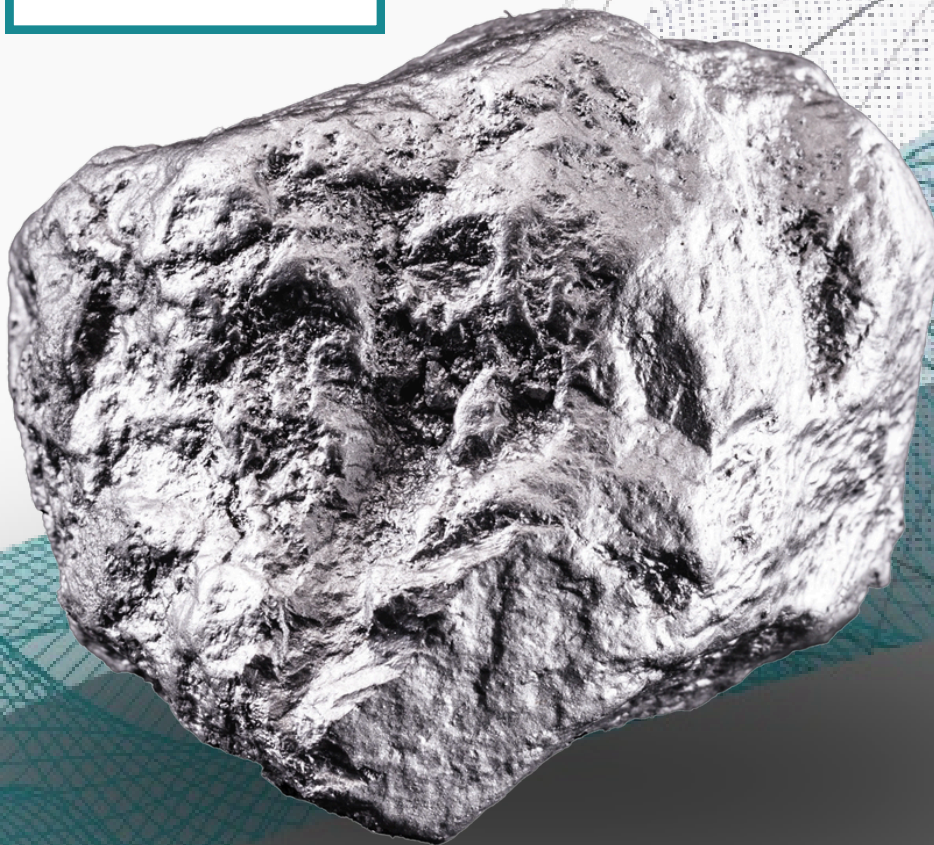


PGM Fact Sheet Palladium

46

Pd

Palladium



Supply &
Demand



Applications



Trends



Geology

May 2026

PGM FACTSHEETS 2026 - PALLADIUM

Written by SFA (Oxford)

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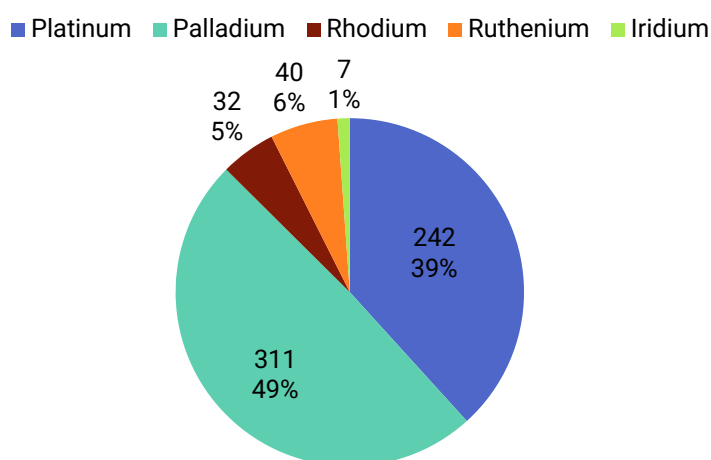
OVERVIEW

Platinum group metals (PGMs)—platinum (Pt), palladium (Pd), iridium (Ir), rhodium (Rh), ruthenium (Ru) and osmium (Os)—share similar chemical characteristics and are considered precious metals like gold and silver yet are equally widely used and essential for many industrial applications. Their unique properties make them fundamental components in a diverse range of technologies.

PGMs' unique properties enable a wide range of technologies; from long-established chemical processes making familiar products, through the autocatalysts (catalytic converters) in every gasoline/diesel vehicle tailpipe which have dramatically improved urban air quality over the past decades, to the emerging end uses in the hydrogen economy and other technologies towards net zero. European companies continue to play a leading role in operating processes based on PGMs, with manufacturing plants in Europe and around the globe. These companies, plus an innovative set of Europe-based start-ups and spinouts, often using computational techniques, are developing new catalysts and novel materials for low-carbon applications.

The current demand split among the five main metals is shown below; palladium accounts for nearly half of demand, followed by platinum at 40%. Together, these two metals comprise almost 90% of demand by mass of metal.

Global PGM demand by metal: 2025 tonnes



Source: Johnson Matthey (January 2026); demand excluding closed loop recycling and reuse

All PGMs, typically in combination with one another or with other metals, can act as highly efficient catalysts, which are exploited in a wide range of applications, including automotive catalysts for emissions control, chemical and petroleum processing and many large volume industrial reactions. Their catalytic use in automotive exhaust aftertreatment alone has enabled very large reductions in pollutants such as carbon monoxide, hydrocarbons, and nitrogen oxides from internal-combustion engines. As life cycle assessments on autocatalysts performed by IPA have demonstrated, over two tonnes of harmful emissions can be reduced by the catalytic

converter systems in one Euro 6d-TEMP 1.4 litre gasoline and one Euro 6d-TEMP 2.0 litre diesel vehicle in use over 160,000 km (Source: IPA - [The Life Cycle Assessment of Platinum Group Metals](#))

Among PGMs, palladium is a silvery white metal similar in appearance to platinum. It is the least dense and has the lowest melting point of the PGMs. It dissolves in concentrated nitric acid, hot concentrated sulfuric acid, and *aqua regia*. It does not react with oxygen at room temperature, but it forms an oxide layer at 800 °C.

Palladium demand is dominated, some 80%, by autocatalysts to clean up tailpipe emissions, mainly from light-duty gasoline combustion engine (including hybrid) vehicles. Chemical catalysts and a range of electrical applications account for around 5% each, followed by a diverse set of medical, jewellery, and minor industrial applications.

Global palladium demand by sector: 2025

tonnes

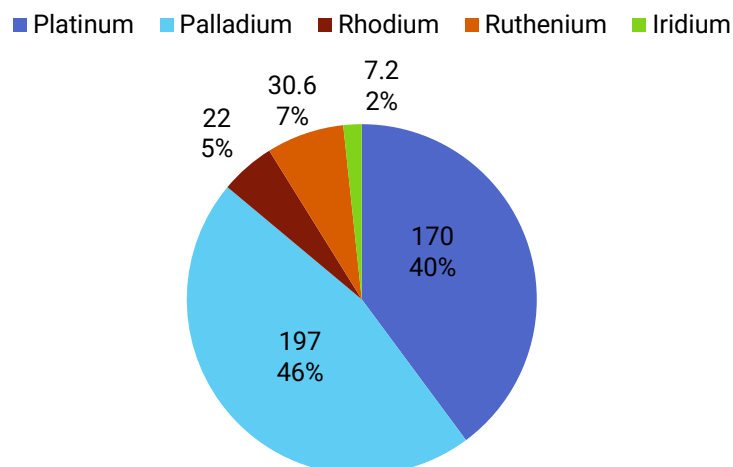


Source: Johnson Matthey (January 2026); demand excluding closed loop recycling and reuse

In general, PGMs are always produced together, as they occur together in nature. Palladium and platinum are considered the main metals, with the other PGMs (rhodium, ruthenium, iridium, osmium) considered by-products. Most PGM imports from primary sources are in concentrated form after a first refining stage.

Globally platinum and palladium make up 86% of the PGM basket by mass of metal produced:

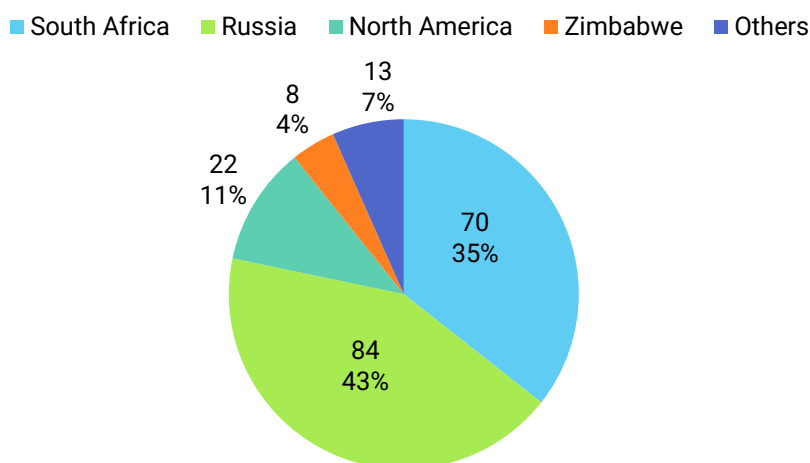
Global PGM primary supply by metal: 2025 tonnes



Source: Johnson Matthey (January 2026)

PGM mine production is highly concentrated in just a few countries. In 2025, global primary palladium mine production is estimated at about 197 tonnes. The principal producing countries are Russia, South Africa, Zimbabwe, Canada and the United States, which together account for roughly 93% of global primary supply. Russia is the dominant producer, despite production mostly coming as a by-product of nickel and copper mining, accounting for around 43% of global mine output, followed by South Africa (35%). There is essentially no primary supply from Europe other than minor by-product supply from nickel mining in Finland.

Global palladium primary supply by origin: 2025 tonnes



Source: Johnson Matthey (January 2026)

Secondary supply refers to palladium recovered from scrap and end-of-life products rather than from newly mined (primary) ore. The largest source is spent autocatalysts from vehicles, followed by electrical product scrap. This segment of supply is strategically valuable as recycled metal can

respond more quickly than new mining projects and usually carries a lower environmental burden.

Secondary supply from spent autocatalysts is complex, and depends on collection rates, scrap prices, vehicle scrappage patterns, technology mix of the vehicle fleet, recycling capacity and the economics of recovery.

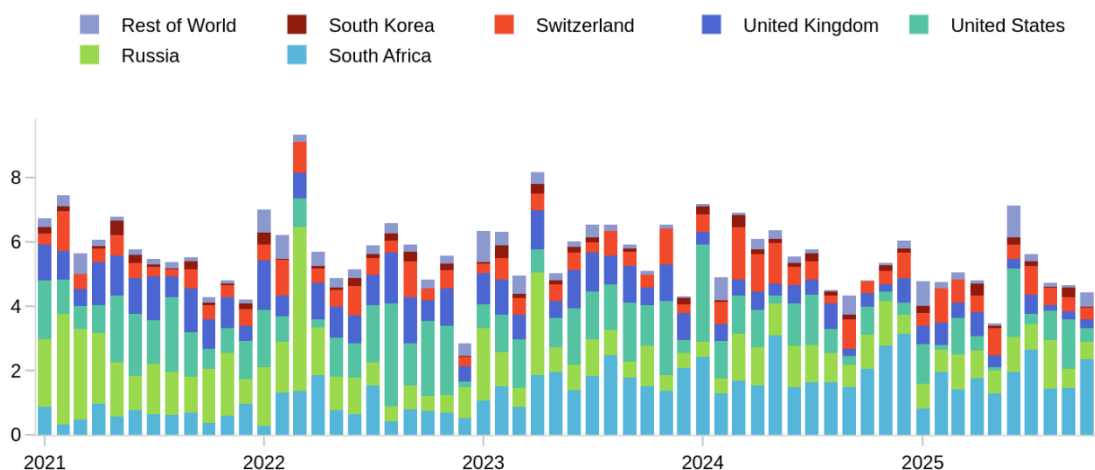
EU TRADE & PRICES

EU TRADE

The EU imports and exports large volumes of palladium in unwrought or powder-form (HS 711021) and semi manufactured form (HS 711029) but overall is a significant net importer. South Africa, Russia and the US are the largest sources for EU imports of palladium, with Germany and Italy being the largest recipients.

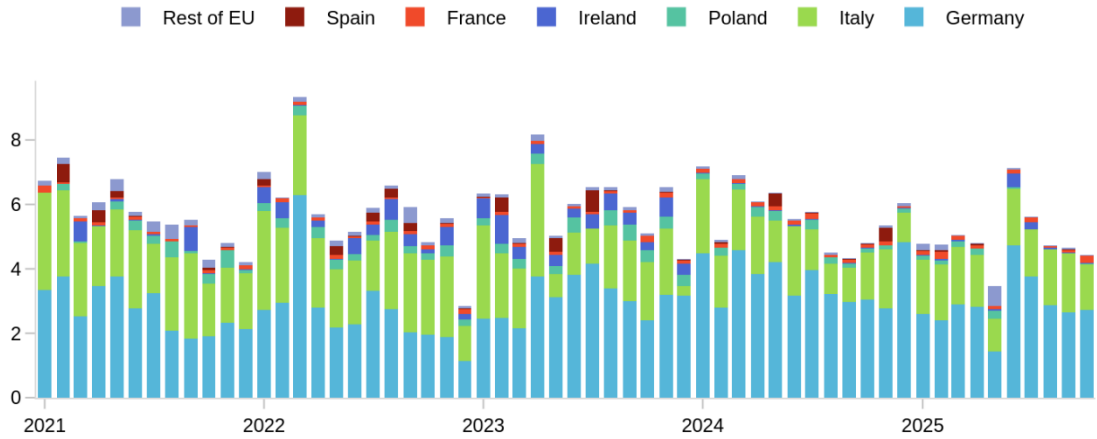
Palladium’s policy relevance has risen because the United States and other countries increasingly treat PGMs as strategically important materials. In the U.S., a formal trade case on unwrought palladium from Russia moved into its final phase in February 2026 after an affirmative preliminary determination by the Department of Commerce that the product was sold at less than fair value; the U.S. International Trade Commission scheduled the final-phase hearing for April 27, 2026. Even before any final outcome, this type of action can alter physical trade routes, hedging behaviour and regional premia.

Palladium: Largest exporters into the EU market
tonnes



Source: Eurostat

Palladium: Largest importers into the EU market
tonnes



Source: Eurostat

EU IMPORT RELIANCE

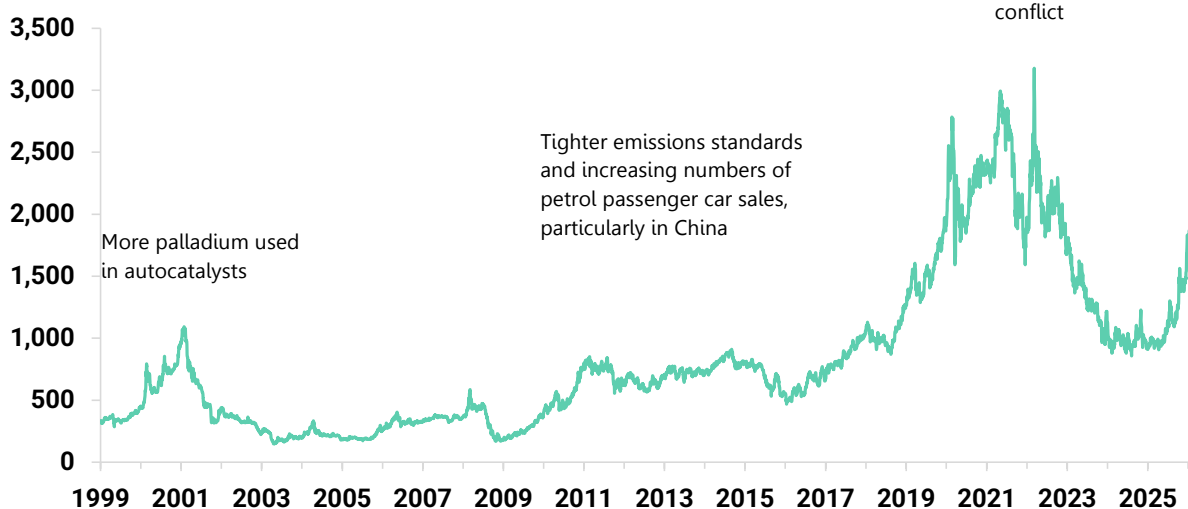
The EU is reliant on imports of palladium to meet its automotive, industrial and jewellery requirements. The EU’s total demand for palladium (ex. investment) has varied from 62 to 73 tonnes per year since 2020. Secondary supply of palladium from autocatalysts sourced in the EU has averaged 17 tonnes per year, and with little primary supply or by-product production the EU’s import requirement has been around 45 to 56 tonnes per year.

PRICE & PRICE VOLATILITY

PGM prices can be volatile. Palladium demand has become increasingly reliant on autocatalysts with overall demand driven by tighter emissions standards and rising global light vehicle production, which tends to result in a rising price during economic expansions, but a falling price during recession. Supply shocks can also cause sharp price increases, as seen in 2022 when Russia invaded Ukraine causing concern that Russia’s palladium could become unavailable to the market.

Palladium price

\$/oz



Source: Bloomberg Finance LP

DEMAND OUTLOOK

GLOBAL AND EUROPEAN END-USES

PGMs have unique properties that make them essential to a wide range of current and emerging technologies. All PGMs, often used in combination with one another or with other metals, can function as catalysts, which explains their importance across many industrial applications. For palladium, the most significant use is in autocatalysts for emissions control from combustion engine vehicles. Other important applications, although smaller in scale, include electronics, chemical process catalysts, jewellery and dental uses. In addition to these industrial applications, palladium and other PGMs are also held as investment assets due to their high value, physical stability and relative price stability.

Globally, autocatalysts for internal combustion engine vehicles (mainly gasoline light vehicles, including hybrids, but some limited use in diesel autocatalysts) remain the dominant demand driver, accounting for around 81% of total palladium demand in 2025, equivalent to 251 tonnes from a total of 311 tonnes.

Global palladium demand by sector: 2025

tonnes



Source: Johnson Matthey (January 2026)

The European demand profile is similar to the Global, with a very slightly higher (84%) autocatalyst share, reflecting the strong autocatalyst manufacturing industry across the continent.

Europe palladium demand by sector: 2025

tonnes



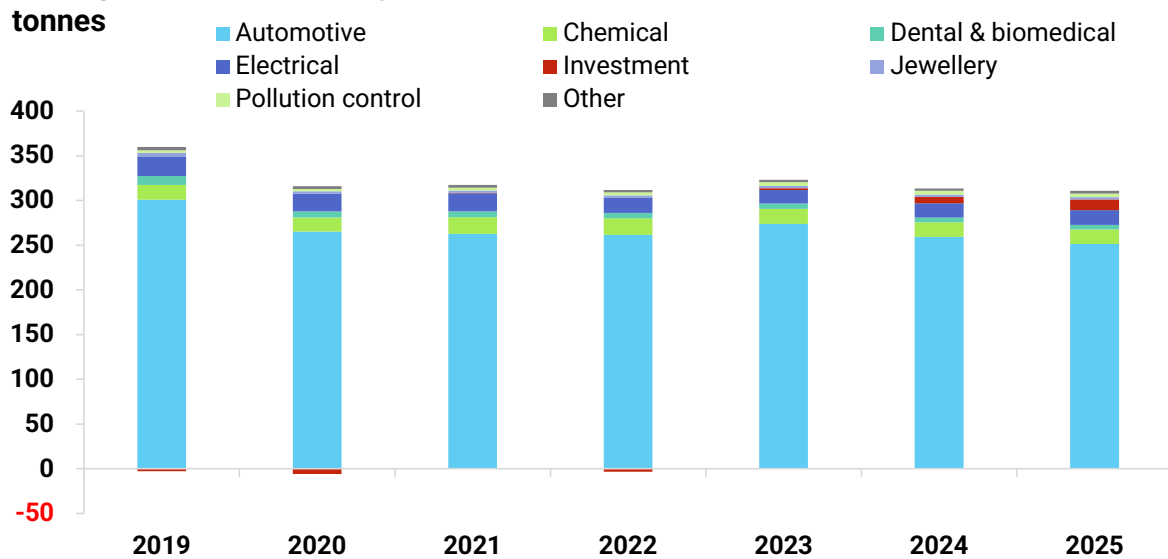
Source: Johnson Matthey (January 2026)

Note: Europe defined here as EU+ (includes UK and Turkey but excludes Russia)

Global demand has declined by almost 47 tonnes from 2019 to 2025, driven by autocatalysts, with some substitution from palladium to platinum in gasoline three-way catalysts. Chemical demand is stable at around 16 tonnes in well-established processes, where catalysts are matched to capital-intensive production plants with minimal potential for substitution. Electrical demand has

decreased slightly as price-induced substitution has occurred in some less critical applications, though the remaining demand is expected to be reasonably sticky.

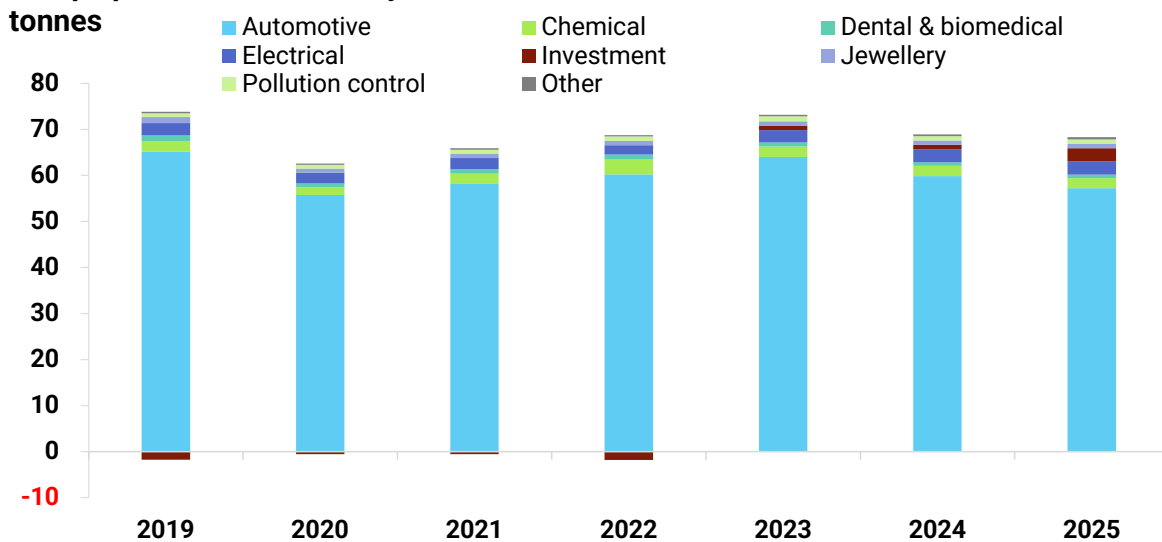
Global palladium demand by sector: 2025



Source: Johnson Matthey (January 2026)

European palladium demand is relatively stable, down by just 4 tonnes from 72 tonnes in 2019 to 68 tonnes in 2025. Autocatalyst demand has declined slightly, affected by some limited substitution to platinum which is now reversing to some extent, and an increasing share of battery electric vehicle (BEVs) production. This is part of a long-term powertrain migration away from combustion engines, driven by CO₂ emissions legislation.

Europe palladium demand by sector

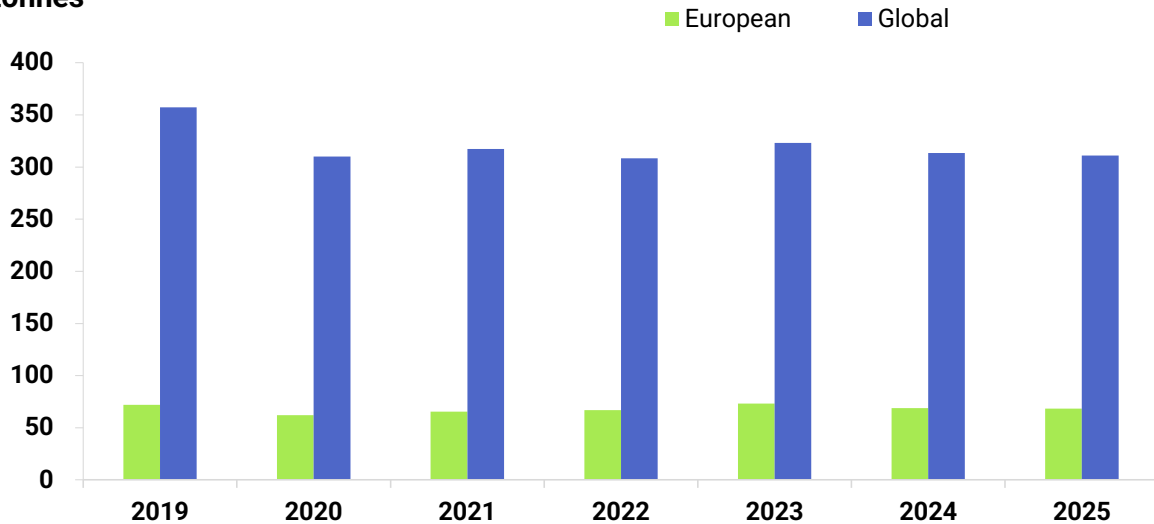


Source: Johnson Matthey (January 2026)

Note: Europe defined here as EU+ (includes UK and Turkey but excludes Russia)

Europe’s share of global palladium demand is essentially stable between 2019 (20%) and 2025 (22%), with the dominant end use, autocatalyst manufacturing, concentrated at relatively few sites serving the main automotive manufacturing regions around the world.

Palladium demand: Europe as a share of Global tonnes



Source: Johnson Matthey (January 2026)

Note: Europe defined here as EU+ (includes UK and Turkey but excludes Russia)

APPLICATIONS

AUTOMOTIVE - AUTOCATALYST

Current applications: Palladium is the dominant platinum group metal used in gasoline autocatalysts and autocatalysts account for the bulk of global palladium demand, with around 80-83% of total palladium use linked to the automotive sector in recent years. It serves as the main active ingredient, together with platinum and rhodium, in three-way catalytic converters that limit emissions of unburnt hydrocarbons, carbon monoxide, and oxides of nitrogen from gasoline-powered vehicles, with most palladium in autocatalysts used in light-duty gasoline engines and a smaller share in diesel systems.

Palladium’s use in diesel-powered vehicles increased in the 2000s as very low sulphur diesel fuels (typically <10 ppm sulphur in current Euro 6/VI standards) and the introduction of catalysed diesel particulate filters (DPF) and diesel oxidation catalysts made it technically feasible to incorporate palladium alongside platinum without sulphur poisoning the catalyst metal and rendering it inactive. Platinum has remained the primary PGM for diesel catalysts, though the light-duty diesel market has now shrunk to below 10% of sales. The relative loadings of platinum and palladium in autocatalysts have shifted over time with technology and relative prices: the sharp rise in palladium prices compared with platinum from 2018 onwards prompted manufacturers to reduce palladium contents and increase platinum use—especially in gasoline catalysts—a substitution trend that is now moderating though is unlikely fully to reverse in existing designs. Average PGM

loadings in autocatalysts range between 3-9 grams, varying by engine type, emissions standard, and technology generation.

Sources: [Auronum](#), [SFA \(Oxford\) – How low can palladium go](#) and [The autocatalyst: A potted history](#)

Substitution potential: palladium can be partially replaced by platinum and rhodium, depending on engine type, fuel quality, emissions rules, relative metal prices, and market balances. Palladium had largely displaced platinum in gasoline catalysts, but more recently, platinum has been returning to some gasoline applications. Battery electric powertrains, which do not require an autocatalyst, are increasingly taking market share from combustion engine powertrains, so reducing autocatalyst PGM demand long term.

CHEMICAL

Current applications: PGMs are widely used as catalysts in industry, primarily in chemical manufacturing and petroleum refining. Their properties and high value make them particularly suitable for catalytic processes, where only a small amount of the metal can have a large impact on production, and they can generally be recovered at the end of the process, with a recovery efficiency of up to 95% in optimised and targeted processes.

Palladium is used by the petrochemical industry to catalyse the hydrocracking process. Palladium is also used in the production of several plastics and polymer precursors. Industrial palladium catalysts are effective in chemical reactions that require hydrogen exchange between two reactants, such as those producing butadiene and cyclohexane – the raw materials for synthetic rubber and nylon. Other applications of palladium-based catalysts include the production of terephthalic acid, hydrogen peroxide and high-purity hydrogen. Complex Pd compounds along with phosphines as ligands are widely used in homogeneous catalysis (eg C-C coupling reactions) in order to manufacture organic pharmaceuticals, fine chemicals, agrochemicals, intermediates, or liquid crystals

Substitution potential: some processes can switch to other PGMs or to base-metal catalysts where chemistry permits. But the risk is process-specific: in many plants, the catalyst is tightly optimised around platinum performance, lifetime and selectivity, which limits easy switching.

ELECTRICAL/ELECTRONICS

Current applications: PGMs have various uses in the electronics industry. Both palladium and platinum are used in the manufacture of some printed circuit boards. Palladium use in electronics has increased with the miniaturisation of components for applications such as mobile phones, where palladium is used in multilayer ceramic capacitors (MLCCs). Palladium-containing tiny components exist in virtually every type of electronic device, each component containing only a fraction of a gram of metal.

Palladium coatings, electrodeposited or chemically plated, are widely used in electronic components as an effective and long-lasting plating on account of palladium's electrical conductivity and durability. The most important use is in MLCCs, especially for demanding applications such as automotive engine management systems, broadcasting equipment, defence and aerospace electronics, medical devices, and consumer electronics requiring high reliability.

Smaller amounts of palladium are used in the conductive Ag-Pd (silver/palladium) tracks of hybrid integrated circuits (HIC) used primarily in the automotive sector. Additional applications in the electronics industry include plating connectors (as an alternative to gold) and using an alternative to Sn-Pb (tin/lead) solder.

Substitution potential: in mainstream MLCC applications, palladium has already been displaced in many cases by far cheaper base-metal electrodes such as nickel and copper. Palladium use is more stable in markets such as defence products, where high reliability, performance, and durability are more important than raw-material cost.

JEWELLERY

Current applications: The value and physical properties of PGMs make them suitable for high-value jewellery. Palladium is used both as an alloying addition to platinum and gold (for example, in white gold alloys) and, to a lesser extent, as a jewellery metal. Jewellery demand for palladium is now a niche segment.

Substitution potential: jewellery buyers can easily switch to other white metals (mainly white gold or silver) or to yellow gold depending on price, fashion, and weight preferences. Jewellery is generally considered a discretionary purchase, so it is at risk of being cut back on in favour of other luxury items.

DENTAL AND BIOMEDICAL

Current application: PGMs, mainly palladium, also find uses in dental applications. Palladium is an essential component of certain dental alloys for restorations such as inlays, bridges and crowns, where it provides strength, stiffness and corrosion resistance, while other metals in the alloy (such as gold, silver, zinc and copper in varying proportions) improve malleability and casting behaviour. In low gold alloys used in dentistry, palladium contents can range roughly from 50 % to 80 % by weight, although the use of precious metal dental alloys varies widely between countries depending on clinical practice, insurance coverage and patient preference. Overall, palladium demand in dentistry has been on a long-term downward trend as ceramics and base-metal alternatives gain share, so the dental segment today represents only a small, gradually declining share of total palladium consumption.

Source: [Johnson Matthey – PGM Market Report May 2023](#)

Substitution potential: In dental restorations, palladium alloys compete with ceramics, metal-ceramics, base-metal alloys, and newer digitally fabricated materials; the American Dental

Association notes the continued shift toward stronger, more aesthetic restorative options. In broader biomedical applications, titanium and zirconia are the main reference materials, which limits palladium mostly to niche roles rather than large-volume use in implants.

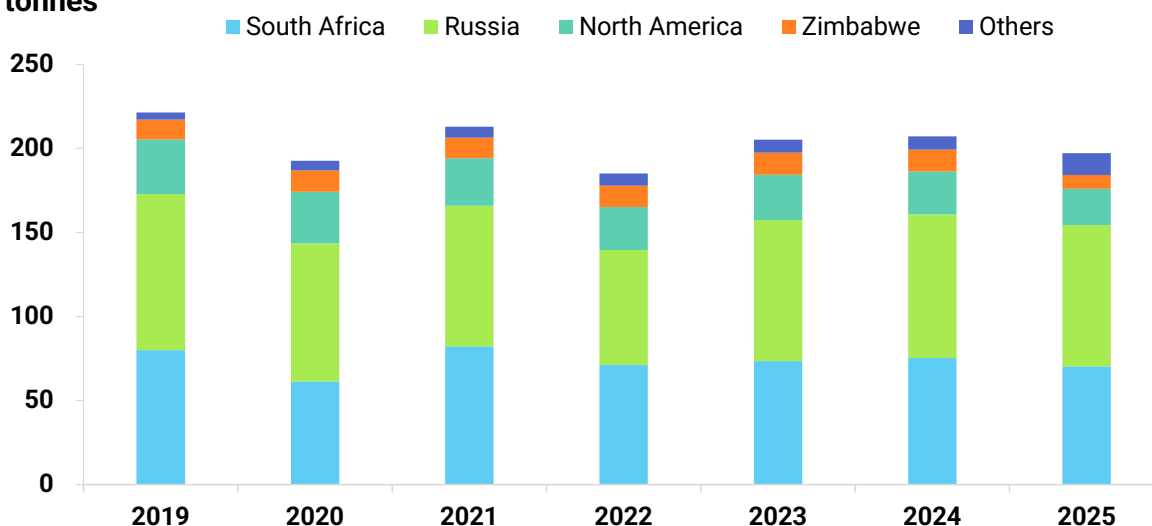
SUPPLY OUTLOOK

SUPPLY FROM PRIMARY MATERIALS

GLOBAL & EU MINE PRODUCTION

Global primary palladium supply shows some variability from year-to-year among each of the producing countries, plus of course significant perturbation through the pandemic years. Production has remained at around 205 tonnes for the past three years.

Global palladium primary supply tonnes



Source: Johnson Matthey (January 2026)

The future supply situation, with Russia and South Africa being the main sources, is unlikely to change in the medium to long term, as these countries hold the largest known resources. Primary palladium supply will therefore remain dependent on known deposits.

However, as Russia is a major producer of PGMs, particularly palladium, the war in Ukraine has created significant supply risks. Sanctions and customer self-sanctions have reduced PGM trade between Russia and its Western and Asian trading partners. The U.S. government has imposed dissuasive import duties on all Russian PGMs, except palladium sponge, starting in April 2023. Trade data indicates continued significant palladium shipments to U.S. counterparts [[Johnson Matthey, 2024](#)]. In Russia, Nornickel has faced difficulties in sourcing equipment (though this has now shifted to Chinese equipment providers) and reagents, as well as restricted access to international banking and bond markets. Nornickel smelter maintenance is scheduled for 2027 while it is also investing in expanding its concentrator plant capacities.

Russia, the United States, and the United Kingdom are primary importers of palladium at the processing stage. Since Russia's invasion of Ukraine in 2022, Western sanctions – including export tariffs, bans on Russian refiners from key markets like the London Bullion Market, and recent US anti-dumping duties up to 828% - have disrupted direct palladium flows, forcing rerouting through third countries and tightening global supply despite Russia's ongoing ~26-40% production share. Global mining production of PGMs is concentrated among a few companies.

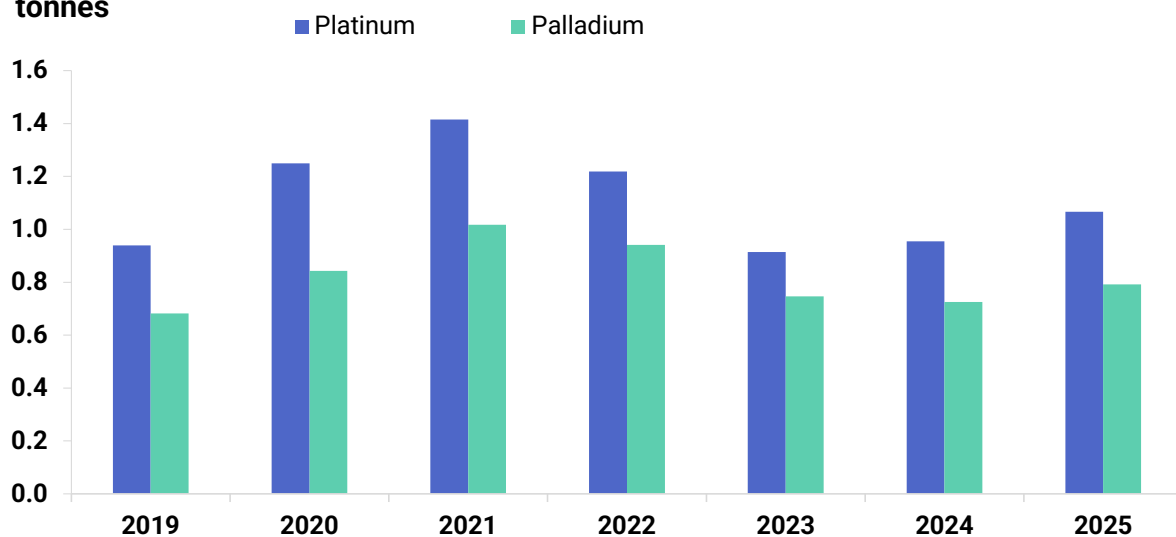
Sources: [EU JRC](#) and [WPIC](#)

Almost all PGMs from mining are marketed as refined metal from integrated mining-metallurgical operations, making producing countries the main exporters. Norilsk Nickel's metal is refined by third parties in Russia (Krastsvetmet), while in South Africa, Valterra Platinum, Sibanye-Stillwater and Impala Platinum have fully integrated mine-to-metal processing infrastructure while Northam sends its high-grade PGM concentrate (after base metal removal) to Europe for final PGM refining.

Only a very small share of global PGM production takes place within the EU, shown in the chart below. This counts supply in the region where the ore was mined, not in the region where subsequent processing takes place (source: Johnson Matthey). Between 2018 and 2022, only palladium and platinum were extracted from EU mines. European palladium mine production was less than 1 tonne in 2023 and came almost entirely from Finland, primarily from the Boliden Kevitsa mine, which produces PGMs as by-products of nickel and copper mining. Source: [World Mining Data 2025](#)

Small quantities of by-product PGMs are also recovered in Europe from processing other metals (for example from KGHM's copper refining residues in Poland), but these are not separately estimated and do not involve dedicated PGM mining. In addition, some PGMs mined outside Europe is processed by European refiners. This includes PGM mined by Glencore in Canada that is refined in Norway, while PGM mined by Northam in South Africa is refined in Germany and the UK. This metal is counted in the North America and South Africa primary supply numbers, respectively.

European primary supply tonnes



Source: Johnson Matthey (January 2026)

PGM production facilities are extensive and complex, with many steps from approval to fully operational. Brownfield restarts and shallower mechanised decline projects with existing infrastructure typically take from 8-18 months, mechanised shallow greenfield projects can take 3-4 years, while large deep level vertical shafts can take around 6-8 years.

PROCESSING

Palladium is marketed in refined form. Since extracted ores contain only low concentrations of palladium, several processing stages are needed after mining to concentrate and purify the metal. Refining takes place mainly in producing countries, which are also the principal exporters. Metallurgical processing and refining to produce high-purity PGM products are complex, costly and time-intensive, and the production of refined metal can take up to six months from the extraction of the first PGM-bearing ore. Processing routes vary between companies, and the specific techniques used are generally not disclosed for commercial reasons. Depending on the mineralogical characteristics of the ore, a range of physical and chemical concentration methods may be used, including crushing and grinding, froth flotation, and in some cases magnetic separation and dense media separation.

The platinum group metals value chain is also highly concentrated at the manufacturing stage. Globally, the PGM manufacturing industry is concentrated among a handful of companies, which together account for around 85% of the manufactured goods market. These companies have a strong presence in Europe, including the United Kingdom. They operate large, integrated facilities that process material from both primary and secondary sources and supply the global market with a wide range of PGM materials and products from specialised plants located across several regions, including Europe.

In the catalytic converter sector, precursor salts are produced within the EU either by specialised manufacturers or by the automotive industry itself. In other applications, refined salts or purified metal are used according to end-use requirements. For example, metal is supplied to the jewellery and electronics sectors, with subsequent manufacturing stages taking place within the EU where relevant industrial capacity exists. Metal production also takes place in the EU after salt production. At this stage, metal salts are heat-treated to produce pure PGMs, and alloying between different PGMs may also occur. In the chemical sector, supply is often in the form of salts, which serve as precursor materials for other chemicals and catalysts. As a result, the EU is active across all downstream stages following initial extraction and primary processing.

Once refined to sponge (or ingot), primary and secondary PGMs are indistinguishable and are traded and used as equivalents.

GEOLOGY, GLOBAL RESOURCES & RESERVES

GEOLOGY

Platinum group metals (PGMs) are among the rarest elements in the Earth's crust, with an overall abundance of around 1.5 ppb in the upper continental crust and 3.7 ppb in the lower continental crust. Palladium is estimated to occur at between 1.5 and around 5 ppb in the Earth's crust, while its abundance in the upper crust is about 0.5 ppb [[British Geological Survey \(BGS\), 2024](#); Rudnick & Gao, 2014].

The geology and formation of palladium-bearing ores and PGM deposits more broadly are complex and linked to a range of specialised geological settings and mineralising processes, including tectonic, magmatic, hydrothermal, and secondary processes such as weathering, erosion, sedimentation, transport, and accumulation. Palladium commonly occurs in native form, that is, in an uncombined state, and as an alloy with other platinum group metals, particularly iron. In ore deposits, palladium is generally associated with other PGMs, notably platinum, as well as with other metallic minerals. PGMs typically occur together in nature and are commonly associated with nickel and copper, and in some cases with iron.

In some deposits, platinum and palladium are the principal products and provide the main economic basis for mining, while the other PGMs are recovered as by-products that make a smaller contribution to revenue. In other deposits, PGMs themselves are by-products, for example, in nickel mining, but they still contribute significantly to the economics of the operation.

Economically significant PGM deposits occur in several forms, but most are associated with mafic and ultramafic igneous rocks and formed through magmatic processes. Most global PGM resources and reserves fall into two broad deposit classes: the PGM-dominant class and the nickel-copper sulphide class. In the PGM-dominant class, platinum is generally the main economic product (though this can vary depending on the orebody), with smaller amounts of palladium and rhodium also recovered, providing the main bulk of revenue.

PGMs are typically present in base-metal sulphide minerals, or in a wide range of discrete PGM-bearing minerals, where they are combined with one another, with other metals in alloy form, or with elements such as sulphur, arsenic, antimony and tellurium. As a result, they are usually extracted together from the same deposit, either as primary products or as by-products.

Sulphide deposits are the most common source of palladium and are generally associated with mafic and ultramafic igneous rocks. Palladium sulphide minerals, such as vysotskite (PdS) and braggite ((Pt,Pd)S), are commonly found alongside other metal sulphides, particularly nickel sulphides, in layered intrusions and ultramafic rocks. Palladium arsenides and antimonides, including PdAs₂, Pd₂(As,Sb) and PdSb, are typically associated with hydrothermal veins and magmatic deposits. Palladium bismuthides and tellurides, such as kotulskite (PdTe), merenskyite (PdTe₂) and michenerite (PdTeBi), may also occur in smaller quantities in certain magmatic and hydrothermal deposits.

Metallic palladium and platinum-palladium alloys are also found in alluvial deposits. In weathered parts of PGM deposits, platinum-palladium, with or without gold, copper, and iron, may occur at concentrations high enough to be worked profitably. However, these occurrences make only a minor contribution to global PGM supply and generally provide income mainly for local artisanal miners.

Palladium deposits are relatively rare and confined to a few regions worldwide. Most global palladium production comes from only a few countries, with the largest reserves and production concentrated in Russia, South Africa and Zimbabwe. PGM enrichment occurs in several deposit types, but only within a narrow range of geological settings. Mineable PGM deposits are geologically rare, and most PGM-bearing ores are very low grade. In the main commercial deposits, ore grades typically range from 1 to 10 grams per tonne for combined PGMs and gold [[USGS, Zientek M. et al., 2017](#)].

Substantial PGM deposits are known to exist beyond those already classified as reserves and resources, and these are likely to be sufficient to support mining for many decades. However, the precise composition of these deposits, particularly the relative distribution of individual PGMs and associated elements, is not always well defined.

GLOBAL RESOURCES & RESERVES

Russia is the world's leading producer of palladium, accounting for around 43% of global output. Its most important deposits are located in the Norilsk-Talnakh region of northern Siberia, where ores are characterised by high grades of palladium, platinum and other platinum group elements. These deposits are associated with nickel and copper sulphide mineralisation hosted in mafic to ultramafic intrusive complexes. They are mined primarily for their nickel and copper content, although cobalt, gold, silver and PGMs also make a significant contribution to overall value where they occur in economically recoverable quantities. In the Portimo complex of Finland, the common base-metal sulfides are pyrrhotite, chalcopyrite, and pentlandite; in the Suhanko/Konttijärvi marginal series, PGE concentrations are commonly up to 2 ppm but locally

exceed 10 ppm, and most deposit types are palladium-dominant. *Source: Iljina, M., Maier, W.D., & Karinen, T. (2015). "PGE-(Cu-Ni) Deposits of the Tornio-Näränkävåara Belt of Intrusions (Portimo, Penikat, and Koillismaa)." In Mineral Deposits of Finland.*

According to Nornickel, the average grade of these deposits is 5.54 ppm of 6E, referring to the combined content of platinum, palladium, rhodium, ruthenium, iridium and gold. Of this total, around 4.25 ppm is palladium and 1.13 ppm is platinum. In Norilsk-type Cu-Ni-PGE ores, palladium generally exceeds platinum; reported Pd/Pt ratios are commonly about 2–4, corresponding to Pt/Pd values of roughly 0.25–0.5, while Maslovskoye reserve data imply Pt/Pd \approx 0.40. *Source: [Pd/Pt imbalance in lava and intrusions of the Norilsk-Talnakh ore region](#)*

These deposits rank among the largest PGM accumulations in the world, with combined reserves and resources exceeding 15,000 tonnes. Russia also hosts a significant alluvial deposit in the Ural Mountains, containing platinum, palladium and other PGEs associated with mafic to ultramafic intrusions, which is still being mined.

Africa is the second-largest producer of palladium, contributing around 35% of global supply. The largest palladium-bearing ore deposits are found in South Africa's Bushveld Complex, which contains extensive reserves of palladium, platinum and other PGMs. The Bushveld Igneous Complex is dominated by two PGE-rich layers, the Merensky Reef and the UG2 Chromitite Reef.

The Merensky Reef consists of extensive, layered mafic-to-ultramafic intrusions in the northern part of the country and contains platinum, palladium, rhodium, and other PGEs. It is made up of laterally continuous but relatively thin mineralised layers, known as reefs, within large, layered intrusions. Current mill-head grades are typically 4 to 7 ppm 6E or 4 to 6 ppm 4E, which include platinum, palladium, rhodium, and gold. At the largest operating mines, the platinum-to-palladium ratio generally ranges between 2.0:1 and 2.5:1 [[IPA](#)].

The UG2 Chromitite Reef has a similar geometry to the Merensky Reef (sitting above the UG2 in the stratigraphy), but consists of thin, continuous layers of chromite. Typical mined grades are between 2.5 and 4 ppm 4E. At Bushveld operations, Pt/Pd ratios are often around 2:1 but can vary to near 1:1 in some ore bodies; current mine data also show that UG2 ores contain higher rhodium, ruthenium and iridium than Merensky ores [[IPA](#)]. The UG2 Chromitite of the Bushveld Igneous Complex is widely regarded as the world's largest known repository of PGM resources.

Although the Merensky and UG2 reefs are the most important, the Platreef, which forms the northern outcrop of the Bushveld Complex, is also significant and is currently mined by open-pit methods. The Platreef appears to extend to depths of at least 2 km, suggesting substantial future potential for platinum group metal extraction if suitable underground mining methods are developed. Typically, palladium is more abundant than platinum in Platreef ore.

South African production dipped slightly in 2024 due to electricity disruptions, higher costs and asset restructuring, but stabilised without major load shedding (load shedding is South Africa's controlled, scheduled power outages to prevent the national grid from collapsing when supply can't meet demand). Load-shedding in South Africa improved dramatically in 2025, with only 26 hours total across four days early in the year and over 231 consecutive days without outages by

year-end, driven by Eskom's Generation Recovery Plan. No significant shifts have altered the Bushveld's dominance or the geological details provided. *Source: [Semafor](#)*

Zimbabwe is another major palladium producer, with deposits located in the Great Dyke, a geological formation that extends from north to south across the country. The Great Dyke is a layered mafic-to-ultramafic complex that contains platinum, palladium, and other valuable minerals. As a major PGM deposit, it is broadly comparable to the Merensky Reef (but with a platinum:palladium ratio closer to 1:1), but the extent of the intrusion is much smaller.

Palladium deposits are also found in the Americas, particularly in Canada and the United States, although production from these countries remains low compared with that of the main global producers. In Canada, economically important platinum group metal resources occur in magmatic nickel-copper sulphide deposits, notably in the Sudbury Igneous Complex. Palladium is mined there mainly as a by-product of nickel and copper production, especially in Ontario and Manitoba.

In the United States, palladium is produced primarily as a by-product of platinum mining in Montana, with smaller deposits occurring in other states. The Stillwater Complex in Montana is much smaller than either the Bushveld Complex or the Great Dyke, but it contains PGMs at significantly higher ore grades. However, the mineralised zones are dispersed and steeply dipping, which limits the volume of ore that can be extracted.

EU RESOURCES & RESERVES

The largest PGM resources in the EU are in Finland and Sweden, where they occur in nickel-copper sulphide ores at concentrations ranging from a few ppm to a few tens of ppm. Most platinum group minerals occur as very small individual grains, either enclosed within silicates (57%) or located along sulphide grain boundaries [Gervilla, F., 2002].

SUPPLY FROM SECONDARY MATERIALS/PRODUCTION

RECYCLING

Palladium's high value and relative rarity make recycling particularly attractive. Secondary production of PGMs also has a significantly lower environmental impact than primary production, because PGM concentrations in many end-of-life products are far higher than those found in mined ores. For example, autocatalysts can contain up to 2,000 g/t of PGMs, compared with 2 to 6 g/t in most PGM ores, while computer motherboards contain around 80 g/t of palladium [I Yakoumis et al, [Recovery of platinum group metals from spent automotive catalysts: A review, Cleaner Engineering and Technology 3 \(2021\)](#)].

Recycling of automotive catalysts is the most important source of secondary supply. Using current refining technologies, around 95% of the PGM content in spent autocatalysts can be recovered.

From a technical perspective, PGMs are highly recyclable, with platinum recovery rates above 95% being achievable under suitable conditions. However, the specific recycling process required

depends on the type of material being treated, the combination of materials present, the contaminants to be removed, and the specific PGM mix to be separated. The choice of treatment method for palladium recovery is therefore influenced by both the purity of the feed material and the value of the final product.

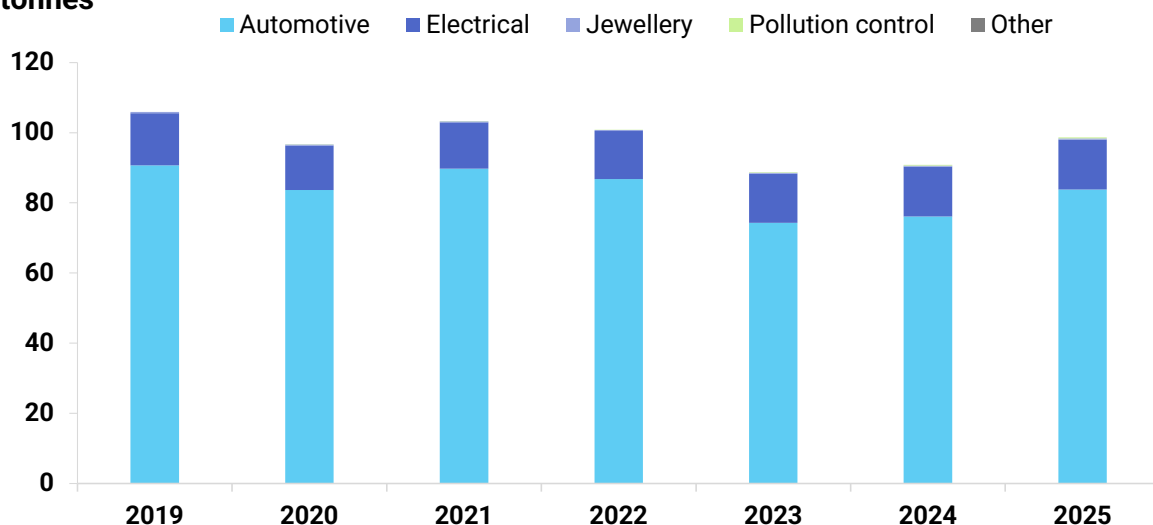
The secondary supply shown in the global and European charts below refers only to open-loop recycling and does not include closed-loop recycling as it is often not visible to the market. In the case of automotive recycling, the figures capture only the PGMs recovered from vehicles first sold within the European region. As a result, the actual quantity of PGMs processed by European refiners may differ because of scrap flows and vehicle imports and exports [Johnson Matthey, January 2026].

Autocatalyst material dominates global secondary supply because it is supported by a highly developed value chain involving dismantlers, collectors and refiners. As noted above, recycling of automotive catalysts is the single most important contributor to secondary PGM supply, with approximately 95% of the contained PGMs recoverable during refining. Average PGM loadings in autocatalysts range between 3-9 grams, varying by engine type, emissions standard, and technology generation.

Autocatalyst recycling is generally more attractive when metal prices are high, as the higher contained metal value improves margins across the value chain. Conversely, recycling volumes tend to decline when consumers keep vehicles for longer. This can happen when new vehicle availability is constrained by supply chain or logistics disruptions, or during periods of economic weakness when consumers are less willing or able to commit to expensive purchases or high-interest financing arrangements.

Electrical scrap, including waste electrical and electronic equipment (WEEE), is also becoming more tightly regulated worldwide, helping improve collection rates. However, recovery processes can be complex and environmentally challenging, and recovery rates are not always high.

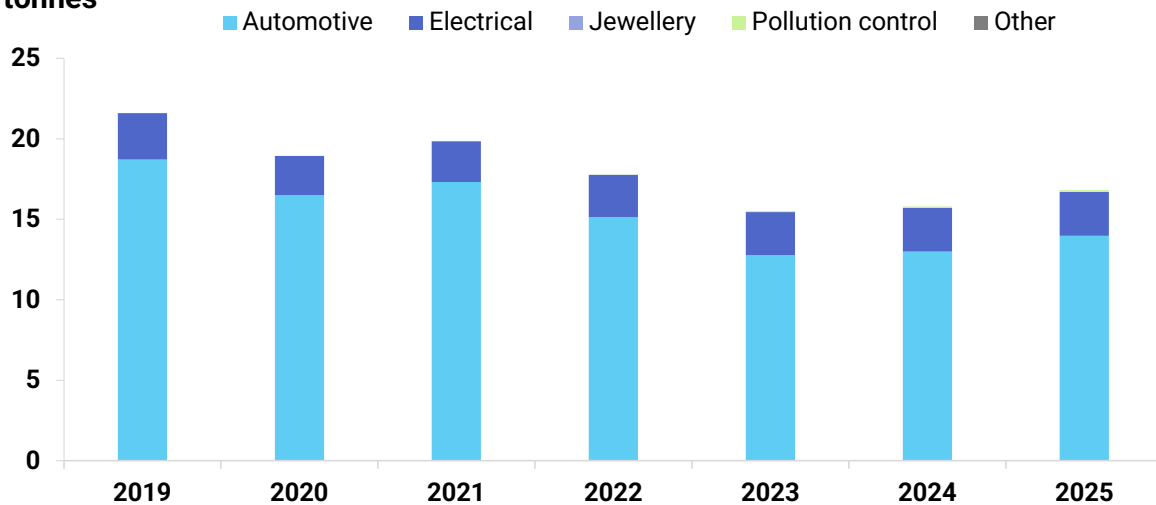
Global palladium secondary supply tonnes



Source: Johnson Matthey (January 2026)

In Europe, the year-to-year profile and split between autocatalysts and electrical demand closely follows the global pattern, dominated again by autocatalysts and with some electrical material.

Europe palladium secondary supply tonnes

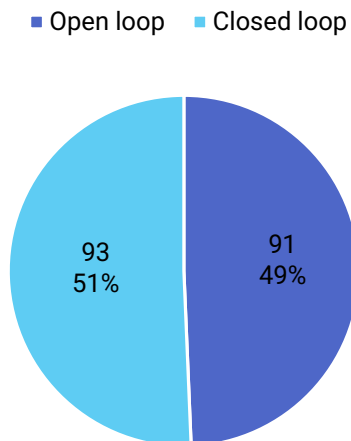


Source: Johnson Matthey (January 2026)

Note: Europe defined here as EU+ (includes UK and Turkey but excludes Russia)

Closed-loop recycling volumes have not been very visible historically. In its 2024 Circularity Whitepaper, Johnson Matthey has provided estimates for the total (open + closed loop) global recycling volumes, shown below. In its [2026 Whitepaper](#), Heraeus Precious Metals shows similar results. The closed-loop and open-loop are half each of palladium recycling and the total is about half the size of the platinum total.

Global palladium total (open + closed loop) recycling: 2024 tonnes



Source: Johnson Matthey (January 2026)

OTHER CONSIDERATIONS

HEALTH AND SAFETY ISSUES

Various soluble palladium compounds encountered in industrial settings have the potential to cause skin sensitisation (allergic contact dermatitis), including simple salts, tetraamminepalladium salts, and chloropalladates. Cross reactivity with nickel is common, and allergic reactions to palladium containing dental alloys and jewellery have been well documented. Palladium compounds are not, though, known to cause sensitisation of the respiratory tract or occupational asthma.

While palladium metal and its monoxide do not have any hazard classifications assigned, various other palladium compounds found in industrial settings are classified for eye irritation and some also for skin irritation. Acute oral toxicity potential is low.

The International Platinum Group Metals Association (IPA) has developed comprehensive guidance on the safe use of PGMs in the workplace. This guidance is used by PGM producers and downstream users to design and continually improve occupational health and safety programmes, helping to ensure that the benefits of PGM-containing technologies are delivered while protecting workers along the supply chain. *Source: [IPA](#)*

ENVIRONMENTAL ISSUES

The IPA routinely conducts Life Cycle Assessments of the PGMs to assess the potential environmental impacts of their production and makes the results for key impact categories available on its website.

In 2025, the IPA has published a CO₂ scenario for primary production in 2030, based on investments by South African producers and the South African government into renewable energy, which shows a potential decrease in the CO₂ footprint of mining of between 35% and 61%, depending on the metal (Bossi/Gediga, [Decarbonisation in the Mining of Platinum Group Metals – A CO₂ Outlook to 2030 | Johnson Matthey Technology Review](#)). As changes in renewable energy use in other regions with high palladium mining (United States, Canada, Russia) were not considered, the global GWP value for palladium benefits less from improvements than platinum, rhodium, ruthenium, and iridium.

Palladium extraction and smelting are associated with local environmental pressures – including risks of acid mine drainage and heavy metal mobilisation where PGMs are coproduced with nickel and copper sulphide ores – and these impacts are well documented in recent criticality and LCA work.

The PGM industry has systematically worked to reduce these impacts by improving energy efficiency, increasing the share of lower carbon electricity, tightening water and tailings management and expanding high-yield recycling routes; these improvements are reflected in the downward trend in impact intensities compared with the original 2010 IPA LCA. Many large PGM mines and refiners now align with, or seek certification under, third-party standards such as the

Initiative for Responsible Mining Assurance (IRMA), ICMM Performance Expectations, and LPPM Responsible Sourcing, which impose additional requirements on environmental performance, community engagement, and transparency beyond local regulation.

From a full life cycle perspective, the environmental benefits of using small amounts of palladium (or platinum/rhodium) in autocatalysts significantly exceed the impacts of producing that metal: IPA’s LCA work on Euro 6d-Temp vehicles shows that a few grams of Pd in a three-way catalyst enable the abatement of well over a tonne of toxic local air pollutants (CO, HC, NO_x, particulates) over a car’s lifetime, with the health and air quality gains far outweighing the 28 kg CO₂-eq per gram associated with producing the palladium itself.

The results for the key impact categories of the primary production of PGMs, as assessed in IPA’s last LCA on production year 2022, can be found below:

Summary of primary production results per kg of metal					
Impact Category	Pt	Pd	Rh	Ir	Ru
Global Warming Potential [kg CO ₂ eq.]	36,828	28,094	38,027	42,096	42,000
Primary Energy Demand [MJ]	494,563	425,546	508,222	548,987	547,114
Acidification Potential [Mole of H ⁺ eq.]	1,687	4,507	1,446	887	926
Eutrophication Potential [Mole of N eq.]	687	450	715	812	811
Photochemical Ozone Creation Potential [kg NMVOC eq.]	258	380	249	236	238
Blue Water Consumption [kg]	297,006	243,960	305,879	335,220	329,931

For the secondary production route (recycling), the IPA has published the following values for Pt, Pd, and Rh (results for Ir and Ru could not be published as a minimum number of three contributing companies could not be met):

Summary of secondary production results per kg of metal

Impact category	Pt	Pd	Rh
Global Warming Potential [kg CO ₂ eq.]	477	497	497
Primary Energy Demand [MJ]	9,976	10,370	10,402
Acidification Potential [Mole of H ⁺ eq.]	1.26	1.29	1.30
Eutrophication Potential [Mole of N eq.]	3.68	3.70	3.77
Photochemical Ozone Creation Potential [kg NMVOC eq.]	0.95	0.95	0.97
Blue Water Consumption [kg]	2,419	3,654	3,458

NORMATIVE REQUIREMENTS

At the sector level, the International Platinum Group Metals Association (IPA) has developed comprehensive guidance on the safe use of PGMs in the workplace, including recommendations on exposure monitoring, medical surveillance and best practices for controlling occupational exposures to certain soluble PGM compounds that can cause respiratory sensitisation. This guidance is used by PGM producers and downstream users to design and continually improve occupational health and safety programmes, helping to ensure that the benefits of palladium-containing technologies are delivered while protecting workers along the supply chain.

Source: [IPA](#)

SOCIOECONOMIC AND ETHICAL ISSUES

The extraction and refining of platinum group metals (PGMs) can place significant pressures on local environments; however, the environmental and social impacts of PGM extraction are taken seriously by industry and have been the focus of substantial improvements in recent years, particularly in water stewardship, air emissions control and waste management. Water remains a critical input to flotation and processing, but major PGM mines in South Africa and elsewhere now operate closed-loop systems that recycle a large share of process water, supported by site-specific water balances and dedicated treatment plants that repurpose mine water for cooling and other uses. Recent case studies from deep-level PGM operations in Limpopo show that membrane-based treatment and reuse can replace a significant portion of potable “board” water, delivering both cost savings and reduced pressure on local water resources, in line with IRMA’s detailed requirements for water management. South Africa continues to face structural water stress in some areas, with renewable water resources of around 800–900 m³ per person per year, but national water use efficiency and mine water management programmes, together with company-level integrated water and waste management plans, are designed to ensure that mining does not crowd out essential domestic and agricultural uses.

Sources: *PGM mining and processing in the circular economy: A framework towards circularity* (J. Kruger, 2022) and [UN](#)

Tailings and waste rock are an inherent byproduct of all hard rock mining, but in the PGM sector, they are managed as engineered storage facilities rather than unmanaged “waste dumps”, with design, monitoring and closure governed by international standards such as the Global Industry Standard on Tailings Management and, increasingly, IRMA requirements. Leading PGM producers report full conformance with these standards for high-consequence facilities and are investing in tailings re-treatment, re-vegetation, and long-term stability measures to reduce legacy impacts and recover additional metal value. Through the IPA, member companies have committed and continue to align their operations with recognised responsible mining and sourcing frameworks, including IRMA and other sustainability assurance schemes (such as the forthcoming Consolidated Mining Standard Initiative – CMSI), demonstrating measurable progress over time and helping ensure that PGM production supports local development while minimising environmental impacts.

PGM mining companies operate under comprehensive mining legislation, environmental regulation, and binding social and labour obligations. Mining companies adhere to rigorous sustainability reporting, environmental permitting and labour compliance requirements.

All IPA PGM mining companies are publicly listed (LSE, JSE, NSE) companies which routinely report about their environmental, social and governance performance and abide by the regulations set out by national/local authorities and the respective stock exchanges.

IPA members apply sustainability reporting principles to ensure organizations communicate and demonstrate accountability for their environmental, economic, and social impacts, in line with global best practices such as the UN Sustainable Development Goals (UN SDGs), the Global Reporting Initiative (GRI), and the UN Global Compact.

Source: [IPA](#)

ECONOMIC IMPORTANCE OF PALLADIUM FOR EXPORTING COUNTRIES

Palladium and the PGM industry are economically significant for South Africa and, to a lesser extent, for Zimbabwe and Russia. In South Africa, platinum-group metals are a major mining industry, a source of export earnings, industrial employment and fiscal revenue, and an anchor for local refining and fabrication capabilities.

PGM mines in South Africa and Zimbabwe are not government-owned but are owned by publicly listed companies and their shareholders.

For producers and their downstream customers, the government policies, infrastructure performance and macroeconomic conditions in the countries where they mine can significantly affect supply. Such issues may cause short-term disruptions, while, of course, the fundamental geology determines the long-term potential of a mine region.

RESEARCH AND DEVELOPMENT TRENDS

Current R&D is practical rather than speculative. In autocatalysts, the focus remains on catalyst formulations that maintain conversion efficiency with lower PGM loadings, better thermal durability and more flexible platinum/palladium balances. In recycling, the emphasis is on higher recovery, better sampling and faster turnaround. In hydrogen-related technologies, palladium retains niche strategic importance due to its hydrogen permeability, though current tonnage demand remains limited relative to that for autocatalysts.

R&D on palladium is increasingly geared towards its role as an enabler of low carbon and green technologies, notably in emission control, hydrogen systems and high efficiency chemical processes. In the automotive sector, research focuses on higher activity, more durable palladium-based three-way catalysts that can meet ever tighter pollutant limits with lower PGM loadings, including designs tailored for hybrid powertrains and higher biofuel or e-fuel blends, thereby cutting CO₂ and local air pollutants from the existing global vehicle fleet.

On the supply side, R&D aims to reduce the footprint of palladium itself by raising recycling rates and improving process efficiency. Company-level decarbonisation programmes and sector wide LCAs are increasingly used to steer investments into mine and refinery upgrades (higher efficiency comminution and smelting, more renewable electricity, improved water and tailings management), so that the palladium deployed in low carbon value chains comes with a progressively lower cradle-to-gate environmental footprint over time.

Sources: [IPA](#)

A new collaboration was launched in February 2026 to develop high-impact PGM technologies and drive the next wave of industrial innovation. This recognises that currently, some 60% of global PGM supply is used in autocatalysts; in the long term, this is threatened by the increasing share of battery electric vehicles (BEVs). Johnson Matthey, Sibanye-Stillwater, and Valterra Platinum launched the programme to explore and scale technologies that leverage the exceptional performance and durability of PGMs, as well as their robust, circular supply chains. Expected to expand with additional partners in the coming months, the collaboration will explore uses across multiple sectors, including clean hydrogen, enhanced emissions detection and reduction across stationary and mobile sources, new electronic materials, and high-performance alloys and other advanced materials.

APPENDIX: RELEVANT HS/CN CODES

PALLADIUM METAL, SEMI-MANUFACTURED AND SCRAP

Level	Code	Description
711021	71102100	Palladium — unwrought or in powder form. Covers bars, ingots, sponge, granules, shot and powder. Palladium has its own dedicated WCO 6-digit subheading, equivalent in structure to platinum's 7110.11.
711029	71102900	Palladium — other semi-manufactured forms. Covers foil, sheet, strip, wire, rod, tube, sputtering targets, and rolled or drawn palladium products.
711230	711230	Ash containing precious metal or precious metal compounds, principally for recovery. Covers palladium-bearing furnace ash, sweepings and spent catalyst fines.
711292	711292	Waste and scrap of platinum, including platinum-group metals — excluding sweepings containing other precious metals. At the WCO 6-digit level palladium scrap shares this code with platinum scrap; there is no separate 7112 subheading dedicated to palladium alone. Covers spent Pd autocatalysts, worn Pd electrodes, off-cuts and turnings.
711299	711299	Other precious metal waste and scrap not elsewhere specified. Used for mixed PGM scrap containing palladium where the material cannot be assigned to a single-metal line (e.g. mixed Pt/Pd/Rh autocat material).

PALLADIUM COMPOUNDS (SALTS, ETC)

Level	Code	Description
2843	2843.10	Colloidal precious metals. WCO notes to heading 2843 explicitly list palladium as one of the precious metals covered in colloidal suspension form; used in coatings and catalysis.
	2843.90	Other inorganic or organic compounds of precious metals; amalgams. Primary code for all palladium salts and chemical intermediates — palladium(II) chloride (PdCl ₂), palladium(II) nitrate, palladium(II) acetate (Pd(OAc) ₂), palladium(II) acetylacetonate, bis(dibenzylideneacetone)palladium (Pd ₂ dba ₃), and other organometallic palladium complexes. India's national tariff adds a named sub-split 2843.90.12 — Noble metal solutions of platinum, rhodium and palladium — covering Pd-bearing solutions.

PALLADIUM REAGENT SOLUTIONS AND KITS

Level	Code	Description (short)
3815	3815.12	Supported precious metal catalysts where the active substance is a precious metal or compound. Covers Pd/C, Pd/Al ₂ O ₃ , Pd/BaSO ₄ and other heterogeneous palladium catalysts widely used in hydrogenation, cross-coupling (Heck, Suzuki, Buchwald-Hartwig) and pharmaceutical synthesis.

	3815.90	Other reaction initiators and accelerators not elsewhere specified. Used for homogeneous palladium catalyst systems (e.g. Pd-phosphine complexes, PEPPSI catalysts) where 3815.12 does not apply.
3822	3822.19	Prepared diagnostic or laboratory reagents (other), including kits. Standard code for palladium ICP/AAS standard solutions and analytical reagent preparations without certified reference material status.
	3822.90	Certified reference materials. Covers palladium single-element CRM standards (e.g. 1,000 mg/L Pd in HNO ₃ /HCl). Plain palladium chloride solutions without CRM certification remain under 2843.90.

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DEFINITIONS & METHODOLOGY FOR DATA

The demand, primary, and secondary data used to create charts and quoted in the text are based on Johnson Matthey's PGM Market Report dataset (most recent edition: May 2025) and have been updated with estimates to reflect the situation as of December 2025.

Primary supply

Supply figures represent producers' sales of primary PGM and are allocated to the region where mining took place, rather than to the region of subsequent processing.

Secondary supply

Secondary supply is the quantity of metal recovered from open-loop recycling (i.e. where the original purchaser does not retain ownership of the PGM).

Outside the automotive, jewellery and electronics markets, open-loop recycling is negligible.

Automotive recycling represents the weight of metal recovered from end-of-life vehicles and aftermarket scrap. It does not include warranty or production scrap.

Demand

Demand figures for any given application represent the sum of industry demand for new metal in that application, net of any closed-loop recycling (i.e. where industry participants retain ownership of the metal: an example would be recycling of spent chemical catalysts, where the metal is retained to be used on fresh catalyst that replaces the spent charge).

Automotive demand is allocated to the region where the vehicle is manufactured and is accounted for at the time of vehicle production. It includes emissions catalysts on vehicles, motorcycles and three-wheelers, as well as fuel cell vehicles. Non-road mobile machinery is counted as industrial demand, in the pollution control category.

Jewellery demand is allocated to the region where the finished jewellery is manufactured, not to the region where it is sold.

Regional definitions

Europe: EU+ (includes UK and Turkey but excludes Russia)

Open-loop recycling

When the original purchaser of the metal does not retain control over the PGM, the metal is available to the market again once recovered. The main source of open-loop metal is automotive catalytic converters, which are widely recovered from scrapped vehicles and recycled to recover the contained platinum, palladium or rhodium contained. Some metal is also recovered from the jewellery and electronics markets.

Closed-loop recycling

Refers to the situation where the metal remains within the application, e.g., when metal is recovered from used chemical catalysts and is used to produce fresh catalysts to replace the spent charge. While this metal is processed by PGM refiners, the equivalent amount of metal is usually returned to the original owner, who retains the metal value. As the net amount of metal in use

has not changed, this returned metal is not counted towards market supply. Re-using metal in such way avoids the need for virgin mined metal, thereby contributing to make demand more sustainable.