium alloys, the major part of EU import of beryllium). For this reason Comext data could not be used in the calculations. For illustration purposes only, trade flows for beryllium in Figure 54 refer to "unwrought beryllium; beryllium powders".

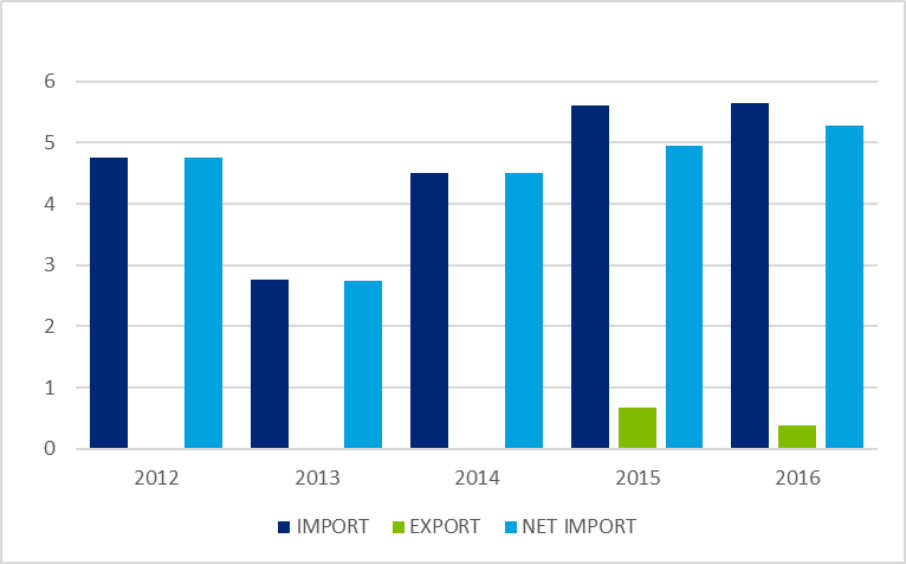

Figure 54: EU trade flows for "unwrought beryllium, beryllium powders" (CN 81121200);. Data source: Eurostat-Comext (Eurostat, 2019a)

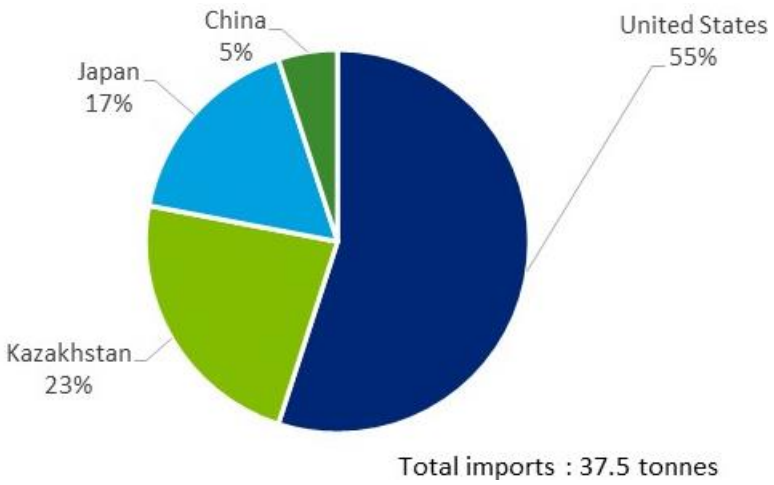

Figure 55: EU imports of refined Be, annual average 2012-2016. Data source: (BeST, 2019a)

There were no exports taxes, quotas or prohibition of Be products in place from countries exporting to the EU (OECD, 2019). However, according to experts, in the defence sector, there was a need of export licenses from the US or Kazakhstan (Freeman, 2016). On the contrary, the United States were not allowed to export Beryllium to China (BeST, 2019a).

4.2.3 Prices and price volatility

Since beryllium is not traded on any metals exchange, there is no quotation on stock market. Prices are established by direct contract negotiation between primary producers and refiners or users (BRGM, 2016). There is no publication of beryllium prices neither on Metal Pages nor Metal Bulletin. The USGS publishes an annual average estimated price of beryllium-copper master alloy as presented in Figure 56.

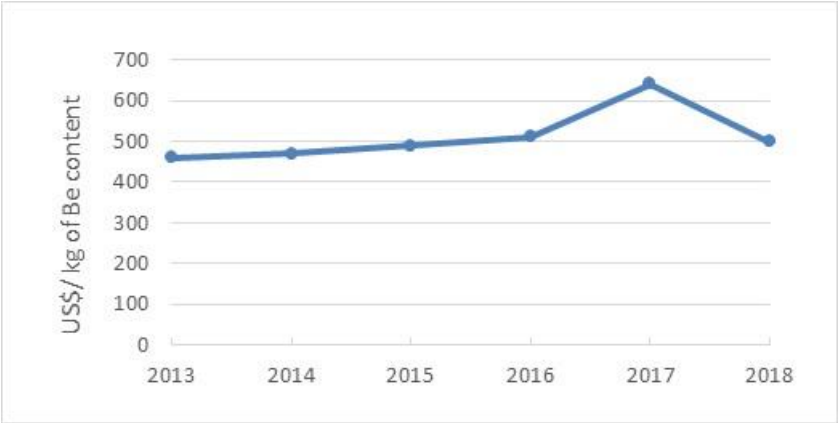

Figure 56: Price trend of beryllium contained in beryllium-copper alloy USD perkg. Data source: USGS (USGS, 2019)

According to experts, the price of beryllium is dependent on its form (BeST, 2016b). The following prices refer to the prices of the specific beryllium containing products.

- As a fully machined aerospace component of pure beryllium: €300 – 1,500/kg
- As a cast aluminium 39% beryllium alloy aerospace component: €200 – €500/kg
- As a copper 2% beryllium alloy: €20 – 50 /kg
- As a copper 0.3% beryllium alloy in strip form: €12 – 20 /kg

4.3 EU demand

Annual worldwide production of refined beryllium (in alloys, metal or ceramics) in 2016 is estimated as 220 tonnes (BeST, 2019a).

4.3.1 EU demand and consumption

The annual EU consumption of beryllium ores is null. In the EU, the consumption of processed beryllium materials is about 37.5 tonnes per year of beryllium content over the average 2012-2016 (BeST, 2019a). Approximately 80% of beryllium used in the EU goes into copper-beryllium alloys (containing 0.2-2% of beryllium) for the manufacture of high performance electrically conductive terminals and mechanical components. About 15% of beryllium is used in a metal matrix containing over 50% beryllium. The remaining 5% of beryllium are used in beryllium oxide ceramics for producing electrical insulation components with high thermal conductivity.

Beryllium's superior chemical, mechanical and thermal properties make it a favourable material for high technology equipment (e.g. in aerospace) for which low weight and high rigidity are important qualities. A large share of the world pure beryllium production is used for military purposes. Due to the high price and unique properties, only small amounts of pure beryllium are used in the civilian sector (European Commission,2014; Freeman, 2016).

4.3.2 Uses and end-uses of Be in the EU

Figure 57 presents the main uses of beryllium in the EU over the year 2012-2016.

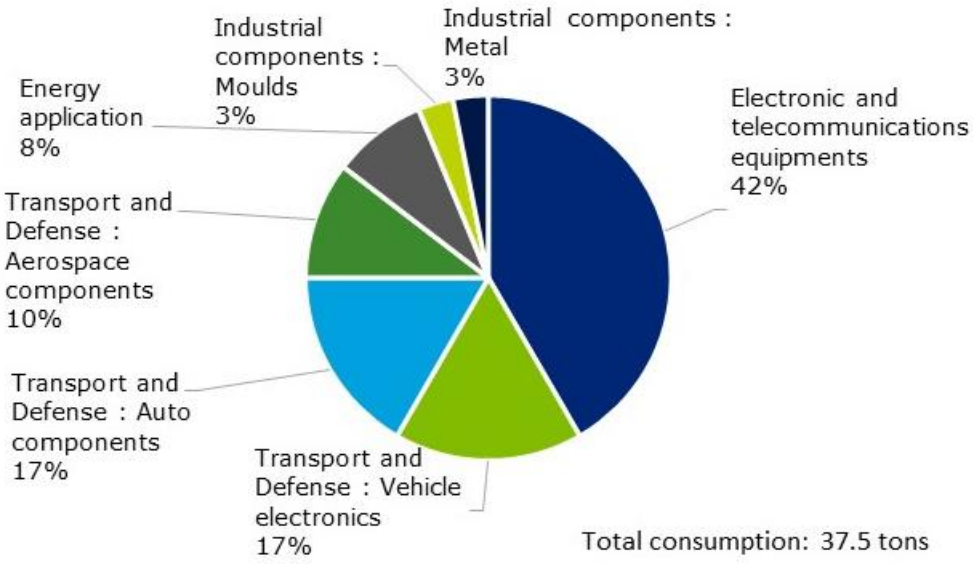

Figure 57: EU end uses of Beryllium. (SCRREEN, 2019; BeST, 2019;

The end-uses of beryllium products in the EU are the following (CRM Experts, 2019):

- Electronics and telecommunication equipment: Beryllium is used as an alloying element in copper to improve its mechanical properties without impairing the electric conductivity. Copper beryllium is used in electronic and electrical connectors, battery, undersea fibre optic cables, chips (consumer electronics + telecommunications infrastructure)
- Transport and Defence:
    - Automotive electronics: connectors in vehicle components (Copper-Beryllium - CuBe) for air-bag crash sensor and deployment systems,

airbags, anti-lock brake systems and many other life safety applications, for weather forecasting satellites, undersea earthquake tsunami detection monitors, air traffic control radar, fire sprinkler systems (Nickel-Beryllium (NiBe), power steering and electronic control systems, etc.
    - Other light metal vehicle components (Be used for recycling process of magnesium containing light alloys in <10 ppm): car body panels, seat frames, car steering components and wheels, etc.
    - Aerospace components: landing gears, engine for aircraft, mirrors for satellites, etc.
- Industrial components:
    - Moulds for rubber and plastics, made of CuBe alloys
    - Metals: Bar, plate, rod, tube, and customized forms
- Energy application: copper-beryllium is used to stop the leaking during the Oil spills, as well as in non-magnetic equipment, down-hole equipment and non-sparking safety equipment used to improve extraction equivalent of energy applications. Pure beryllium is used in fusion research and fission energy production.
- Others: among others, Be in medical application is used as beryllium foil for high-resolution medical radiography, including CT scanning and mammography; beryllium oxide ceramic in lasers; beryllium as components to analyse blood and in X-ray equipment, etc.

Relevant industry sectors are described using the NACE sector codes (Eurostat, 2019c) in Table 24.

Table 24: Beryllium applications, 2-digit and associated 4-digit NACE sectors and value added per sector (Data from the Eurostat database; Eurostat, 2019c)

Applications	2-digit NACE sector	Value added of 2-digit NACE sector (M€)	4-digit NACE sectors
Electronic and telecommunications equipment	C26 - Manufacture of computer, electronic and optical products	65,703	C2610 Manufacture of electronic components, C2630 Manufacture of communication equipment
Transport and Defence: Vehicle electronics	C26 - Manufacture of computer, electronic and optical products	65,703	C2651 Manufacture of instruments and appliances for measuring, testing and navigation, C2670 Manufacture of optical instruments and photographic equipment
Transport and Defence: Auto components	C29 - Manufacture of motor vehicles, trailers and semi-trailers	160,603	C2930 Manufacture of other parts and accessories for motor vehicles: Airbags, car body panels, seat frames, car steering components and wheels
Transport and Defence: Aerospace components	C30 - Manufacture of other transport equipment	44,304	C3030 Manufacture of air and spacecraft and related machinery: Landing gears, engine for aircraft, mirros for satellites

Applications	2-digit NACE sector	Value added of 2-digit NACE sector (M€)	4-digit NACE sectors
Energy application	C26 - Manufacture of computer, electronic and optical products	65,703	C2651 Manufacture of instruments and appliances for measuring, testing and navigation
Industrial components: Moulds	C28 - Manufacture of machinery and equipment n.e.c.	182,589	C2823 Manufacture of machinery for metallurgy ceramic
Industrial components: Metal	C24 - Manufacture of basic metals	55,426	C2420 Other non-ferrous metal production: Bar, plate, rod, tube, and customized forms

4.3.3 Substitution

Substitution of beryllium always leads to a loss of performance. As beryllium is expensive, it is used only when it is absolutely needed (Freeman, 2016). For example, copper-beryllium is used when reliability is essential to ensure safe operation in the defence, transport or energy sector. Pure beryllium and aluminium-beryllium (with 62% of beryllium) are used only in applications where the unique property combinations are essential for mission capabilities. (BeST, 2016a).

No other alloys offer the same combinations of copper-beryllium alloys, aluminium-beryllium alloys or pure beryllium properties. In all cases, there is a reduction in performance.
Alternate materials for copper-beryllium alloys may include (BeST, 2016a):

- Copper nickel silicon alloys (Corson alloys)
- Copper iron alloys
- Copper titanium alloys
- Copper Nickel Tin Spinodal Alloys (Cu-Ni-Sn)
- Phosphor bronzes (Cu-Fe-P)
- High Performance Bronzes (Cu-Pb-Sn + Al / Fe / Mn)

Alternate materials for the mechanical properties provided by beryllium metal could include (BeST, 2016a):

- Titanium alloys
- Magnesium alloys
- Aluminium alloys
- Carbon fibre composite

Alternate materials for the thermal properties provided by beryllium metal:

- Aluminium metal matrix composites with Silicon Carbide / Boron Nitride
- Carbon Reinforced Composites

The share of applications where beryllium can be substituted by these materials is less than 10%, especially for some applications in the defence, transportation and energy sector.

In parallel to substitution, reduction in the quantity of beryllium used in applications is also not feasible, since in practice beryllium is only used where absolutely necessary, for high priceconstrain. Furthermore, the most prevalent use of beryllium occurs in copper-beryllium alloys, which only contain between 0.2% – 2% of beryllium (BeST, 2019c).

4.4 Supply

4.4.1 EU supply chain

The flows of beryllium through the EU economy are demonstrated in Figure 58.

The EU has only limited involvement in the supply chain of beryllium for the manufacturing of products made of pure beryllium and copper-beryllium (CuBe) alloys. The supply chain of beryllium in the EU is summarised as follow:

- The extraction and processing stage of beryllium takes place outside the EU. There are no known reserves of beryllium in the EU and no beryllium ores and concentrates are imported into the EU. Primary beryllium is processed into beryllium oxides and hydroxides outside the EU (Bio Intelligence Service, 2015).
- Over the years 2012-2016, the import reliance of the EU on beryllium has been estimated at 100%. The EU entirely depends on imports of processed and semi-finished products, mainly under the form of beryllium master alloys and alloys (around 30 tonnes of beryllium per year), beryllium metal (around 5.6 tonnes of beryllium per year), and beryllium oxide (around 1.9 tonnes). There is no production of alloys or metal but reprocessing (rolling, stretching, slitting, cutting) of imported strips and bars (BeST, 2019a; Bio Intelligence Service, 2015). Some beryllium ceramics are produced in the EU out of imported beryllium oxides. The European industry uses these processed materials to manufacture various finished products. Some beryllium-copper alloy strip, rod, bar and plate products are produced in France, Germany and Switzerland.
- During the manufacture step, the European industry generates a lot of scrap (around half of the beryllium input) which is generally sent back to suppliers outside Europe for recycling (Freeman, 2016). The EU also imports a large quantity of finished products containing beryllium (Bio Intelligence Service, 2015). One company in France is known to treat Beryllium-copper alloy scrap to produce new alloy (Sundqvist Ökvist et al. 2018).
- The beryllium contained in the waste ends up in landfill or is downcycled with a large magnitude material stream. However, there is no post-consumer functional recycling of beryllium in Europe and in the world (Bio Intelligence Service, 2015).

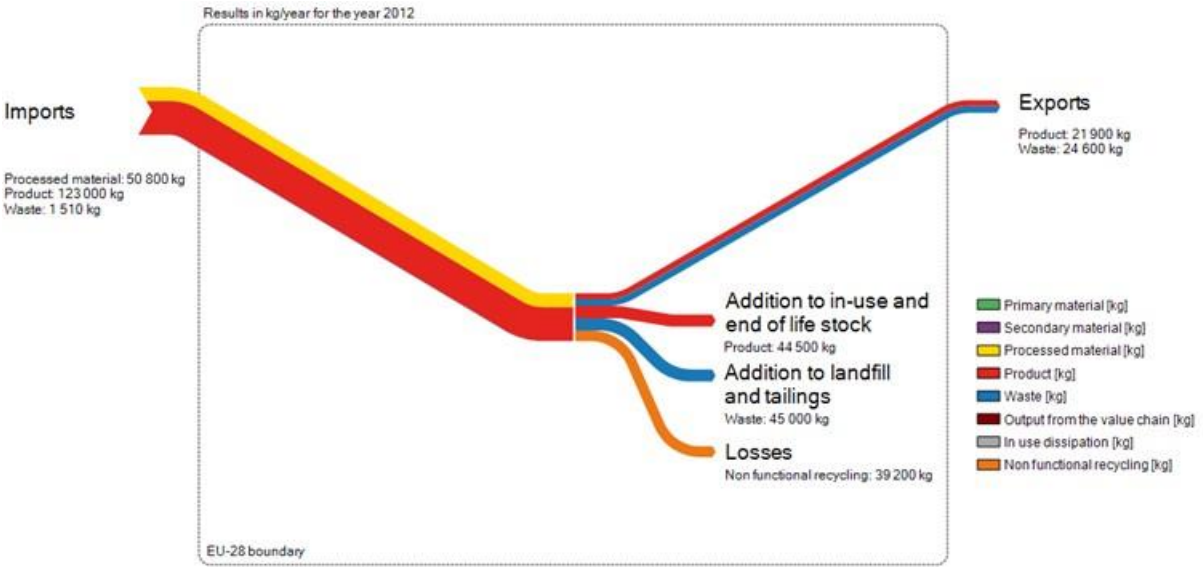

Figure 58: Simplified MSA of beryllium flows in the EU in 2012 (BIO Intelligence Service, 2015)

4.4.2 Supply from primary materials

4.4.2.1 Geology, resources and reserves of beryllium

Geological occurrence: Beryllium is a relatively rare element with a concentration of about 2.8-3 ppm in the earth's crust, and 2.1 ppm in the uppercrust (Rudnick, 2003). It is concentrated in some minerals, predominantly in beryl and bertrandite (BeST, 2016b; European Commission, 2014).

Until the late 1960s the only beryllium mineral commercially exploited was beryl ($Be_3Al_2Si_6O_{18}$). Beryl contains between 3 and 5% of beryllium but the material is harder than bertrandite ($Be_4Si_2O_7(OH)_2$) leading to difficulties to refine into beryllium. Today the most important commercial beryllium mineral is bertrandite (over 75% of mining operations) which is extracted from ores containing 0.3-1.5% beryllium. Beryllium is also extracted from beryl as a by-product of small-scale emerald gemstone mining operations in Brazil, Argentina and other countries in South America and Africa (BeST, 2016b).

Global resources and reserves: World resources of beryllium are estimated at about 100,000 tonnes, of which 60% of it is located in the Spor Mountain deposit in Utah, United States. The proven and probable reserves from this deposit is estimated at 21,000 tonnes of beryllium content respectively (USGS, 2019). No information is available for the breakdown of world reserves by country.

EU resources and reserves: The Minerals4EU reports no data on beryllium resources and reserves in the EU (Minerals4EU, 2019).

According to experts, there are very limited resources (about 12 tonnes) of beryllium in Europe. (Bio Intelligence Service, 2015). There are known resources of beryllium in several locations in Europe, notably the Bordvedaga deposits at Rana in the north of Norway. Smaller deposits are also known to exist in Germany, Czechia and Ireland (Bio Intelligence Service, 2015). These resources are in the form of beryl crystals and areusually found in a matrix of granitic pegmatite rock.

According to a report by Lauri, L. et al. (2018), the following countries in Europe are known to have resources of beryllium, though most of them are not of economic significance:

- Austria. Beryl-bearing complex pegmatites are known to be present in various locations in Austria. Only two deposits (Spittal/Wolfsberg feldspar deposit and Markogel granite quarry) are reported to have extracted in the past, but no data for beryllium is given.
- Czechia. Rare-metal pegmatites and granites containing contain beryl as an ore mineral are known to exist, but only two occurrences (Rasovna Maršíkov and Vetrny Vrch) report beryllium as the main commodity.
- Finland. Beryllium minerals are known to be present in Finland. Beryllium contents are reported from four deposits in Finland. The resource estimate available is available for the Rosendal deposit (South-West of Finland) with 206.85 tonnes of beryllium.
- France. According to BRGM (2016), there are some known resources in France in 6 deposits, including one evaluated at 2,400 tonnes of contained beryllium (BRGM, 2016). Tens of granite intrusions and granitic pegmatites with beryllium minerals are known in France, mostly located in Bretagne in (North-West of France) and in the Pyrenees (Lauri et al., 2018)
- Germany. Beryllium minerals are present in many granites and granitic pegmatites. No records available for beryllium mining (Lauri et al., 2018)

- Italy. Some occurrences of beryllium associated with granitic pegmatites are known, but they are mainly with mineralogical interest.
- Portugal. Portugal has had deposits in complex granitic pegmatites containing beryl in addition to Sn, Nb, Ta, and W minerals. Small-scale beryllium production took place in the mid-1900s from several deposits.
- Spain. Four beryllium-bearing occurrences are listed. Three of these are granitic pegmatites that contain beryl as an ore mineral. One occurrence (Galiñeiro) is associated with peralkaline gneisses and is currently of interest in terms of REE exploration.
- Sweden. One beryllium deposit and closed mine, Selvitberget, was reported but there is no resource estimate available
- In addition, the area of Högtuva in the middle of Norway, Nordland County was reported to host several spatially restricted Be beryllium deposit with phenakite as the main ore mineral (Schilling, et. al., 2015).

However, according to experts, there are no reserves of beryllium in Europe (Bio Intelligence Service, 2015).

4.4.2.2 World and EU mine production

The world annual production of beryllium ores in average between 2012 and 2016 was approximately 251 tonnes of beryllium content, mainly in the United States (220 tonnes), China (20 tonnes) (Figure 59). There is no reported mining of beryllium ores in the EU (USGS, 2019).

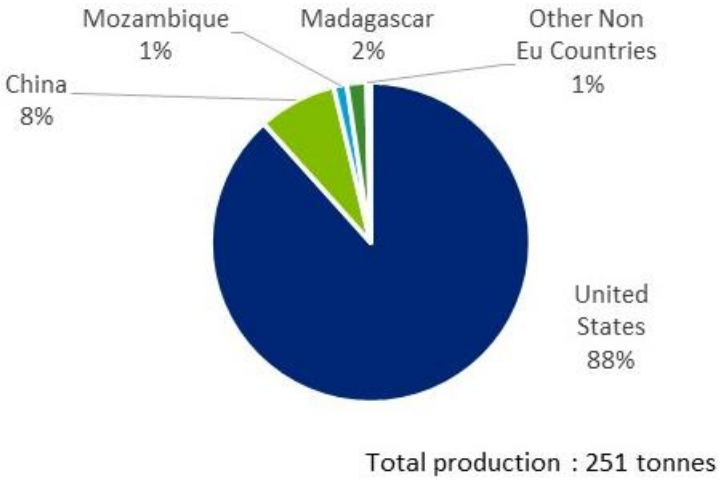

Figure 59: Global mine production of beryllium in tonnes and percentage. Average for the years 2012-2016. Data source: USGS (USGS, 2019)

4.4.3 Supply from secondary materials/recycling

4.4.3.1 Post-consumer recycling (old scrap)

There is no known post-consumer functional recycling of beryllium in Europe and in the world. Beryllium is not recycled from end finished products (BeST, 2016b), therefore the end of life recycling input rate is 0%. The recuperation of pure metal of beryllium from end finished products is extremely difficult because of the small size of components and the tiny fraction of beryllium contained in appliances (less than 40 ppm in appliance having the highest amount of Be) (BeST, 2016b). The beryllium contained in the waste usually

ends up in landfill. The stock accumulated in landfill in the EU over the last 20 years is estimated at around 610 tonnes of beryllium content (Sundqvist Ökvist et al. 2018).

4.4.3.2 Industrial recycling (new scrap)

Beryllium can be recovered from new scrap generated during the manufacture of beryllium products and from old scrap. Almost all the new scrap (between 94% and 100%) is sent back to the producer and recycled (Freeman, 2016). In 2013 secondary beryllium production from new scrap recycling was between 100 and 135 tonnes, i.e. about 20% of global demand (BRGM, 2016).

There are some companies that recycle beryllium new scrap, for example Monico Alloys and Materion (United States). In the EU, NGK Berylco (France), located near Nantes, is known to treat Beryllium-copper alloy scrap to produce new alloy. (Sundqvist Ökvist et al. 2018).

4.4.4 Refining of beryllium

The extraction of beryllium from its main source's beryl and bertrandite involves several stages. After mining the ores, they are first converted to an acid-soluble form. To obtain comparatively pure beryllium hydroxide or oxide, and in a further step beryllium chloride or fluoride, complex chemical processes are used. These halogenides are then reduced to metallic beryllium with other metals or by melt electrolysis. The beryllium metal obtained is subject to one or more refining processes and finally to further treatment. The metal or other product is then incorporated into the end product, before being sent on for use (BeST, 2016b).

Annual worldwide production of refined beryllium (in alloys, metal or ceramics) in 2016 is estimated as 220 tonnes. The US production accounted for 50% (110 tonnes) of the share of global production followed by Kazakhstan (55 tonnes), Japan (37.4 tonnes) and China (17.6 tonnes), each with 25%, 17%, and 8% of share respectively. (BeST, 2019a)
The United States possesses fully integrated beryllium producer in the world, involved in the mining, ore processing, manufacture, sale and recycling of beryllium-bearing products. Japan does not extract beryllium ores but refine it from imports (Freeman, 2016) Kazakshstan refines its beryllium from stockpiled ores and will most likely to continue to do so in the future (BeST, 2019c).

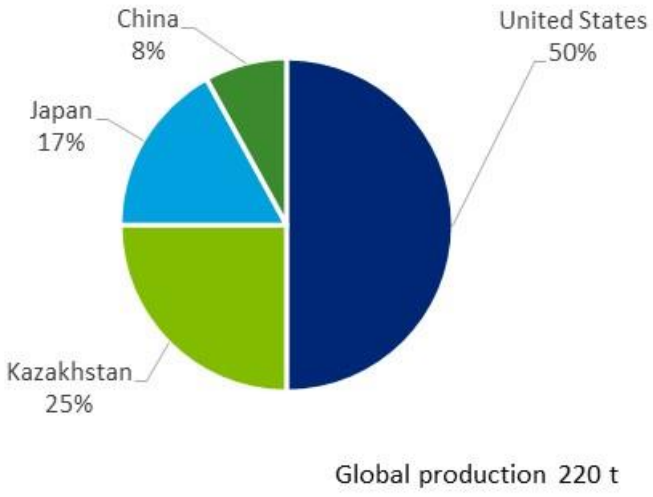

Figure 60: Global production of refined beryllium products. (BeST, 2019a), year 2016

4.5 Other considerations

4.5.1 Environmental and health and safety issues

Because of the toxic nature of beryllium, various international, national, and State guidelines and regulations have been established regarding beryllium in air, water, and other media. Industry is required to carefully control the quantity of beryllium particles as dust, fumes, and mists in the workplace (USGS, 2019).

In the EU, beryllium is classified under the European regulation as a carcinogenic material of 1B category under the Guidance on Labelling and Packaging. It is highly toxic if inhaled in dust form during some operational steps, leading to chronic respiratory disease called chronic beryllium disease (European Commission, 2014).

Beryllium was evaluated by the German Federal Institute of Occupational Safety and Health, BAuA[30] under the REACH Community Rolling Action Plan (CoRAP) in 2014. The evaluation concluded that the risk associated to the exposure of beryllium is limited to the workplace. Beryllium is not on the REACH Substance of Very High Concern (SVHC) list and is not restricted under REACH or any other EU Directive in relation to its uses. In line with BauA's recommendation, beryllium was considered for regulation under the EU Carcinogen and Mutagen Directive (CMD)[31] and an EU wide binding occupational exposure limit was adopted. The EU adopted a binding occupational exposure limit (OEL) for Beryllium and compounds of 0.2 µg/m^3 – inhalable fraction 8 Hour Time Weighted Average – in the frame of the Carcinogens and Mutagens Directive. A transitional OEL of 0.6 µg/m^3 was adopted until 11 July 2026 in order to aid industry to comply with the new occupational exposure limit (BeST, 2019c)). In 2017, a voluntary workers protection programme was launched by industry in the sector to engage various stakeholders to improve workers safety during the production and processing of beryllium-containing materials in the EU[32].

4.6 Comparison with previous EU assessments

The assessment has been done using the same revised methodology as used in the assessment for the CRM list 2017. The results of this and earlier assessments are shown in Table 25.

Table 25: Economic importance and supply risk results for beryllium in the assessments of 2011, 2014 (European Commission, 2011; European Commission, 2014) and 2017

Assessment	2011			2014			2017			2020	
Indicator	EI	SR		EI	SR		EI	SR		EI	SR
Beryllium	6.17	1.32		6.74	1.45		3.9	2.4		4.17	2.29

The economic importance of beryllium has slightly reduced compared to the value from 2017. Since the end-use sectors of beryllium remained the same as in the assessment in 2017, this decrease is the result of the change in the value added in the sectors for which beryllium is relevant.

In this criticality assessment, the supply risk of beryllium was assessed at both extraction and refining stage. The supply risk presented in Table 25 referred to the value of supply risk at extraction stage, which resulted higher than the value of the refining stage. In general, the supply risk of beryllium has lowered in comparison to the supply risk in 2017,

[30] Bundesanstalt für Arbeitsschutz und Arbeitsmedizin

[31] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32019L0983

[32] "Be Responsible" – www.berylliumsafety.eu

because the global supply of beryllium ores and concentrates over the year 2012-2016 was less concentrated than in 2010-2014.

4.7 Data sources

The quantitative data for Be production at extraction stage for the 2012-2016 period was available from World mining data (in metric tonne of concentrates) and the USGS. Preference was given to the data provided by the USGS since it reported beryllium mine production in beryllium content.

Eurostat data was not usable for beryllium refined products (only beryllium oxide and powders, and no master alloys) (Eurostat, 2016a; Eurostat, 2016b). The SCRREEN experts network provided information on refined beryllium products global supply for the year 2016 and EU supply for the assessment of supply risk of beryllium at refined stage for the year 2012-2016.

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