01 September 2023

PFAS restriction: EPMF input into public consultation

Since 2007, the European Precious Metals Federation has supported European companies working with gold, silver, rhenium and the platinum group metals (platinum, palladium, osmium, rhodium, ruthenium, and iridium). Our 35 Members companies and 3 national association include work leaders in extraction, refining and recycling of precious metals. They also include a highly diverse range of companies involved in consumer and industrial applications. The EPMF facilitates the interface between policy makers, regulatory authorities, and the precious metals industry in a wide range of issues. Furthermore, the EPMF promotes sustainability and ethical standards in the precious metals industry, including responsible sourcing and supply chain management. The organisation collaborates with other industry associations and stakeholders to achieve these goals and to ensure a sustainable and responsible future for the precious metals industry.

Executive summary

The Precious Metals industry supports the PFAS restriction. However, the current scope is far too broad and not based on hazard nor risk related to the different substances. This means that the impact on the precious metals industry using directly or indirectly the PFAS to produce and recycle precious metals will be significant. Indeed, the Precious Metals industry has identified direct (electroplating) or indirect (industrial equipment, PPE and analytical equipment) uses of PFAS but also some uses intrinsically related to the use of precious metals (green hydrogen). These uses occur in a well-controlled (industrial) environment, with negligible potential for release / exposure to humans and the environment.

It is worth noting that the PFAS is a huge group of substances with different levels of hazard. A lot of these substances are considered of low concern (cf. OECD[1]), such as the fluoropolymers.

For most of the uses related to precious metals, PFAS are selected because of their unique properties and there are no alternatives available today with a comparable performance. If these uses were no longer allowed and/or the exemption time is not sufficient to find alternatives, this might have significant impacts on the precious metals manufacturing and recycling activities in the EU, and thus be incompatible with e.g., the EU Green Deal.

[1] Data Analysis of the identification of correlations between polymer characteristics and potential for health or ecotoxicological concern, OECD 2009. https://www.oecd.org/env/ehs/risk-assessment/42081261.pdf

PFAS are also present in recycling streams containing precious metals ('PM'). The PFAS are all being destroyed during the recycling process, trapped from the flue gas and duly disposed of. Any limitation on the use of PM recycling streams containing PFAS will restrict PM recycling activities in Europe.

It is worth noting that the PGMs (Platinum Group Metals) have been identified at Critical Raw Materials. The Critical Raw Materials act sets targets to allow Europe to be resilient. The ban of all PFAS in the EU at short notice will for sure jeopardize the success of the Critical Raw Materials act.

Hence, the EPMF would like to request that:

- **the hazard profile of the PFAS is considered to prioritize the PFAS included in the restriction.**
- **the scope of the restriction is limited and that substances of low concern (as per OECD criteria) are exempted from the restriction.**
- **if the exemption must be use driven, the uses of PFAS outlined above must be exempted for at least 12 years and a mechanism to renew these exemptions must be put in place.**

Critical uses for the precious metals industry

Industrial equipment in the precious metals industry

The restriction proposal affects the precious metals industry because PFAS (predominantly fluoropolymers) are present in its production lines. These are mostly fluorinated polymers used in electrical equipment, seals, hoses, wires, pipe coatings, tank-linings, or gaskets. Fluoropolymers are extremely important in this equipment due to their water repellent properties and thus critical to avoid leakage of process fluids in the surrounding environment. PFAS-containing materials are also needed in extreme conditions because of their chemical and thermal resistance (high or low temperatures, high frictional resistance, aggressive/corrosive/toxic chemical conditions; gas tightness or a combination of these in relevant industrial processes). Typical PFAS used are PVDF (CAS 24937-79-9), PTFE (CAS 90003-84-0), FKM/FFKM or ETFE (CAS 25038-71-5) and are considered as polymers of low concern following the OECD criteria. Non-PFAS alternatives, such as polypropylene are significantly less durable under the conditions of use in precious metals refineries and would carry increased risk of premature failures leading to safety incidents, such as loss of primary containment, involving high value and often corrosive refinery streams.

Many uses of these PFAS (and others) that are critical for industrial equipment are not mentioned in the restriction proposal. The use of PFAS-containing gaskets, hoses, wires, valves, pipes, pumps, and coating is only temporarily exempted in the restriction proposal and only in certain industrial uses (e.g.: food and feed production). No exemption is foreseen in industrial equipment to produce precious metals which means that this will deeply impact the production of precious metals in the EU while on the other hand the Critical Raw Materials Act has listed Platinum Group Metals ('PGMs') as critical and strategic in achieving the targets of green technologies. Potential supply risk can only be mitigated by more recycling and production in the EU. There is hence an obvious incoherence between the way the PFAS restriction has currently been drafted and the need to have a resilient European Union. A lack of these plant components would have a considerable influence on the service life, functionality, and safety of industrial plants.

On top of the precious metals production/recycling, other industries intrinsically related to the use of precious metals have not been exempted like the electrolysers or the photovoltaic systems.

Based on current knowledge, there are no suitable alternatives to PFAS for industrial equipment meeting modern safety and chemical containment standards. Considering the price of PFAS, it is also important to highlight that the use is limited to the maximum extent. Investments in production facilities are needed in the EU to produce the necessary materials to address the green-transition and net-zero targets. The potential ban not only puts the future employment of the new technologies at risk but is at present proving to be a substantial barrier for this urgent need of investments. For some processes, glass equipment could be considered as an alternative. However, in the latter case, PFAS are still needed in sealings. It is worth noting that historically, gaskets requiring sufficient thermal or chemical resistance were made of asbestos. Due to its classification as a carcinogenic substance, asbestos has been substituted by fluoropolymers (Teflon) belonging to the wide group of PFAS.

Another important issue is the lifetime of an industrial installation. Plants are built to be operational for several decades, and changes in processes and/or infrastructure cannot be readily implemented. Moreover, the installations must continuously be maintained during their entire lifetime. Accordingly, it is pivotal to consider the potential impact on spare and used parts in the discussion. This must be reflected in the exemptions but also in the transition periods which have been set. Currently, after the transitional period of 18 months, repairing or regular replacement of wear parts in long-life equipment/products which are not derogated (like seals or hoses in precious metals production plants) would no longer be possible. It is also very Important to foresee a mechanism to be able to prolong some exemptions when relevant and to exempt the substances of low concern and not only specific uses.

Strong acid precious metals electroplating

1H,1H, 2H, 2H-Perfluorooctanesulfonic acid/Tridecafluorooctanesulfonic acid (CAS 27619-97-2) is used as a tensioactive agent/surfactant in precious metals electroplating products (jewellery and watchmaking). Precious metals electroplating solutions are very acidic (pH<1) and corrosive. PFAS are stable under these extreme and acidic conditions whereas other (alternative) tensioactive substances would be destroyed quickly. The PFAS is diluted in the acidic aquatic solution, and there is no reaction occurring. The amount of PFAS used is low (estimated at 50 kg per year) and there is no emission to the environment. Currently, there is no alternative (neither substance nor technology) to this type of PFAS due to the lack of stability of potential alternatives in such an acid environment (pH<1). Further research and development will be needed, but the risk is high of finding a substance far less stable with unknown technical consequences on customer processes. The aim still is to substitute PFAS, but the process could be long.

Personal Protective Equipment

The precious metals industry is using Personal Protective Equipment (PPE) containing PFAS to protect workers against risks related to substances and mixtures which are hazardous to health (cf. Regulation (EU) 2016/425, annex I, risk Category III (a)). The derogation of 12 years proposed in the restriction is welcomed and based on the current knowledge. This period should be sufficient to find alternatives and develop, test and approve the new safety products essential for the precious metals industry. If this derogation time is not sufficient, it is then recommended to have a mechanism in place to prolong the exemption.

Analytical equipment

PFAS are used in crucibles for microwave fusion during analysis of precious metals rich materials. Inert and thermal/chemical resistant materials are needed for this application and today there exists no alternative available for this use.

Please note that this issue is more horizontal within the analytical field, and also applies to e.g., laboratory analyzers (like ICP-OES) where inert materials such as Teflon are critical to ensure proper functioning.

Hydrogen technologies

The EU has set a very ambitious target of becoming the first climate-neutral continent by 2050. To meet this target, the EU put in place the European Green Deal, a hydrogen strategy and REPowerEU, with the development of the EU hydrogen economy, a strong focus across all three. To meet a target of 10 million tonne domestic production, the vision is to install 6 GW of renewable hydrogen electrolysers by 2024 and at least 100-120 GW of renewable hydrogen electrolysers by 2030 (today Europe has less than 1.5 GW).

Renewable hydrogen is produced using energy from renewables, such as wind and solar, to split water into hydrogen and oxygen in a device known as an electrolyser. There are several different electrolyser technologies available but the two most frequently used now are alkaline water electrolysis (AEL) and proton exchange membrane (PEM) electrolysis. At the heart of every PEM electrolyser is a catalyst coated membrane (CCM) which is responsible for the conversion of water into hydrogen. CCMs consist of a proton exchange membrane made from an ion conducting fluoropolymer (ionomer) and precisely engineered layers of platinum group metals (PGMs) and ionomer.

Hydrogen fuel cells, that use hydrogen to generate power electrochemically, are seen as major future contributors to decarbonising transport, one of the most significant contributors to greenhouse gas emissions globally. Fuel cells that are PEM-based (as with PEM electrolysers) have PGMs and fluoropolymers as key components.

For both PEM electrolysers and fuel cells, at their end of life, recovery of the critically and strategically important PGMs will be a key factor, so it is fully expected that the sector will reach a near-closed loop model which will have the additional benefit of controlling PFAS emissions to the environment in this lifecycle phase. That is, current PGMs refining employs an initial pyrometallurgical process which is capable of destroying the ionomer and controlling PFAS emissions. Regulated “producer responsibilities” and mandates on recycling could serve to “close the loop”.

For more information on PFAS and hydrogen: Hydrogen-Europe-position-paper-on-PFAS-ban_v12_FINAL.pdf (hydrogeneurope.eu).

The EPMF supports the comments and the requests of Hydrogen Europe to the public consultation.

The application of PGMs in fuel cells (FC) is widely known, but the application of PGMs in water electrolysis (WE) and hydrogen refining is also an important application. Anode catalysts in these electrolysers are usually based on PGMs (iridium or ruthenium, with iridium being the preferred component). Iridium and ruthenium are mined as by-products to platinum mining and therefore the mined supply of platinum could also supply the demand for widespread electrolysers. Palladium can be used to generate, purify, store, and detect hydrogen, thus performing many important functions in the hydrogen economy. As a thin membrane, palladium will allow hydrogen to permeate through the membrane, but block all other gases. The further discovery of the stability of palladium-silver alloys and the ability to manufacture membranes of these alloys makes hydrogen purification using palladium-silver membranes a possible future source of demand for these precious metals. This means that the use of PGMs is intrinsically linked to the use of PFAS in the PEM for FC and WE. The restriction of PFAS will therefore have a tremendous impact on the precious metals industry.

For more information on PGMs as catalysts in fuel cell and electrolysers: Resources | Free Full-Text | Platinum Group Metals: A Review of Resources, Production and Usage with a Focus on Catalysts (mdpi.com).

An exemption is needed for the use of fluoropolymers in industrial uses and especially in the hydrogen sector (PEM WE and PEM FC) to avoid threatening the hydrogen industry in the EU, as well as the Green Deal objectives and the EU's RePower EU strategy. No exemption of these PFAS, will also mean a huge impact on the precious metals industry and especially on PGMs production/recycling in the EU.

Process steps for silver inks handling

Silver inks are based on reactive solvents and not compatible with unprotected polymeric surfaces. Accordingly, all process steps that requires ink handling in terms of storage, transport, dispensing, manufacturing, and separation require robust materials. Some of these operations could be done using alternatives like glass or stainless steel. However, interfaces and flexible components require more flexible robust materials. In this case, typical rubber, silicone, or polymeric surfaces are dissolved easily and cannot be considered as suitable alternatives to PFAS. PFAS containing polymers are the only sufficiently robust materials that can resist to the ink. The fluoropolymers behave inertly and there is no reaction between the ink and the PFAS.

Precious metals recycling streams

Precious metals recycling streams can contain PFAS.

The most popular and in the future utmost relevant example is the recycling of the fuel cell/electrolysis membranes which contain precious metals (see Is iridium demand a potential bottleneck in the realization of large-scale PEM water electrolysis? – ScienceDirect) and PFAS. If membranes cannot be recycled in the future due to the proposed restriction this will hamper the recovery of PGMs and the access to these materials which are critical for a series of green technologies. This will have a negative impact on the different EU policies (Green Deal, REPower EU etc.). This will also have a consequence on the Critical Raw Materials Act and the recycling targets set for critical materials like the PGMs.

Another important recycling stream containing PFAS comes from the electronics industry. Several electronic devices contain PFAS which are either intentionally added or present as an impurity coming from manufacturing process (see Check-your-Tech_230420.pdf (chemsec.org)). These streams are very important for the recycling of precious metals, mainly silver and gold (BCPS_34523_-_E-waste-as-a-source-_0000.pdf (polsl.pl)). During the recycling process, there is a thermal treatment with temperatures above 900°C and in most companies >1100°C, the temperature considered sufficient to destroy PFAS. PM recycling facilities are equipped with flue gas cleaning technologies that also collect fluorine. This will be duly disposed of and thus not emitted to the environment or be at risk of poisoning any further lifecycle of the PM.

It is important to ensure that -until all these streams have been cleaned from PFAS- the precious metals industry could continue to recycle feedstock containing PFAS despite the ongoing restriction. Special attention is required to ensure that electronic scraps are not exported outside the EU due to the presence of PFAS. This would give a very negative impact on EU resilience and access to Critical Raw Materials. Also, the presence of PFAS does not impact the quality of the recycled PMs.

For more information on elimination of PFAS in waste streams or of PFAS waste please see the following literature:

- Recent advances on PFAS degradation via thermal and nonthermal methods - ScienceDirect
- PFAS fate and destruction mechanisms during thermal treatment: a comprehensive review - Environmental Science: Processes & Impacts (RSC Publishing)
- Critical Review of Thermal Decomposition of Per- and Polyfluoroalkyl Substances: Mechanisms and Implications for Thermal Treatment Processes | Environmental Science & Technology (acs.org)
- IJERPH | Free Full-Text | A Review of PFAS Destruction Technologies (mdpi.com)
- A Review of PFAS Destruction Technologies - PubMed (nih.gov)
- Waste incineration of Polytetrafluoroethylene (PTFE) to evaluate potential formation of per- and Poly-Fluorinated Alkyl Substances (PFAS) in flue gas - ScienceDirect
- Database US EPA: https://www.epa.gov/chemical-research/pfas-thermal-treatment-database-pfastt
- Critical Review of Thermal Decomposition of Per- and Polyfluoroalkyl Substances: Mechanisms and Implications for Thermal Treatment Processes | Environmental Science & Technology (acs.org)
- United States Environmental Protection Agency, PFAS Thermal Treatment Database (PFASTT): https://pfastt.epa.gov/
- Thermal decomposition of perfluorinated carboxylic acids: Kinetic model and theoretical requirements for PFAS incineration - ScienceDirect
- Technical_brief_pfas_incineration_ioaa_approved_final_july_2019.pdf (epa.gov)
- Examining thermal destruction for PFAS waste - GHD

Conclusion

PFAS have several applications in the Precious Metals Industry. It is however important to highlight that most of these uses are solely industrial uses of PFAS monomers or polymers for which no risk has been identified, due to limited or no exposure to human health and environment. Also, because of their extreme resistance, there is no degradation of the PFAS in these uses. The emissions and mobility (in environmental media) of the different PFAS sub-groups has to be considered in the restriction proposal, and exceptions must apply where there is no emission/exposure into the environment or for humans.

Moreover, industrial applications mainly involve fluoropolymers which have been clearly identified as “polymers of low concern” (PTFE, ETFE, FEP, PVDF etc.). They have been shown to be chemically stable, non-toxic, non-bioavailable, non-water soluble and non-mobile[2]. We would therefore like to ensure a general exemption of fluoropolymers, which are considered as “polymers of low concern” based on the OECD criteria, in the context of this restriction.

Overall, we are confident that PFAS and PFAS-containing materials and -products can be continued to be used safely in the precious metals sectors throughout their entire lifecycle via adequate risk management. Therefore, a generic exemption of fluoropolymers in industrial uses must be considered to ensure compliance with the EU Green deal.

While derogations are already foreseen for some use/sector listed above (but not all), there is no mechanism foreseen to prolong these if needed. This must be considered considering the challenges related to substitution, especially for long-life products (e.g.: industrial equipment). However, it is important to avoid unnecessary administrative burden to prolong the exemptions; the system must be pragmatic and straightforward.

It will be important to carefully assess the impact on recycling since recycling streams (from fuel cells or electronics) could still contain PFAS a long time after the end of the derogations. However, recycling of precious metals should not be hampered by this situation.

Hence, the EPMF would like to request that:

- **the hazard profile of the PFAS is considered to prioritize the PFAS included in the restriction**
- **the scope of the restriction is limited and that substances of low concern (as per OECD criteria) are exempted from the restriction**
- **if the exemption must be use driven, the uses of PFAS outlined above must be exempted for at least 12 years and a mechanism to renew these exemptions must be put in place.**

[2] Henry, B.J. ; Carlin, J.P.; Hammerschmidt, J.A.; Buck, R.C.; Buxton, L.W.; Fiedler, H.; Seed, J; Hernandez, O, Acritical Review of the application of Polymer of Low Concern and Regulatory Criteria to Fluoropolymers. Integr. Environ. Assess. Manage. 2018, 14 (3), 316-334).

Annex 1: Economic data on precious metals

Silver

A variety of uses of the silver and silver compounds have been identified through the literature review and engagement with industry (Section 3.1). The key broad uses/sectors are visualised in Figure 4.1 below.

Figure 4.1: Overview of uses of silver and silver compounds

Notes: the colours refer to natural groupings of the products, with interconnections between EEE, aerospace and defence and medical devices; whilst the jewellery, tableware and silverware are accounted for together in following sections.

The manufacture and and/or import of the silver and silver compounds feed into a variety of different downstream uses:

- **Electronics and electrical equipment (EEE)** – electronics and electrical equipment used in consumer applications, industrial applications, automotive use, green energy (including solar and wind) and brazing and soldering applications.
- **Aerospace and defence** – the aerospace and defence industry, including uses that feed into

aeroplanes, satellites and defence applications (e.g. missiles and torpedoes). Some of these uses relate to electronics and electrical equipment used in the sector.

- **Medical devices** – medical devices and in-vitro diagnostic (IVD) medical devices. This too includes electronics uses, but these are not accounted for in the EEE.
- **Photographic** – photographic films, papers and emulsions. These are applied in different sectors, including for healthcare (X-rays) and for aerospace and defence (Non-Destructive Testing).

Jewellery – watches, necklaces, rings and other ornamental objects that are intended to be worn.

Tableware/silverware – in table service and tasting (e.g. cutlery) and decorative objects for use on the table and in homes (e.g. candle holders).

Cosmetics – in personal care products, which includes products often found in health and beauty shops and/or departments.

All other industrial uses – in a variety of industrial applications not accounted for in the list above, especially biocides, diamond tools, investments, manufacture of other chemical substances (including manufacture of ethylene oxide), mirrors, surface treatment etc.

All other consumers uses – in some consumer applications, not accounted for the list above. According to the literature, this included button batteries, adhesive, silver threads (e.g. in conducting gloves) and toys. However, no explicit evidence was noted of these uses with the EEA and Switzerland through the industry survey and interviews.

121.000 workers are involved in the silver manufacturing or refining process in the EEA and Switzerland. This does not include the employees working for the sector in service like administration, etc.

According to the 2020 World Silver Survey, global silver supply was approximately 31,821 tonnes of silver metal in 2019, and is expected to drop by approximately 1% in 2020. As set out in Table 5.1 and the left hand side of Figure 5.1, mining production has consistently been the primary source of silver metal globally, followed by recycling. Mining production in Europe[3] is approximately 8% of global supply, with the world's largest silver mine situated in Poland (Silver Institute, 2020). According to the world survey, the vast majority of the mining production from silver in Europe is from copper (73%) followed by lead/zinc (24%) and small volumes of primary silver and gold (2%) (Figure 5.2).

Table 5.1: Global supply of silver metal (2019)

Sources of supply	Volume (tonnes/year, 2019)
Mining production	26,019
Recycling	5,284
Net hedging supply [a]	487

[3] Europe refers to the continent of Europe, including EEA and Switzerland. This does not include the countries of Commonwealth of Independent States, including Russia.

Net official sector sales [b]	32
Global supply	**31,821**

Source: Silver Institute (2020).

Notes:

[a] Refers to financial options that are taken by producers of silver to limit their risks on production.

[b] A definition of what this refers to is not included in the Silver Institute report.

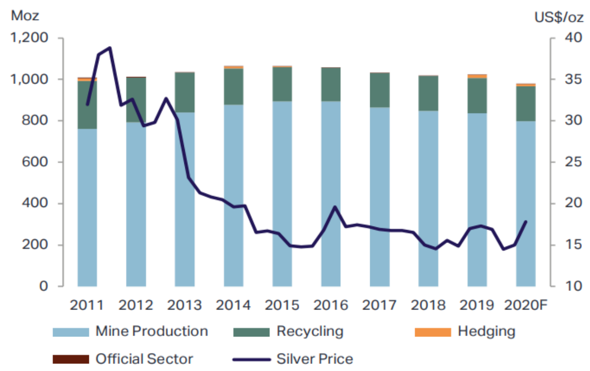

Figure 5.2: Total global supply of silver

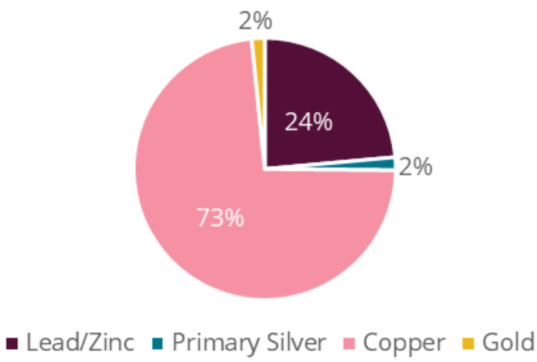

Figure 5.3: Silver mining production, by source metal in Europe

Source: Metals Focus, Bloomberg (Silver Institute, 2020)

Recycling of silver in Europe is approximately 24% of global supply of recycling (Silver Institute, 2020). Although no information is reported on the different sources of recycling in Europe, recycling sources globally are (Silver Institute, 2020): primarily from industrial uses like electronics scrap and catalysts; followed by jewellery and silverware; photographic uses, including from historic supplies of x-rays and other uses; and a small proportion from silver coins.

Global demand for silver can be split up into four broad sources of demand:

- Industrial demand;
- Photography;
- Physical investment; and
- Jewellery and silverware.

As set out in Table 5.2, the majority of global demand is from industrial demand (approximately 15,891 tonnes in 2019), largely from 'electronics and electricals', but a significant volume is also from 'brazing alloys and solder' and the broader category of 'other industrial demand'. This 'other industrial demand' includes all industrial applications that are outside of the former categories, such as cosmetics, aerospace applications, some medical applications, use in ethylene oxide, mirrors etc. The second highest source of volume is from jewellery and silverware (8,122 tonnes/year) – the majority of which is used in the fabrication of jewellery - followed by physical investment by investors into silver as a commodity (5,788 tonnes/year) and finally use in photography (1,047 tonnes/year).

Table 5.2: Global demand of silver metal (2019)

Sources of demand	Sub-category	Volume (tonnes/year, 2019)
Industrial demand	Electronics and electricals	9,257
	Brazing alloys and solder	1,565
	Other industrial demand	5,070
Physical/Retail investment	-	5,788
Jewellery and silverware	Jewellery	6,262
	Silverware	1,860
Photography	-	1,047
Global demand		**30,848**

Source: Silver Institute (2020).

According to interviewees, the reference price globally for silver is the London Bullion Market Association (LBMA) silver price. As seen in Figure 5.3, there has been significant variation of the silver price in the last ten years, with current prices sitting close to the lowest levels in the last decade. As all information in this report is in metric units, the comparable current price is the monthly average London Bullion Market Association (LBMA) price in April 2020 of **€488,263/tonne**[4]. Although the price of silver has been subject to significant levels of volatility since 2008 (peaking in Q1 2011), since the start of the Covid-19 pandemic, there has been further fluctuation fuelled (especially) by uncertainty. The initial decline in March 2020 to a low of €474,964/tonne has rebounded in light of a potential second wave to hit €801,884/tonne in August 2020[5].

[4] The average LBMA silver price for April 2020 is €13.842/ounce of silver, which was then converted into tonnes. See: http://www.lbma.org.uk/precious-metal-prices

[5] The average LBMA silver price for March 2020 is €13.465/ounce of silver and in August 2020 is €22.733/ounce of silver, which was then converted into tonnes. See: http://www.lbma.org.uk/precious-metal-prices

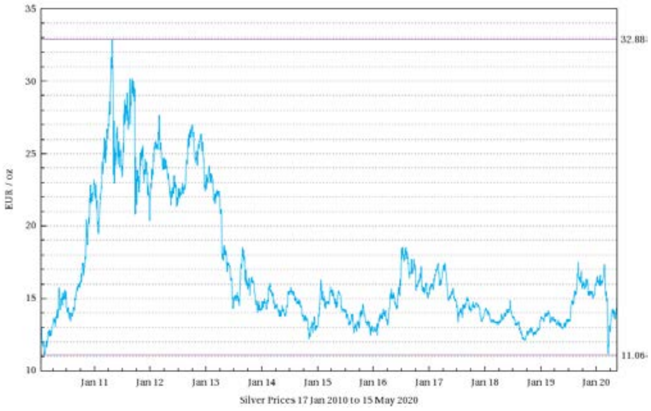

Figure 5.4: LBMA silver price (€/ounce, 2010-2020)

However, it is important to note that the silver price is only a partial reflection of the value of the silver metal, particularly given that there will be some additional costs to cover the production costs for the manufacture/processing, handling fees and/or some value added (according to interview responses). No information was found on global production and price on any of the other silver substances, but interviewees indicated that the price of these substances may (in some instances) be derived from the silver content of the silver compound.

Market within the EEA and Switzerland

The volumes reported above are only a partial measure of the supply and demand of the silver and silver compounds within the EEA and Switzerland. This is partly because this does not account for the import and export of silver substances, but also driven by the limited information publicly reported on the supply and demand specifically within the EEA and Switzerland.

Table 5.3 summarises the results of the best available dataset on supply within the region – with the merged datasets from the EPMF (2019) study and responses to the industry survey (M/I version) for this project. In general, for each substance, the higher volume reported was taken as the more up to date estimates. Overall, these results are likely to be more representative of the EEA than both the EEA and Switzerland, due to the availability of information for Switzerland[6]. There is also insufficient information to report on export volumes from across the EEA for the silver substances[7].

Table 5.3: Estimated manufacture/import of silver substances (EEA)

[6] Note, the EPMF results were reported for the EU, and there is insufficient information on the manufacture and/or import of the silver substances within the rest of the EEA (i.e. Iceland, Liechtenstein and Norway) as any refiners/producers are expected to be accounted for in the EPMF dataset.

[7] Based on Eurostat data shared by an interviewee, the total volume of silver (metal) powder exported from the EU27 in 2018 is approximately 212 tonnes.

<table>
<tr><th>Silver substance</th><th>Total tonnage bands registered under REACH (tonnes/year) *</th><th>Estimated EU Volume (tonnes, 2015/16) **</th><th>Updated estimated EEA volume (tonnes/year, 2017-19) ***</th></tr>
<tr><td>Silver metal</td><td>100,000 – 1,000,000</td><td>10,310</td><td>10,310</td></tr>
<tr><td>Silver nitrate</td><td>1,000 – 10,000</td><td>1,050</td><td>3,100</td></tr>
<tr><td>Silver chloride</td><td>100 – 1,000</td><td>55</td><td rowspan="3">800</td></tr>
<tr><td>Silver bromide</td><td>100 – 1,000</td><td rowspan="2">Unknown</td></tr>
<tr><td>Silver iodide</td><td>0 – 10</td></tr>
<tr><td>Disilver oxide</td><td>100 – 1,000</td><td>100-1000</td><td rowspan="3">400 – 2,410</td></tr>
<tr><td>Disilver (1+) sulphate</td><td>0 – 10</td><td rowspan="2">Less than 30</td></tr>
<tr><td>Silver carbonate</td><td>1,000 – 10,000</td></tr>
<tr><td>Silver acetate</td><td>Not registered</td><td>Unknown</td><td>Unknown</td></tr>
</table>

Notes:

* Tonnage bands reported based on substance registration dossiers.

** Estimated from figures from respondents to EPMF (2019) and the estimated coverage of respondents. All figures are rounded to 10 tonnes, unless more accurate information is available (i.e. 100% response received for silver chloride manufacture/import).

*** Estimated volume based on respondent data

The evidence, however, indicates that the reported estimated volume of silver metal of **10,310 tonnes/year** (2017-2019) is likely a reasonable best estimate for manufacture and/or import within the EEA and Switzerland. In comparison, according to the World Silver Survey, the supply of silver metal in Europe is likely to be over 3,230 tonnes/year[8] (2019). The difference in these values is partly accounted for by the import of silver metal into the EEA, but may also reflect some under-reporting in the World Silver Survey dataset.

For demand of silver within the EEA and Switzerland, the estimated demand in Europe from the World Silver Survey is the most comprehensive dataset currently available. Based on feedback from the Silver Institute, the most appropriate estimate is the volume of silver metal fabrication[9] in each category.

[8] Includes reported values for Europe for Mining production (1,940 tonnes/year) and recycling (1,290 tonnes/year).

[9] Fabrication data is based on responses from companies in Europe that use the silver metal in their production process. In contrast, estimated demand is based on feedback from manufacturers/importers operating in Europe, on the volume of silver demanded by their downstream users. Although this will be equivalent at a global scale, there are some nuances at a regional scale which indicate that fabrication is more closely aligned with the information requirements of this assessment.

According to data from the Silver Institute, approximately 5,942 tonnes of silver metal is demanded within Europe. Table 5.4 maps the seven downstream uses of silver (metal) within the scope of this assessment to the categories used by the Word Silver Survey. The table also compares the estimated demand against the volumes reported by respondents. As expected, the World Silver Survey volumes are significantly higher than reported by respondents (as our survey was not completed by all companies using silver), except in the case of the electronics sector. In order to prevent any false sense of accuracy, the values are rounded to the nearest 10 tonnes. Based on this approach, the total estimated demand for silver metal in the EEA and Switzerland is approximately **5,940 tonnes/year** (2019).

Table 5.4: Estimated demand for silver metal (EEA and Switzerland, 2019)

<table>
<tr><th rowspan="2">Silver impact sector</th><th colspan="2">World Silver Survey †</th><th rowspan="2">Respondent data*</th><th rowspan="2">Revised estimate ‡</th></tr>
<tr><th>Category</th><th>Volume</th></tr>
<tr><td>EEE</td><td rowspan="2">Industrial fabrication - Electronics and electricals; brazing alloys and solder</td><td rowspan="2">1,553</td><td>1,510</td><td rowspan="2">1,550</td></tr>
<tr><td>Aerospace and defence</td><td>20**</td></tr>
<tr><td>Medical devices</td><td rowspan="3">Industrial fabrication – other</td><td rowspan="3">931</td><td>10</td><td rowspan="3">930</td></tr>
<tr><td>Cosmetics</td><td>Less than 10</td></tr>
<tr><td>Other industrial uses (exc. Investment)</td><td>280</td></tr>
<tr><td>Investment</td><td>Retail investment</td><td>1,358</td><td>Unknown</td><td>1360</td></tr>
<tr><td>Jewellery and tableware/silverware</td><td>Fabrication of jewellery and tableware</td><td>1053</td><td>Less than 10 tonnes</td><td>1050</td></tr>
<tr><td>Photographic</td><td>Photographic</td><td>1,047</td><td>Unknown***</td><td>1050</td></tr>
<tr><td colspan="2">Total</td><td>5,942</td><td>-</td><td>5,940</td></tr>
</table>

Notes:

† Based on information provided by the Silver Institute on tonnage in Europe (Metals Focus, pers. comms. July 2020) and reported in the World Silver Survey (2020).
‡ Volume is rounded to the nearest 10 tonnes.
* See each of the sector chapters for more information.
** Overlap with all elements of industrial fabrication.
*** Information reported on use of silver chloride, bromide and iodide, rather than silver metal.

There is, however, insufficient information to comment on whether this estimate is an under/over-estimate for the quantity of silver metal produced in the EEA and Switzerland. For example, feedback on the EEE sector has indicated that a number of companies in the sector have not responded to the survey (although the largest respondents may have provided a response). These results do not also report on the estimated volume of the other silver substances that are in use.

Information on the use of silver compounds within Switzerland (only) is limited. In general, a significant volume of silver is believed to be used in the jewellery and watch sectors (see Jewellery and luxury goods chapter) in Switzerland, and it is still also a large exporter of silver (metal). According to the World Silver Survey, within Europe, it is second only to Europe on the export of silver bullion in 2019, and according to the 'World's Top Exports', the country was the 10th largest exporter (in US$) of silver globally in 2018, following the UK and Germany (Workman, 2020).

Table 5.5 provides an overview of the use of silver metal and the other silver compounds in the seven downstream use sectors within the EEA and Switzerland, based on the data collection exercise. Overall, some volume information was reported (cells highlighted in blue) on the majority of the silver substances that were identified to be in use within the sector (cells with a tick box). Due to confidentiality concerns it is not possible to report volume data on specific substances for some of these uses. Note, however, some of these substances are only used as intermediates in the production process – for example, in the photographic sector silver nitrate is produced from the silver metal, which is in turn subjected to a reaction with metal halide salts (e.g. sodium bromide) to produce silver chloride, bromide and/or iodide. In line with expectations, the only substance that was not noted to be in use within the EEA and Switzerland was silver acetate. Other silver substances (outside of the scope of this assessment) were noted by respondents for each of the uses, e.g. silver cyanide in surface treatment and silver sulfadiazine in medical devices). For more information on the use of the silver and silver compounds for a particular sector, please refer to each of the chapters.

Table 5.5: Overview of use of silver substances (Respondent data)

Silver impact sector	**Silver substance**								
	Silver metal	**Silver nitrate**	**Silver carbonate**	**Disilver oxide**	**Disilver (1+) sulphate**	**Silver chloride**	**Silver bromide**	**Silver iodide**	**Silver acetate**
Aerospace and defence	□	□				□			
Cosmetics	□	□				□			
EEE	□	□	□	□	□	□			
Jewellery and tableware/silverware	□	□							
Medical devices	□	□				□			
Photographic	□	□				□	□	□	
Other industrial uses	□	□							

Notes:

□ refers to where one or more survey respondent and/or interviewees have indicated the use of this substance within the sector.

Cells coloured in blue refer to where survey data has been reported in the relevant sectors.

Finally, significant volumes of silver and silver compounds are believed to be recycled within the EEA and Switzerland. Based on data reported by the Silver Institute, approximately 1,290 tonnes of silver metal scrap is generated within the EEA (Metals Focus, pers. comms.) – i.e. 22% of the estimated 5,940 tonnes of silver used within the region. Although it is unclear what proportion of this is fed back into the refineries operating within the EEA and Switzerland[10], it gives an indication that a significant proportion of the

[10] Note, this may differ from where the silver substances are actually recycled as the silver substances may be shipped to a different region for processing.

volume of silver and silver compounds fed back into the supply chain (Figure 4.2). This means there may be wider-reaching consequences on the quantity that is recycled and/or the ability to recycle with any potential changes in manufacturing and/or downstream use practices.

Platinum Group Metal[11]

Platinum Group Metals (PGMs) consist of six silver-white metals: platinum, palladium, rhodium, ruthenium, iridium, and osmium. They are naturally occurring metallic elements that are considered precious metals because they are rare (i.e., supplied in relatively small quantities compared to base metals) and have high economic value. The European Commission considers PGMs as both critical raw materials (CRMs) and strategic raw materials that are crucial to Europe's economy (European Commission, 2023).

Figure ES.1 illustrates the 10 "broad use" categories of PGMs, where those using the most PGMs are the automotive industry and industrial processes. Within each broad use category there are examples of further "specific uses" of PGMs. In total, the survey respondents reported over 55 different specific uses of PGMs.

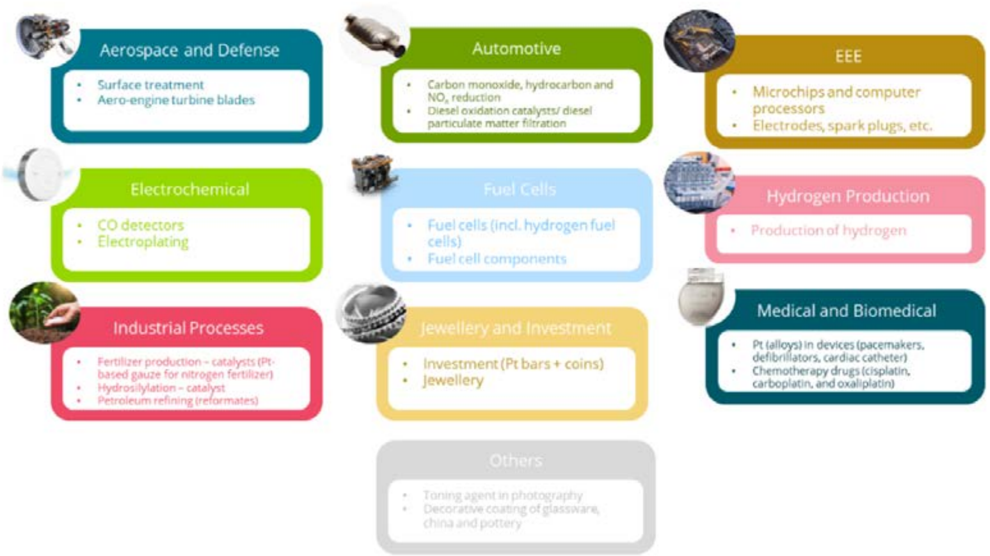

Figure ES.1: The 10 broad uses of PGMs

Note: The specific uses listed under each broad use are not exhaustive

The main use of PGMs in the conventional automotive sector is its use in autocatalytic converters[12]. PGM-based catalysts are used in internal combustion engine (ICE) vehicles to convert air pollutants such as carbon monoxide, hydrocarbons and nitrogen oxides into carbon dioxide, water, and nitrogen. This

---

[11] Eftec, *Platinum Group MEtals (PGMs) Value Chain*, final report, IPA, July 2023.

[12] There are also other uses of PGMs in the automotive sector, so the use of PGMs is not solely related to emissions control.

process reduces exposure to potent air pollutants, which benefits both human health and the environment. PGMs are also used in the emissions control systems of ICE vehicles because of their superior catalytic properties, which enable effective performance even in harsh environments. Additionally, some PGMs, such as iridium, are used within the ICE itself, specifically in spark plugs, owing to their stability in harsh environments.

Whilst the use of PGMs in the automotive sector will eventually decline in Europe, there is uncertainty on the timings for phasing out petrol and diesel vehicles in Europe. It is expected that ICE vehicles will still be used (albeit in declining numbers) in Europe and globally for the foreseeable future so there will be a continued need for PGMs within the automotive sector. New markets are also expected to emerge for PGMs between 2025 and 2040, related to use in fuel cells, and electrolyser and hydrogen systems, which are largely driven by the energy transition in response to meeting climate change goals.

There are multiple metrics that make up a value chain, including measuring aspects such as sales revenue, employment, and the number of companies, to name a few. Figure ES.2 illustrates that the **total economic value of the European PGM supply chain is estimated at ~€95 billion per year**, which includes the value of PGMs refined and the value added at each subsequent level of the supply chain3. The size of the PGM supply chain is estimated to include **~13,430 companies in Europe**, of which 430 companies **employ 21,500 people** (including contractors). **Indirect and induced employment** from the PGM supply chain is estimated to employ a further **36,900 people**.

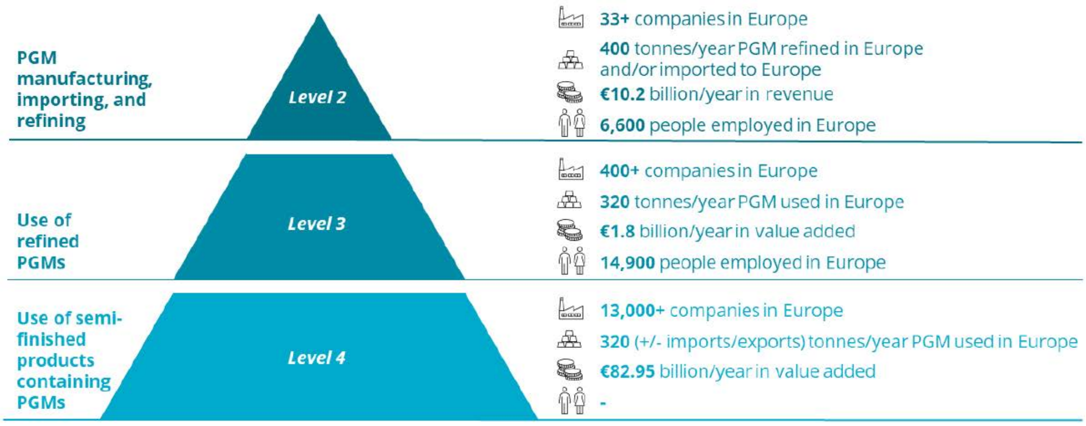

Figure ES.2: Summary diagram PGM value chain in Europe

Environmental and human health values are an important aspect of the value chain but have not been quantified in this study. For example, PGMs are currently used in automotive exhaust catalysts, which significantly reduce the air pollution associated with fossil fuel based internal combustion engines. These significantly help convert harmful gases (e.g., Nitrogen Oxides (Nox) and Sulfur Oxides (Sox), and Particulate Matter (PM 2.5 and 10)) into less toxic gases such as nitrogen and carbon dioxide, thereby improving air quality. This has both environmental benefits, by reducing the global warming impact of the emissions released, and human health benefits, by reducing the emission of harmful pollutants.