23 SILICON METAL

23.1 Overview

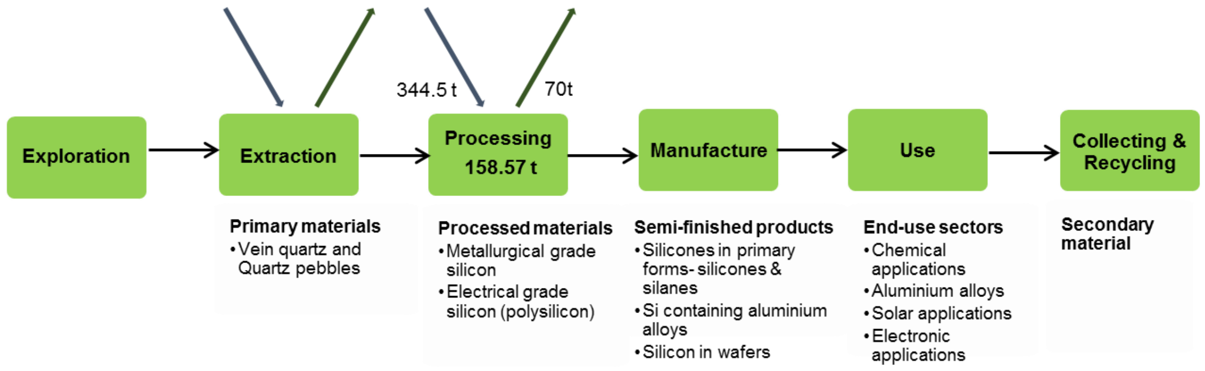

Figure 456: Simplified value chain for silicon metal[256], averaged over 2012-2016

Silicon metal (chemical symbol Si) is the second most abundant element in the Earth's crust in the form of silicate minerals. It is an inert element extracted from vein quartz and quartz pebbles due to their high silica content. Silicon has no metallic properties but is known as silicon metal in the industry because of its lustrous appearance. There are two grades of silicon metal: metallurgical grade silicon (typically around 99% of Silicon, trade code CN 28046900), representing the majority of the volumes produced, and polysilicon (with a 6N to 11N purity, trade code CN 28046100). Altogether these products are the focus of this assessment. Silicon metal was on the EU's list of CRMs in 2014 and 2017. Unless otherwise specified, all figures in this factsheet are reported in silicon metal content.

[256] Source: JRC elaboration on multiple sources (see next sections).

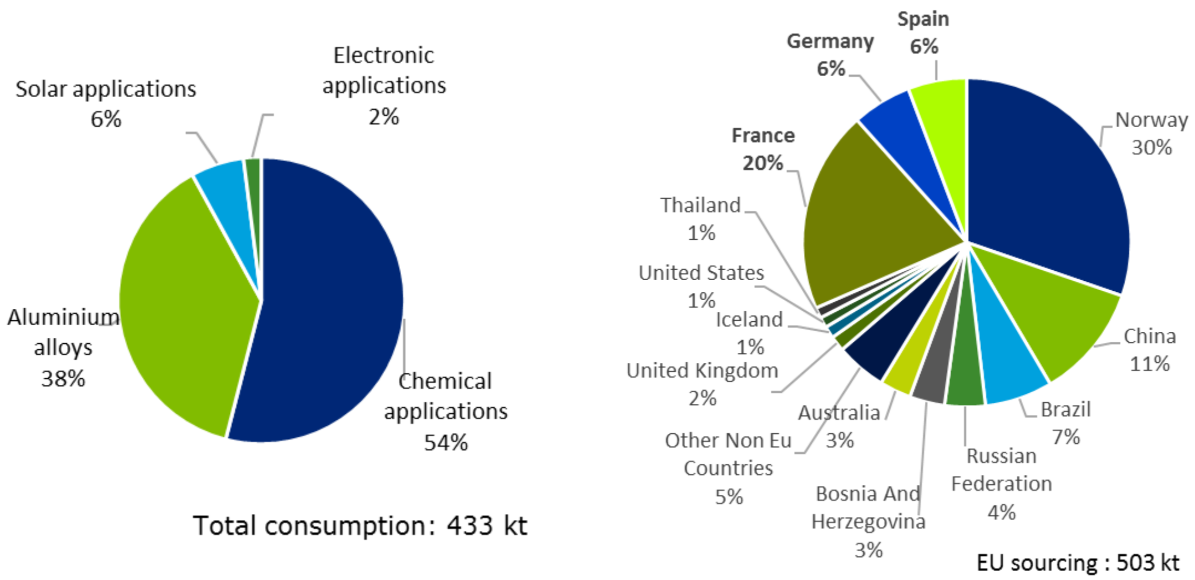

Figure 457: End uses of silicon metal in the EU (SCRREEN, 2019) and EU sourcing of silicon metal, average 2012-2016[257]

Global Silicon Metal market size in 2017 was estimated at 6520 Million US$ in 2017, at a CAGR of 4.4% (Marketwatch, 2019). China remained a leading producer of silicon metal and ferrosilicon. China production accounted for approximately 66% of total global estimated production of silicon materials in 2018 (USGS, 2019). Over the year 2012-2016, the annual EU consumption of silicon metal reached 433 kt per year, which was sourced from import and domestic production. The EU is a net importer of silicon metal with an average import at 344 kt per year over the considered period. The EU imports of silicon metal were mainly from Norway (30%), China (11%) and Brazil (7%). In the EU, silicon metal was produced in France, Germany and Spain, accounting for a total of 158 kt per year in the same period.

The major uses of metallurgical grade silicon are in metallurgy and for the production of silicones and silanes, representing more than 90% of the total world and EU silicon metal consumption. Polysilicon is used as a semiconductor in photovoltaic applications or in microelectronics (Euroalliages, 2016). There are no materials that can replace any of the main uses of metallurgical silicon without serious loss of end performance or increase of cost.

Being silicon solar cells, the most common cells used in commercially available solar panels, silicon metal will significantly contribute to achieving the objectives of the "European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy"[258]. Under this strategy, the transition to clean and renewable electricity is expected to decarbonize also other sectors such as heating, transport and industry. Silicon plays a strategic role in the reduction of CO_2 emissions as component of other green tech applications such as wind turbine generators and as anode component of Li-ion batteries. The contribution of Silicon to the low carbon economy is and will significantly increase as Li-ion batteries are subject of extensive research with the aim of increasing their capacity for electric vehicles (Euroalliages, 2020).

[257] JRC elaboration on silicon metal production figures reported in World Mining Data (2019) and EU-extra EU trade of silicon metal in Eurostat Comext (2019)

[258] COM(2018) 773 final A Clean Planet for all. A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy

USGS (2019) estimated that the world resources in the producing countries among others, China, United States, Brazil, Norway, are sufficient to supply world demand of silicon metal for many decades. There are no quantitative estimates of reserves of silicon metal worldwide.

The quantity of world annual production of silicon metal during the year 2012-2016 was 2,541 kt per year. China dominated the production with 66% of share, followed by United States (8%), Brazil (7%), and Norway (6%) (World Mining Data, 2019). The EU production of silicon metal occurred in France, Germany, and Spain, each with 6% of share in global supply over the same period (World Mining Data, 2019).

The End-of-Life Recycling Input Rate (EoL-RIR) for silicon metal is estimated to continue to be low (0%) despite the development of several recycling plants in place in Europe. Most chemical applications of silicon metal are dispersive, thus not allowing for any recovery. There is no functional recycling of silicon metal in aluminium alloys.

The production of silicon metal is energy intensive, therefore the energy cost is a major production cost element. In Europe, silicon production is subject to the European Directive on the Emissions Trading Scheme[259] which entails direct and indirect carbon costs.

The United States, the EU, and Canada have been imposing anti-dumping duties on silicon metal from China, the current biggest producer of silicon metal (Monnet, 2019).

23.2 Market analysis, trade and prices

23.2.1 Global market analysis and outlook

China remained the biggest producer of silicon metal over the year 2012-2016. China will continue to increase its market share among global producers until 2025, following the same trend observed in the past years. This trend may be explained by production costs in China remaining at the lowest level globally speaking as well as by the Chinese production overcapacity (Euroalliages, 2016). The United States, the EU, and Canada have been imposing anti-dumping duties on silicon metal from China, the biggest producer of silicon metal (Monnet, 2019).

Growth in the silicon metal market is expected to continue in the coming years. Consumption for silicon metal comes primarily from the aluminium and chemical industries. Ferroglobe estimated world silicon metal consumption to be divided between the silicone (50%), aluminium (40%), and solar (10%) markets (Monnet, 2018).

Solar PV cells are predicted to become a crucial part of the overall energy mix between 2013 and 2050 to meet low carbon future (World Bank, 2017). Global PV electricity production is projected to rapidly increase and many studies assume that the majority of future solar PV installations will be of the crystalline silicon variety. (Euroalliages, 2019).

Global consumption of polycrystalline silicon for solar-grade and semiconductors was forecast to increase by a compound average growth rate of 10.2% from 2016 to 2025 (USGS, 2016b)

The estimations for the outlook for supply and demand of silicon metal are shown in Table 188, provided by industry experts.

[259] Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC

Table 188: Qualitative forecast of supply and demand of silicon metal (source: European Commission, 2017)

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
Silicon metal	x		+	+	+	+	+	+

23.2.2EU trade

The EU is a net importer of silicon metal with an average annual net import figure in the period 2012-2016 of 344kt per year. There has been an increasing trend of EU import of silicon metal between the years 2012-2016 (Figure 458).

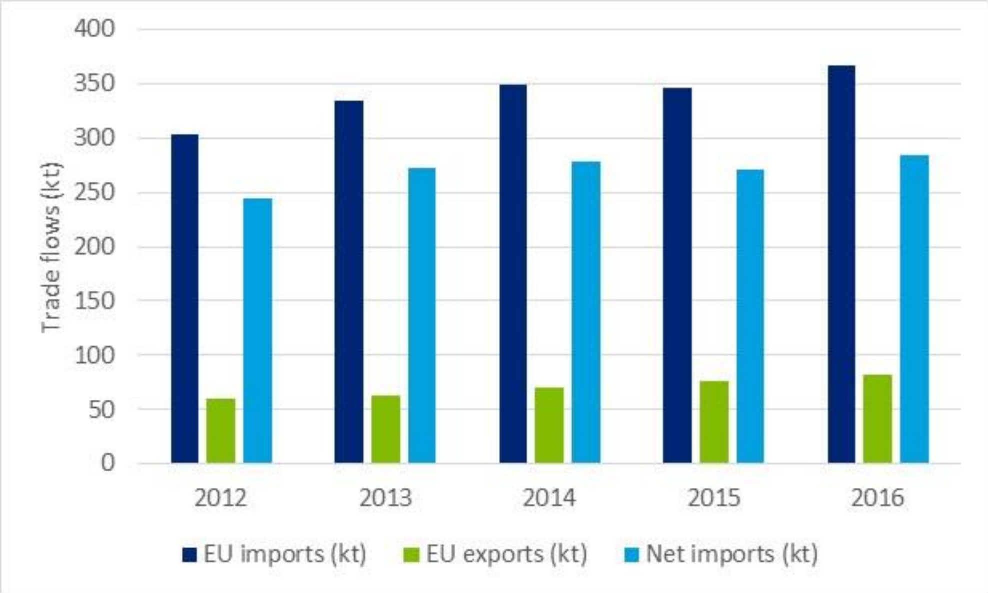

Figure 458: EU trade flows for silicon metal. Data from Eurostat, 2012-2016 (Eurostat, 2019a)

Approximately 68% of the EU apparent consumption of silicon metal was supplied from outside EU. The main suppliers of the EU are Norway, China, and Brazil which represent 44%, 16% and 10% of the total EU imports respectively (Figure 459) – although these shares are evolving along the years.

There is no restriction on commercial trade of silicon metal (i.e. no export tax, export quota or export prohibition of silicon metal from extra-EU countries) with the EU Member States. However, China applied a 15% export tax on all exports of silicon metal, re-establishing de facto some level playing field with the EU according to several industrial players, which was removed in 2013 (OECD, 2016; Euroalliages, 2016).

Some free trade agreements exist with major EU suppliers: Norway and Bosnia Herzegovina (European Commission, 2016).

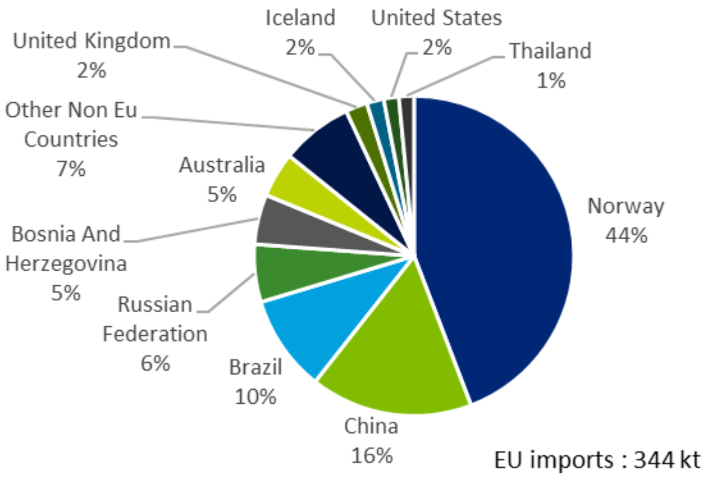

Figure 459: EU imports of silicon metal, annual average for the year 2012-2016. Data from Eurostat. (Eurostat, 2019a)

23.2.3Prices and price volatility

Silicon metal prices trend is shown in Figure 460. Silicon metal prices increased slowly between 2002 and late 2007 and reached the peak around spring 2008. The economic recession in 2008 and 2009 resulted in prices decreasing sharply back to 2007 levels. Another pike in silicon prices was experienced in 2011. Spot prices of silicon have dropped between 2013 and 2015, due to a flat demand and a steady draw-down of silicon inventories outside China in 2014-2015 (CRU, 2015). In 2016, the price of silicon metal dropped again at USD 2006 per tonne. The oversupply in the market combined with decreased steel production and weak aluminium alloy demand contributed to decreased silicon prices in 2015-2016 (USGS, 2017).

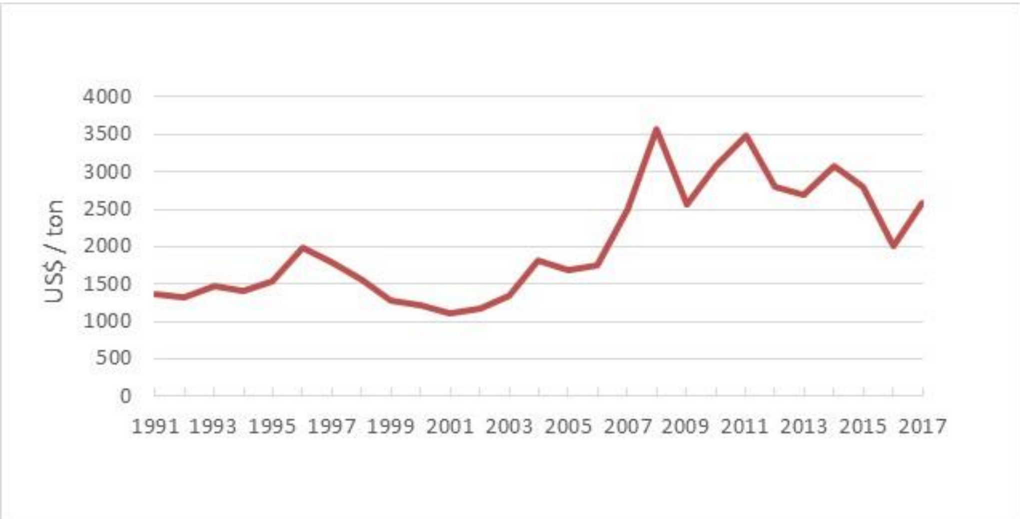

Figure 460: Prices of metallurgical grade silicon metal (USD per tonne) from 1991 to 2017. Data from DERA mineral price monitor (DERA, 2019)

23.3 EU demand

23.3.1 EU demand and consumption

The annual European consumption of silicon metal totalled around 433 kt in over the period 2012-2016. Approximately 68% of the EU consumption of silicon metal came from import activity with non-EU countries (Eurostat, 2019). The main suppliers to the EU are Norway (44%), China (17%) and Brazil (10%) and The EU domestic production of silicon metal represented 32% of the total quantity consumed in the EU.

23.3.2 Uses and end-uses of silicon metal in the EU

The major uses of silicon in the EU remained the same as in 2010-2014 (Figure 461). The main uses of silicon metal are in the aluminium and chemical industries (European Commission, 2014). In addition, silicon metal is a strategic raw material used in the renewable energy (photovoltaic industry) and in electronic devices.

- Chemical industry: Silicon metal is used to produce silicones, synthetic silica and silanes. Silicone products such as surfactants, lubricant, sealants and adhesives are used in various sectors including construction (e.g. in insulating rubbers), industrial processes (e.g. as antifoam agent in the oil and gas industry), as well as personal care (e.g. cosmetics) and transport (CES, 2016). Silanes are used in the glass, ceramic, foundry and painting industries (European Commission, 2014; Euroalliages, 2016).
- Aluminium alloys: Silicon is dissolved in molten aluminium to improve the viscosity of the liquid aluminium and to improve the mechanical properties of aluminium alloys. There are two important groups of aluminium alloys which contain silicon as a main element: casting alloys and wrought alloys. In the former the silicon content is 7% to 12%; wrought alloys contain magnesium and silicon, where the silicon content is between 0.5% and 1%. The primary use is in castings in the automotive industry due to improved casting characteristics described above and the reduced weight of the components (European Commission, 2014; Euroalliages, 2016).
- Solar cells: Ultrahigh-purity grades silicon is used for the production of solar panels. Silicon solar cells are the most common cells used in commercially available solar panels. Crystalline silicon PV cells have laboratory energy conversion efficiencies as high as 25% for single-crystal cells and 20.4% for multicrystalline cells. However, industrially produced solar modules currently achieve efficiencies ranging from 18%–24%. Solar cell prices dropped significantly in 2011, partly due to polysilicon selling price decrease resulting from over production (European Commission, 2014; Euroalliages, 2016).
- Electronics: Ultra-high purity grade silicon is used extensively in electronic devices such as silicon semiconductors, transistors, printed circuit boards and integrated circuits. Semiconductor-grade silicon metal used in making computer chips is crucial to modern technology (European Commission, 2014; Euroalliages, 2016).
- Other applications of silicon metal include explosives, refractories and ceramics.

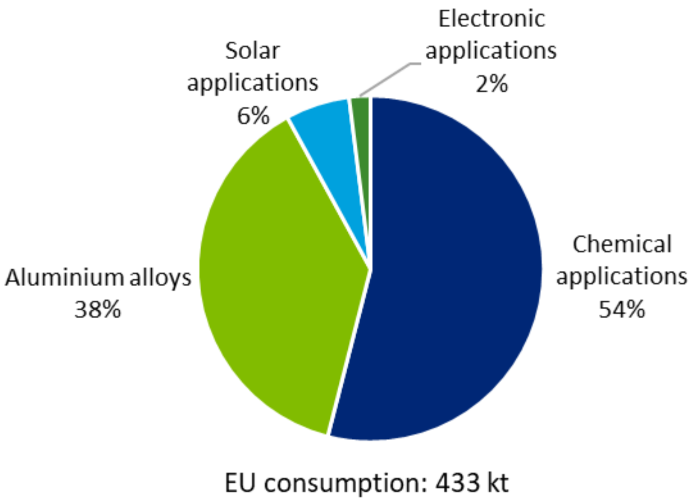

Figure 461: EU end uses of silicon metal (SCRREEN, 2019). Annual average figures for 2012-2016[260].

Table 189 presents the main uses of silicon metal in the EU. Relevant industry sectors are described using the NACE sector codes (Eurostat, 2019b).

Table 189: Silicon metal applications, 2-digit and associated 4-digit NACE sectors, and value added per sector. [Data from the Eurostat database, (Eurostat, 2019b)]

Applications	2-digit NACE sector	4-digit NACE sectors	Value added of NACE 2 sector (millions €)
Chemical applications	C20 - Manufacture of chemicals and chemical products	C2016 - Manufacture of plastics in primary forms; C2017 - Manufacture of synthetic rubber in primary forms; C2030 - Manufacture of paints, varnishes and similar coatings, printing ink and mastics; C2041 - Manufacture of soap and detergents, cleaning and polishing preparations	105,514
Aluminium alloys	C24 - Manufacture of basic metals	C2442 - Aluminium production	55,426
Solar applications	C26 - Manufacture of computer, electronic and optical products	C2611 - Manufacture of electronic components	65,703
Electronic applications	C26 - Manufacture of computer, electronic and optical products	C2611 - Manufacture of electronic components	65,703

[260] Apparent consumption figures for silicon metal is derived from adding EU production (based on the figures reported by British Geological Survey, 2019) and imports and subtracting exports (imports and exports figures are based on the information reported by Eurostat-Comext, 2019)

23.3.3 Substitution

Substitutes are identified for the applications and end uses of the commodity of interest. In the case of silicon metal, there are no materials that can replace any of the main uses of metallurgical silicon without serious loss of end performance or increase of cost.

In chemical application, there is no material for replacement of silicon in silicones and silanes, or in end-use products based on these chemicals. In comparison, materials such as thermoplastics or rubber are not as durable and heat resistant as silicones. Therefore, the use of silicones vs. substitutes depends on the expected properties of the final product; this characteristic is already accounted for when selecting the most appropriate material. No viable current substitute is currently considered (CES, 2016).

In manufacturing of aluminium, silicon is used to lower the melting point in aluminium manufacturing and to increase strength, machineability and corrosion resistance in aluminium products. There is currently no substitute to silicon metal for this application (Tercero, 2018).

In solar application, replacement technologies to silicon-based technology for solar applications exist (however this is not material to material substitution but rather equivalent technology), with reduced performance. An example is, CIGS technology, which is up to twice more expensive than silicon-based technology. It is estimated that Si technology represent 92% of the EU market; the rest is shared between CdTe and CIGS technologies. New hybrid technologies are currently being developed, but not on the market yet.

In the micro-electronics industry, GaAs is a substitute for silicon but with lower performance and is not used for mainstream applications. Germanium may be used as well in combination to silicon (i.e. silicon remains as physical support/monocrystalline, Ge on the top of layer). R&D on replacement technologies concerns graphic layers, carbon nanotubes (Wacker, 2016).

23.4 Supply

23.4.1 EU supply chain

The EU supply chain of silicon metal can be described by the following key points:

- Quartz mines and resources in the EU were reported by Lauri, L. et. al, (2018). However, it is not clear if any of these has high-purity quartz necessary for silicon metal production. High purity quartz is extracted in three EU Member States and processed into silicon metal – namely France, Spain and Germany. There is no precise data on high purity quartz extraction, at EU level or at global level. The majority of high purity quartz is directly turned into silicon metal onsite (Bio Intelligence Service, 2015).
- The 5-year average EU production of silicon metal between 2012 and 2016 was 158 kt per year, which accounts for 8% of the global production. Producing EU countries are France, Spain and Germany (WMD, 2019).
- The traded quantities of silicon metal show that the EU is a net importer of silicon metal. Domestic production of silicon cannot satisfy the EU demand. Norway is the main country supplying silicon metal to the EU due to its geographical proximity, and accounts for 44% of total imports over the year 2012-2016 (Eurostat, 2019a).
- Europe imports silicon in the forms of silicon metal as well as intermediate products such as silicon-based chemicals and silicon wafers.
- The import reliance for silicon metal in the EU is estimated at 63%, which is not an unexpected figure considering the relatively small EU production, high import and low exports figures.

- An end-of-life recycling plant for PV waste exists in France. In 2017, Rousset in Bouches-du-Rhône, Veolia, PV CYCLE and the Syndicat des Énergies Renouvelables opened the first line in France and in Europe dedicated to recycling end-of-life photovoltaic panels. The plant was planned to process 1,800 tonnes of material in 2017 pear year that will gradually increase to 4,000 tonnes by 2021 (Veolia, 2018).

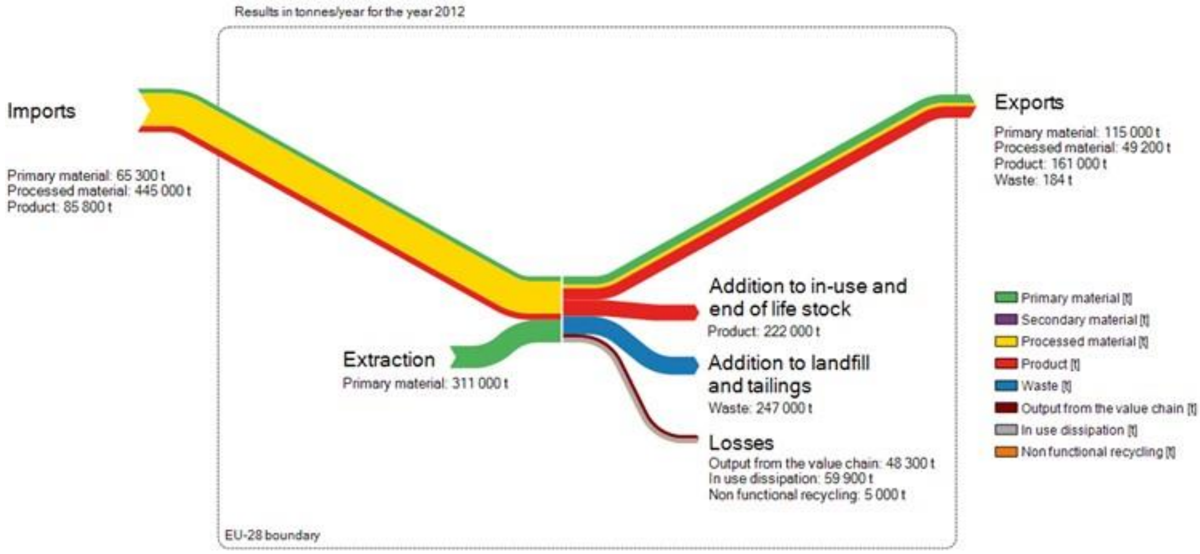

Figure 462: Material system analysis of silicon metal, reference year 2012 (simplified for EU-27 and the UK)(BioIntelligence Service, 2015)

The flows of silicon metal through the EU economy are demonstrated in Figure 462.

23.4.2Supply from primary materials

23.4.2.1 Geology, resources and reserves of silicon metal

Geological occurrence:

Quartz makes up approximately 12% by weight of the lithosphere, making it the second most common mineral in the Earth's crust. SiO_2 accounts for 66.62% of the mass of the upper crust (Rudnick, 2003). Quartz is found in magmatic, metamorphic and sedimentary rocks and may be distinguished between numerous quartz types, depending on its genesis and specific properties.

Quartz occurs in many different settings throughout the geological record; however, only very few deposits are suitable in volume, quality and amenability to tailored refining methods for speciality high purity applications, which require extreme qualities, with specific low-ppm or sub-ppm requirements for maximum concentrations of certain trace metals (European Commission, 2014).

Magmatic SiO_2 rocks represent more than 90% of quartz and other SiO_2 minerals of the lithosphere, however this share is not representative of the materials used to process silicon metal. The majority of quartz in SiO_2-rich igneous and volcanic rocks (granite, rhyolite) is intergrown with other rock-forming silicates. Therefore, quartz from these rocks does not play an important role as raw material. In contrast, pegmatite bodies and hydrothermal veins Quartz makes up approximately 12% by weight of the lithosphere, making it the second most common mineral in the Earth's crust. SiO2 accounts for 66.62% of the mass of the upper crust (Rudnick, 2003). Quartz is found in magmatic, metamorphic and sedimentary rocks – and may be distinguished between numerous quartz types, depending on its genesis and specific properties.

Quartz from metamorphic rocks represents only about 3% of the whole quartz in the lithosphere (Rösler, 1981) and are not usable as high-quality SiO2 raw material. However, metamorphic quartzites of high chemical purity (98% SiO2) can sometimes be used as raw materials for high-technology industries. Moreover, metamorphogenic quartz mobilisates often represent a high-purity SiO2 material that can be used e.g. as raw material for single-crystal growth (Haus, 2012).

Finally, sedimentary SiO_2 rocks represent the majority of the high-purity quartz volumes supplied to the industry worldwide. However, quartz in sedimentary rocks (mostly under the form of quartz sands, quartz gravel or sedimentary quartzite) is used in silica sands or ferrosilicon value chains, but its purity does not rank high enough for any use as silicon metal (Haus, 2012).

Global resources and reserves of high purity quarts[261]:

Information on high purity quartz from the Minerals4EU platform (2014) is available in the silica sands factsheet, but is not displayed here as only a small – and unknown – share or it is part of the silicon metal value chain.

It is acknowledged that reserves of high purity quartz are large enough to meet the worldwide consumption needs for the next decades.

EU resources and reserves[262]***:***

In the EU, a number of quartz mines and resources have been reported. However, it is not clear if any of these has high-purity quartz necessary for silicon metal production. In Austria, Bulgaria, Greece, and Italy, some deposits were identified with no information on their resource. In Austria and Portugal, there were some deposits and production of quartz in the past. In Finland, there are two active quartz mines with a production quantity of 93 kt of quartz in 2016, some of which may be categorised to medium to high-purity quartz. There are 52 quartz deposits in Sweden, including three active mines producing 100 kt of quartz per year used in the ferro-alloy industry.

[261] There is no single source of comprehensive evaluations for resources and reserves that apply the same criteria to deposits of silicon metal in different geographic areas of the EU or globally. The USGS collects information about the quantity and quality of mineral resources but does not directly measure reserves, and companies or governments do not directly report reserves to the USGS. Individual companies may publish regular mineral resource and reserve reports, but reporting is done using a variety of systems of reporting depending on the location of their operation, their corporate identity and stock market requirements. Translations between national reporting codes are possible by application of the CRIRSCO template. which is also consistent with the United Nations Framework Classification (UNFC) system. However, reserve and resource data are changing continuously as exploration and mining proceed and are thus influenced by market conditions and should be followed continuously.

[262] For Europe, there is no complete and harmonised dataset that presents total EU resource and reserve estimates for silicon metal. The Minerals4EU project is the only EU-level repository of some mineral resource and reserve data for silicon metal, but this information does not provide a complete picture for Europe. It includes estimates based on a variety of reporting codes used by different countries, and different types of non-comparable datasets (e.g. historic estimates, inferred reserves figures only, etc.). In addition, translations of Minerals4EU data by application of the CRIRSCO template is not always possible, meaning that not all resource and reserve data for silicon metal the national/regional level is consistent with the United Nations Framework Classification (UNFC) system (Minerals4EU 2019).Many documented resources in Europe are based on historic estimates and are of little current economic interest. Data for these may not always be presentable in accordance with the UNFC system. However, a very solid estimation can be done by experts.

There are also known unexploited occurrences in Sweden, containing medium to high quality quartz (Lauri, L. et. al., 2018).

23.4.2.2 Mining of high purity quartz and processing of silicon metal

Quartz extraction occurs by drilling and blasting operations from veins deposits (vein quartz) as well as from fluvial deposits (quartz pebbles), by simple excavation methods. The major deposits of high purity quartz currently mined for silicon metal processing are located in Turkey, Egypt and Spain, among others (Euroalliages, 2016). Others include the USA, Norway and Russia. High purity quartz for the silicon metal industry is extracted as main product; most of the quartz processed in the EU into silicon originates from European countries, namely Spain and France (BGS, 2016). There is no reliable worldwide data.

Once mined, quartz is reduced to silicon metal by carbothermic reduction. This takes place in a submerged electric arc furnace containing quartz and carbon materials, such as coke and charcoal. Electric energy is supplied by electrodes submerged in the charge – with temperatures from 800 to 1,300°C at the top of the furnace, and exceeding 2,000°C at the bottom, near the electrodes (Aasly, 2008). Molten silicon metal is produced at the bottom of the furnace. The silicon produced has a purity of approximately 98.5%; the main impurities are iron, aluminium and calcium. Most silicon applications require further refining to reach 99% purity; this is done by treating the molten silica with oxidative gas and slag forming additives. Silicon of this purity is known as metallurgical grade silicon and is used in the aluminium, chemical and polysilicon industries. Semiconductor and solar grade silicon (polysilicon) must be of ultra-high purity (between 6N and 11N) to ensure semiconducting properties; this is commonly done through the Siemens process (European Commission, 2014). In this process, the metallurgical grade silicon is converted to a volatile compound that is condensed and refined by fractional distillation. Ultra-pure silicon is then extracted from this refined product.

The quartz raw material follows specific requirements from the industry to be used in silicon metal processing, among which: chemistry (specifications on impurities), lump size; as well as mechanical and thermal strength, and softening properties. These characteristics may influence the process itself or the purity of the silicon metal processed (Aasly, 2008).

The processing of silicon also generates silica fumes which have been successfully transformed by the silicon (and ferro-silicon) industry from waste to a by-product.

23.4.2.3 World and EU production of silicon metal

Production share of refined silicon metal by country (average 2012-2016) is presented in Figure 463. The production in this period reached an average of 2,541 kt per year. Global supply of silicon metal is dominated by China with about 1,669 kt per year equivalent to 66% of the global annual productionover the years 2012-2016. United States and Brazil were the second and third largest producing countries, each accounting for 198 kt per year (8% of global supply) and 190 kt per year (7% of global supply).

The overcapacity built in China in the past decades is equivalent to more than twice the world consumption (2,9 million tonnes) in 2019 (Euroalliages, 2020). Chinese production capacity of silicon metal increased from 4 million tonnes in 2014 to 6-7 million tonnes in 2019. This expansion of more than 2 million tonnes is concentrated in the Xinjiang province. This region is able on its own to almost supply the worldwide consumption of silicon. It is important to note that almost 100% of power generation in this region is coal based.

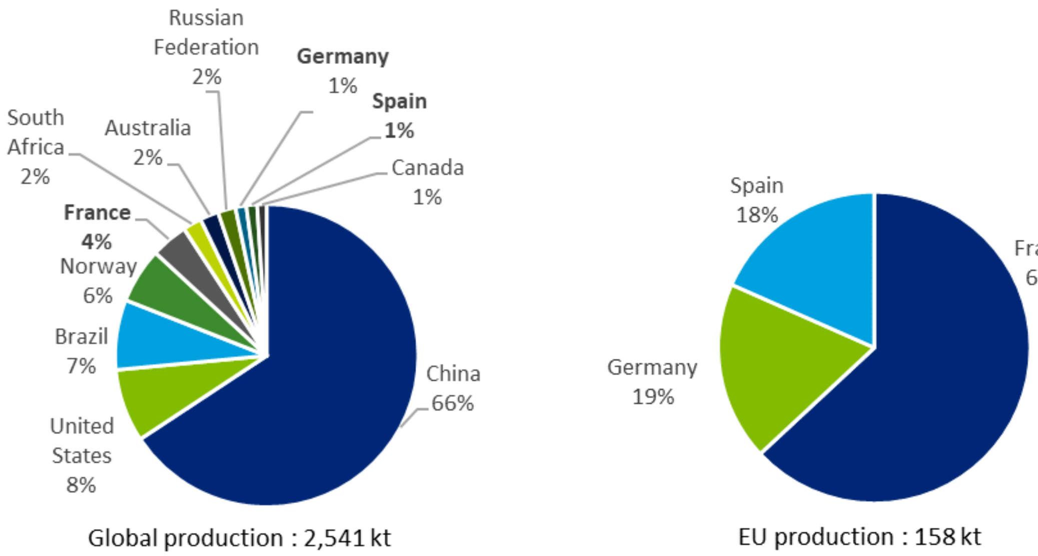

Figure 463: Global (left) and EU (right) refined production of silicon metal, average 2012–2016 (Data from BGS, 2019)

23.4.3 Supply from secondary materials/recycling

Most chemical applications of silicon metal are dispersive, thus not allowing for any recovery. In recent years there have been functional recycling plants of Si scrap from wafers and from photovoltaic panels, such as:

- Resitec in Norway that recycles wafers generated in the production of photovoltaic materials (PV). ReSiTec produces more than 500 tons of recycled, high-purity silicon metal powder per year (Moen, et. al., 2017)
- The recycling plant Veolia in France that treat end-of-life solar panel

Silicon metal used in the electronic industry is of higher quality than for other applications. Most of the silicon scrap generated during crystal ingot and wafer production for electronic applications can therefore be used in the photovoltaic industry (Woditsch and Koch, 2002).

There is no functional recycling of silicon metal in aluminium alloys.

In the industry buying metallurgical grade silicon, for economic and environmental reasons, recycling streams exist as well as separate or specialised processes for utilisation of any side streams. However, very little material is sold back into the market by metallurgical silicon users (Euroalliages, 2016).

Although there were new functional recycling plants for silicon metal, it has not been possible to quantify the precise updated end of life recycling input rate for silicon metal. The recycling input rate, was estimated to remain low. According to the MSA study of silicon metal, the end of life recycling input rate for silicon metal is 0% (Bio Intelligence Service, 2015). This value was used for the calculation of criticality.

Table 190: Material flows relevant to the EOL-RIR of silicon metal[263]

MSA Flow	Value (t)
B.1.1 Production of primary material as main product in EU sent to processing in EU	180,719
B.1.2 Production of primary material as by product in EU sent to processing in EU	0
C.1.3 Imports to EU of primary material	65,254
C.1.4 Imports to EU of secondary material	0
D.1.3 Imports to EU of processed material	444,806
E.1.6 Products at end of life in EU collected for treatment	206,619
F.1.1 Exports from EU of manufactured products at end-of-life	183
F.1.2 Imports to EU of manufactured products at end-of-life	0
G.1.1 Production of secondary material from post consumer functional recycling in EU sent to processing in EU	0
G.1.2 Production of secondary material from post consumer functional recycling in EU sent to manufacture in EU	0

23.5 Other considerations

23.5.1 Environmental and health and safety issues

The production of silicon metal is energy intensive, therefore the energy cost is a major production cost element. The energy source used by the major silicon producing country, China, is coal. According to Euroalliages, Chinese producers also benefit from lower power tariffs (European Commission, 2017). On the contrary, most silicon metal plants in Europe are historically located close to hydropower sources. A new silicon metal plant based on exclusively renewable energy was going to be scheduled in Iceland in 2018. The plant would process raw material from quarry in Poland.

In Europe, silicon production is subject to the European Directive on the Emissions Trading Scheme (2003/87/EC) which entails direct and indirect carbon costs. Today there is no global level playing field when it comes to climate requirements (Euroalliages, 2016). Silicon is not hazard classified.

23.5.2 Socio-economic issues

No specific issues were identified during data collection and stakeholders consultation.

23.6 Comparison with previous EU assessments

The assessment has been conducted using the same methodology as for the 2017 list. The results of this and earlier assessments are shown in Table 191.

Table 191: Economic importance and supply risk results for silicon metal in the assessments of 2011, 2014, 2017, 2020 (European Commission, 2011-2014-2017)

Assessment	2011			2014			2017			2020	
Indicator	EI	SR		EI	SR		EI	SR		EI	SR
Silicon metal	-	-		7.13	1.63		3.8	1.0		4.2	1.18

[263] EOL-RIR=(G.1.1+G.1.2)/(B.1.1+B.1.2+C.1.3+D.1.3+C.1.4+G.1.1+G.1.2)

The economic importance of silicon metal has slightly increased in comparison to the economic importance value in criticality assessment 2017. The increasing value is caused by the change in value added in the sectors to which the economic importance of silicon metal was assigned.

The supply risk of silicon metal showed a higher score in comparison to the result in criticality assessment 2017. This change can be explained by the increase of the production from China over the period 2012-2016, making the global supply more concentrated. Moreover, there was a decreasing EU domestic production of silicon metal during the same period.

23.7 Data sources

The trade data of silicon metal in this assessment included codes 28046100 'Silicon containing ≥99.99% by weight of silicon' and 28046900 'Silicon containing <99.99% by weight of silicon'. These data were averaged over the five-year period 2012 to 2016.

End-use application shares figure for silicon metal in the EU is based on the criticality assessment 2017. Their validity was verified by industry experts (Euroalliages, 2019). Production data for silicon metal are from BGS World Mineral Statistics dataset. Trade data were extracted from the Eurostat Easy Comext database (Eurostat, 2019). Data on trade agreements are taken from the DG Trade webpages (European Commission, 2019). Information on export restrictions are derived from the OECD Export restrictions on the Industrial Raw Materials database (OECD, 2019).

23.7.1 Data sources used in the factsheet

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23.8 Acknowledgments

This factsheet was prepared by the JRC. The authors would like to thank SCRREEN experts network, the EC Ad Hoc Working Group on Critical Raw Materials and all other relevant stakeholders for their contributions to the preparation of this Factsheet.