Palladium: Impact assessment for supply security

HIGHLIGHTS

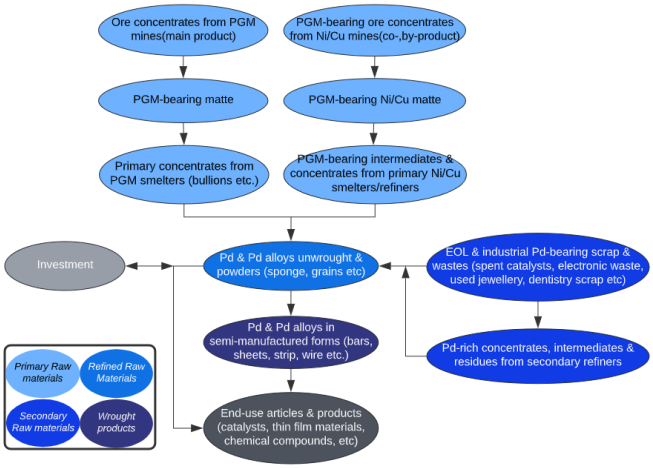
- → The global supply chains of palladium, a crucial automotive metal, are heavily dependent on Russia. In 2020, Russia accounted for 41% of world's mining production, and was the leading exporter of refined palladium with a 30% share in global export value.
- → There is limited production capacity worldwide to fill a gap in case of constrained supply from Russia in the short term. The global reliance on Russia is expected to ease gradually after 2025 due to the anticipated ample supply and weaker demand for autocatalysts.
- → The EU relies significantly on third countries for refined palladium supply. Imports are estimated to represent about half of the EU's supply. Russia used to be a prominent supplier accounting for about one-third of the EU's imports in 2021 and 15% of the EU's sourcing in the last decade. EU imports from Russia decreased after the invasion of Ukraine compared with 2021.
- → Diversification of EU's supply is feasible through existing producers. South Africa, Zimbabwe, and the USA are expected to contribute the most to additional primary supply in the next decade. The UK is also an important supplier of refined palladium globally.
- → EU's industrial base to refine platinum group metals from secondary sources mitigates supply risks. The gradual decline in European demand, in combination with increased availability of secondary raw materials (imports or increased circularity) could alleviate reliance on Russia.

QUICK GUIDE – This briefing is one of a series of overviews in the Raw Materials Information System (RMIS) about the potential supply disruption of non-food, non-fuel raw materials due to Russia's war against Ukraine.

Joint Research Centre

Palladium (Pd) is a precious metal and one of the six elements of platinum-group metals (PGM)[1]. PGMs are among the least abundant of the Earth's elements and are classified as critical and strategic in the EC 2023 list of Critical Raw Materials. Palladium is widely used in catalytic converters to curb vehicle emissions and, to a lesser extent, in the chemical and electronics sectors. Palladium is important for the green transition due to the increasing use of electronic components and catalysts in emerging and renewable energy technologies.

Figure 1 – Overview of palladium's value chain



Source: JRC

IMPACT ASSESSMENT

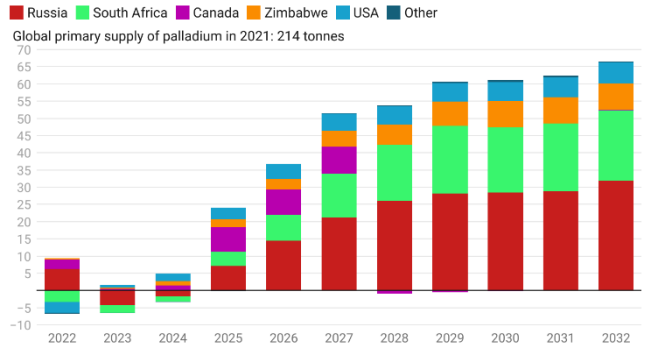
Short-term impacts and medium-term outlook globally

Russia's aggression against Ukraine triggered concerns about a palladium supply shock. Russia dominates the palladium market, accounting for over one-quarter of the world's total palladium supply, 40% of mine supply and about 30% of global exports in value terms. Until February 2023, Russia's Nornickel — the world's biggest producer of palladium (and Class 1 refined nickel) and a major producer of platinum — has not been directly targeted by sanctions[2], and neither has Russia imposed restrictions on PGM exports.

Western countries are the primary export markets for Russian palladium. The large share in global production suggests that Russian supplies are hard to replace. Additionally, the PGM supply has little flexibility to accommodate shortages. A supply disruption would primarily negatively affect the automotive industry, the largest end-user of palladium consuming over 80% of supply annually (Box 1).

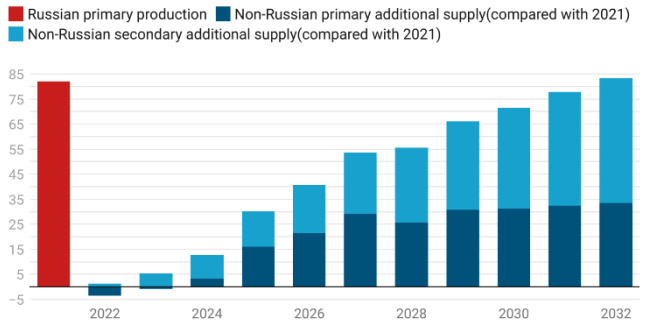
Besides Russia, most of the new primary production in the next decade is anticipated from South Africa, Zimbabwe, the USA and, to a lesser extent, Canada (Figure 2). The potential for additional mining production from non-Russian sources is estimated to be about 17 tonnes in 2025 and 35 tonnes in 2032 (compared to circa 130 tonnes of ex-Russian output in 2021). Surplus palladium supply – also considering the contribution of recycling - from non-Russian sources will be scarce in the short term (2023-2024) to offset a potential loss of Russian supply. However, it may exceed 20 and 50 tonnes by 2025 and 2032, respectively (Figure 3).

Figure 2 – Forecast of additional primary production (Medium-Supply Scenario - MSS)[3] compared to its 2021 level, tonnes of Pd



Source: JRC modelling based on background data from various sources such as (S&P Global, 2022), *company reports & announcements.*

Figure 3 – Forecast of additional primary and secondary supply (MSS) from non-Russian sources, tonnes of Pd



Source: as in Figure 2

Palladium was undersupplied for nine years, as the mine output (Figure 13) did not keep up with strong demand until a market rebalancing in 2021-2022 (Figure 4). The prolonged supply deficits decreased above-ground inventories and raised sensitivity to supply disruption risks. According to the JRC forecast (Figure 5), palladium demand globally will rise in the short term due to more stringent emissions standards and higher passenger vehicle sales,

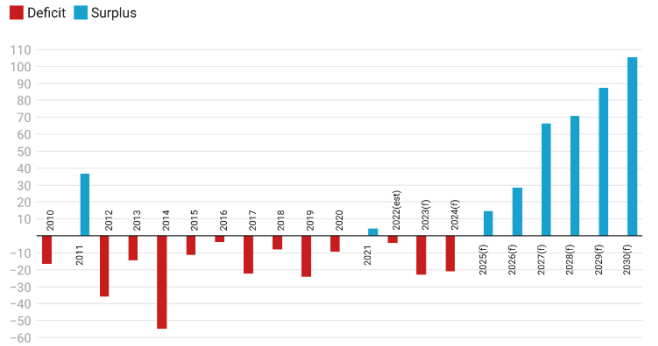
[1] PGMs is a collective term for six elements. Major PGMs are palladium and platinum, and minor PGMs are iridium, osmium, rhodium, and ruthenium.

[2] Newly refined Russian palladium and platinum was suspended from trading in London Platinum and Palladium Market (LPPM) (*https://www.lppm.com/palladium-list/*) since April 2022 (removal from the LPPM 'Good Delivery Lists'), while Nornickel's largest shareholder is facing sanctions in the USA, the UK, Canada and Australia (*Reuters 23/1/23 'Potanin says sanctions constrain Nornickel, force it to adjust strategy') (Bloomberg 15/12/22 'US Sanctions Russia's Richest Tycoon, Nornickel Boss Potanin').*

[3] The analysis includes PGM-bearing mine projects scheduled for start-up in the 2020s, recent and foreseen expansions of operating mines, projected mine closures and restarts, projects shelved or postponed, and PGMs produced as by-products of base-metal mining. The modelling is based on standard JRC in-house assumptions and methodology. Additionally for PGM, the modelling approach also considers a negative impact on the projected output due to declining ore grades and power supply disruption in South Africa. Furthermore, the carry-over of unprocessed stocks in South Africa in 2022 is taken into account. Lastly, an impact of international sanctions on Russian production and the development of new mines in Russia is modelled in the forecast.

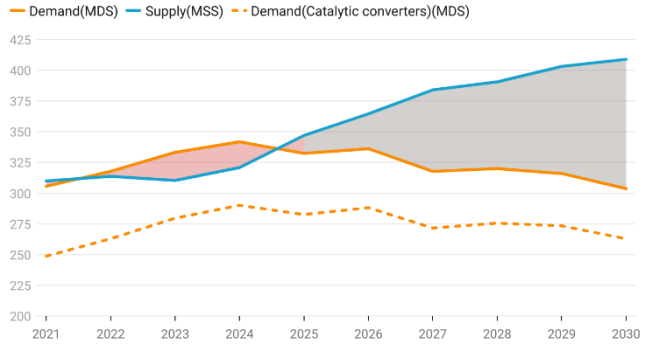
despite an ongoing platinum-for-palladium substitution in gasoline catalytic converters. The forecast demonstrates that the palladium market will be in deficit in 2023-2024; thus, Russian palladium supplies will remain essential in the short term. Yet, demand is predicted to decline from 2027 onwards as electric vehicles will gradually replace internal combustion engine vehicles (ICEs)[4]. Structural market surpluses are expected after 2025, favouring the adjustment of global trade flows to alternative suppliers.

Figure 4 – Market balance[5,6,7] (stock movements), tonnes of Pd



Source: (JM, 2022b) *for 2010-2017,* (JM, 2022a) (Heraeus-SFA Oxford, 2022) *for 2018-2022, JRC forecast for 2023-2030*

Figure 5 – Forecast of global supply-demand[5,6,7] for palladium (2023-2030), tonnes of Pd

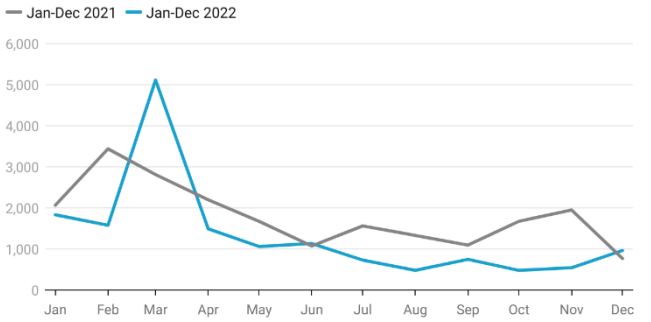


Source: JRC elaboration based on several sources and background data [8]

Short-term impacts and medium-term outlook in the EU

EU imports of unwrought palladium and powders from Russia amounted to 21.5 tonnes in 2021, being more than one-third of total EU import value. After Russia invaded Ukraine and on mounting fears of supply disruption, the EU imported from Russia in March 2022 a monthly record high of 5.1 tonnes of palladium (unwrought & powders) worth EUR 380 million (Figure 6). Nevertheless, EU imports originating from Russia decreased greatly later[9], i.e. by 21% year-over-year in March-December 2022, whereas total EU imports increased by 8% in the same period. Russian supply of unwrought palladium and powders was replaced mainly by imports from South Africa, Switzerland, and Norway.

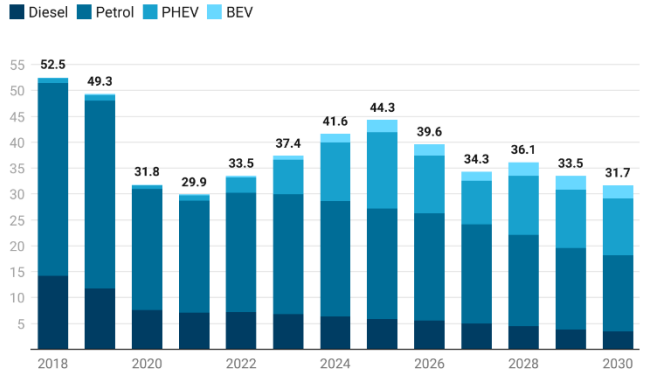
Figure 6 – Monthly EU imports from Russia of unwrought palladium and powders in 2021 and 2022, kilograms



Source: Data from (Eurostat Comext, 2023)

The forecast of palladium demand for passenger cars reveals that the auto sector's demand will continue to support the need for Russian metal in the coming years. Based on current global production shares and the forecast of primary supply (Figure 2), EU imports from Russia could be switched to primary supply from South Africa, Zimbabwe, the USA and Canada.

Figure 7 – Estimate of Pd content in EU passenger cars[10] placed on the market (POM), tonnes of Pd



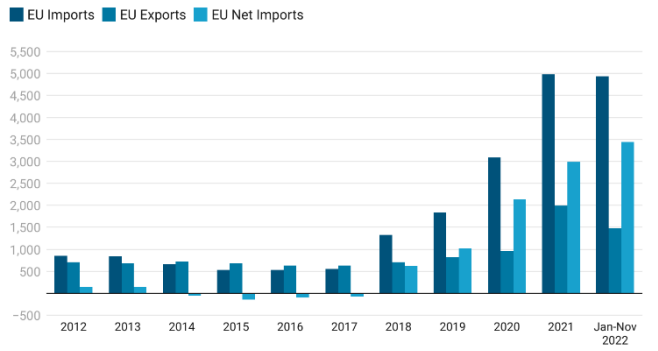
Source: JRC elaboration based on (RMIS, 2021)(Bobba et al., 2021)(Carrara et al., 2023)

In addition, the circularity perspective is vital for alleviating supply risks of palladium. The existing production base in the EU for refined PGM (Figure 19) can contribute substantially to supply

[4] Battery (BEVs), hybrid (HEVs) and fuel cell electric vehicles (FCEVs)
[5] Derived from JRC's Medium-Supply Scenario (MSS) and Medium-Demand Scenario (MDS) (most plausible scenarios) in 2023-2030.
[6] Supply comprises primary production and recycling. Basic assumption are that the mine output of new projects will not be constrained by infrastructure and smelting capacity limitations, or PGM basket price (when PGMs are extracted as main products). Finally, the realization or suspension of investment plans for the expansion of mined production in Russia as shown in Figure 2 is highly uncertain
[7] Among the factors of uncertainty in future demand is the level of investment in each year; the annual investment is regarded in the forecast as equal to the historic (20-year) net annual average, i.e. 2 tonnes per year. Moreover, the extent to which each PGM can be substituted for one another is complex; market scenarios and forecasts are used for estimating substitution of platinum for palladium in autocatalysts. Demand assumptions in the modelling are specific by sector at the global level.
[8] Placed-on-market number of vehicles derived from (Bobba *et al.*, 2021) (Carrara *et al.*, 2023); Pd content in POM vehicles from (RMIS, 2021); collection rate of ELV from (Kitazume *et al.*, 2020); assumptions for Pt-for-Pd substitution globally are based on (WPIC, 2022a) and other estimates. Supply data in 2021-2022 are sourced from (JM, 2022a)(Heraeus-SFA Oxford, 2022). The forecast of supply in 2023-2030 is based on analysis of data from (S&P Global, 2022), company reports & announcements, etc.
[9] It is noted that *Council Regulation (EU) 2022/576* banned Russian trucks and ships in European ports. By way of derogation, the competent authorities of a Member State may authorise the transport, after having determined that it is necessary for the purchase, import or transport of palladium (among other specific raw materials) into the EU.
[10] Pd consumed in catalytic converters and vehicle electronics. The impact of platinum-for-palladium substitution is not accounted for.

security using feedstock from domestic or imported secondary sources. Noteworthy, imports of PGM-bearing waste & scrap in the EU had a large increase since 2017 (nine-fold by value and almost six times by quantity), amounting to about EUR 5 billion in both 2021 and January-November 2022 (Figure 8). At the same time, palladium available for recycling from end-of-life vehicles (ELV) in the EU, the largest contributor to secondary supply, is forecast to remain stable in the next decade[11]. Ensuring adequate supplies of secondary raw materials to the EU refiners is among the strategies for addressing supply shortages.

Figure 8 – EU trade of PGM waste & scrap[12], EUR million



Source: (Eurostat Comext, 2022)

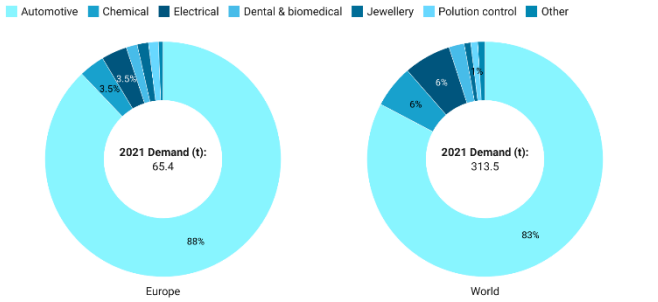
DEMAND

Palladium is used in a wide range of applications, often as an alloy with other PGM alloying elements. Like all PGM, palladium has unique catalytic properties and excellent corrosion resistance. The most widespread palladium usage is in catalytic converters for internal combustion engine vehicles (ICE), mainly in gasoline-powered vehicles. The automotive industry accounted for 88% of the overall demand for palladium in 2021 in Europe and 83% worldwide (Figure 10). Besides autocatalysts, palladium is employed in the manufacture of electronics, process catalysts for the production of petrochemicals and chemicals, dental alloys, jewellery and investments (such as exchange-traded funds).

Box 1: Palladium and the automotive industry

The main drivers of Pd demand are sales of gasoline vehicles and emissions regulations, which have changed considerably over the years and continue to evolve (e.g. from Euro 1 to Euro 6). Palladium's demand benefited in the last years from stricter requirements on exhaust emissions that have led to a net increase in the PGM loading per vehicle, as well as from a shift from diesel-powered vehicles. However, demand for PGM was severely impacted in 2020-2021 as Covid-19 lockdowns, and semiconductor shortages affected the automotive sector. Furthermore, the increasing market share of Battery Electric Vehicles (BEV) will continue to erode automotive demand. The uptake of BEV will reduce the total amount of Pd used in catalysts for exhaust emission control in ICE and hybrid vehicles. Also, the reported partial substitution of Pt for Pd in autocatalysts is another factor affecting the short- to medium-term outlook. Finally, the Pd content in vehicle electric & electronic devices will continue to be supportive for demand.

Figure 9 – Demand[13] for palladium by end-use sector, 2021



Source: JRC based on data from (JM, 2022a)

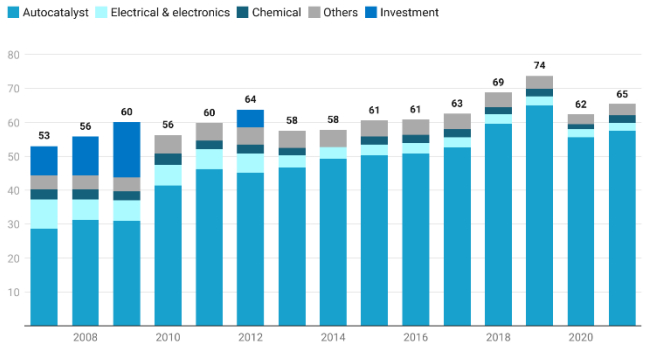
Figure 10 – Palladium's applications in EU[14] industrial sectors, 2021

Applications	Industry producing end-use products	Industries using Pd products	Industrial Ecosystem	Palladium consumption (%)
Autocatalyst	C29.32 Manufacture of other parts and accessories for motor vehicles	C29.10 Manufacture of motor vehicles	Mobility-Transport-Automotive	88%
Chemical	C20.59 Manufacture of other chemical products n.e.c.	C20.13 Manufacture of other inorganic basic chemicals; C20.14 Manufacture of other organic basic chemicals; C19.20 Manufacture of refined petroleum products	Energy-Intensive Industries	4%
Dental & biomedical	C32.50 Manufacture of medical and dental instruments and supplies	C32.50 Manufacture of medical and dental instruments and supplies	Health	2%
Electrical & electronics	C26.11 Manufacture of electronic components; C26.12 Manufacture of loaded electronic boards; (capacitors and circuits)	C26.40 Manufacture of consumer electronics; C26.51 Manufacture of instruments and appliances for measuring, testing and navigation electronics for other than consumer applications);	Digital	4%
Jewellery	C32.12 Manufacture of jewellery and related articles	-	Retail	2%
Pollution control	C20.59 Manufacture of other chemical products n.e.c (catalysts)	C28.24 Manufacture of power-driven hand tools; C28.30 Manufacture of agricultural and forestry machinery;	Energy-Intensive Industries	1%
Other				1%

Source: JRC elaboration based on (Eurostat, 2008) and (JM, 2022a)

The palladium consumed in Europe reached a record of 74 t in 2019 (Figure 11). Palladium consumption declined substantially in 2020, and recovery in 2021 was weak. European demand had a percentage of 20% of the global demand in 2021 (JM, 2022a).

Figure 11 – Evolution of palladium consumption in Europe[15] in 2000-2021, tonnes of Pd



Source: JRC elaboration based on data from (JM, 2022a) (JM, 2022b)

[11] JRC analysis based on (RMIS, 2021) (Bobba *et al.*, 2021)(Carrara *et al.*, 2023) (Kitazume *et al.*, 2020)

[12] Data for CN 71129200 'Waste and scrap of platinum'. The expression 'platinum' refers to platinum, iridium, osmium, palladium, rhodium and ruthenium, according to the HS explanatory notes.

[13] Figures represent the sum of industrial demand for new metal in each application (gross demand); demand covered by closed-loop recycling is not included. Gross demand also includes any changes in unrefined metal stocks. Demand for investment is excluded.

[14] Demand data refer to Europe (EU including UK and Turkey). Investment is included.

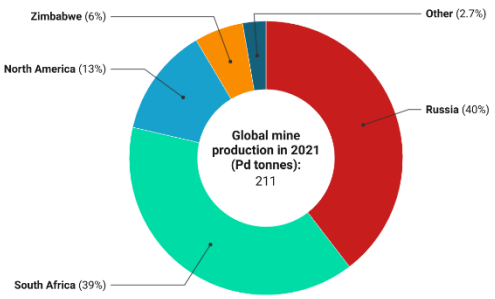
[15] Data refer to Europe (EU including UK and Turkey). Negative demand for investment is excluded. Demand for

SUPPLY

Global production

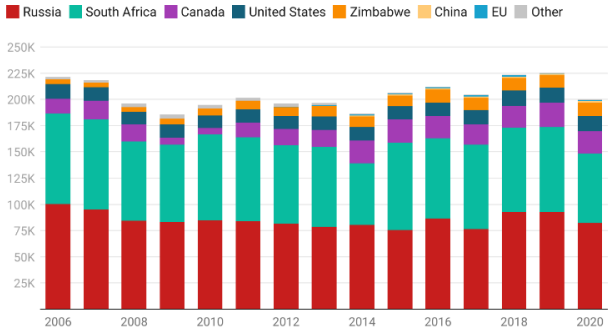
Palladium mining is highly concentrated in a few countries. Russia is the foremost producer globally, with a share of 40% in 2021, followed by South Africa (39% in 2021). Other significant producers are Canada (11% in 2020), the USA (7% in 2020), and Zimbabwe (6% in 2021) (Figure 12 & Figure 13). The global supply (mine and secondary) reached a record high of 327 tonnes in 2019. Russia accounted for between 26% and 35% of the world's supply in 2006-2021 (Figure 14). Palladium's mining production in the EU is not more than 0.5% of the global output.

Figure 12 – Main global suppliers of primary palladium in 2021



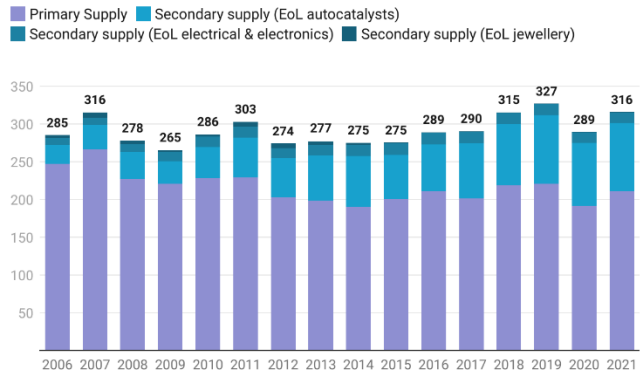
Source: : (JM, 2022a)

Figure 13 – Mined production of palladium, kilograms of Pd



Source: (WMD, 2022)

Figure 14 – Global supply of palladium[16], tonnes of Pd



Source: JRC based on data from (JM, 2022a) (JM, 2022b)

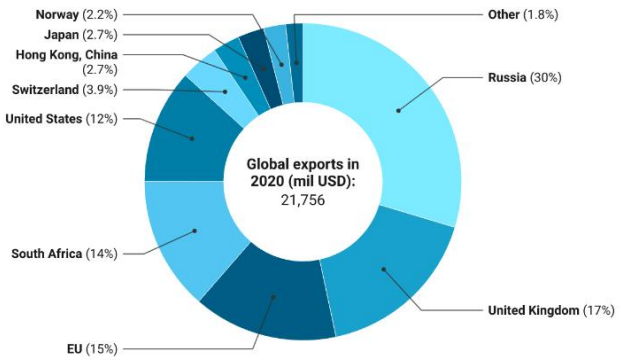
Box 2: Recycling of spent catalysts and electronics from end-of-life vehicles (ELV)

PGMs like palladium (Pd) have good recycling rates at end-of-life. Their high price has incentivised recycling and advanced technology has been developed that allows effective recovery. Recycling accounted for more than 30% of global Pd supply in 2021. Approximately 85% of secondary Pd supply globally came from recycled end-of-life autocatalysts with the remainder from waste electronic equipment (JRC based on (JM, 2022a; Heraeus-SFA Oxford, 2022)). The recycling of spent autocatalysts is well-established driven by PGM high value and easy disassembly from a car. However, recycling rates of PGM from autocatalysts are 60%-70%, whereas the metallurgical recovery rate may be over 95% (Hagelüken *et al.*, 2016). The recycling rates of post-consumer ELV components for Pd recovery (and PGM in general) has the potential to grow in case the number of ELV treated in the EU increases; one-third of ELV accounts for the so-called unknown whereabouts (Williams *et al.*, 2020). Further, it is foreseen that Pd scrap supply may change significantly in the longer term. Available quantities of autocatalyst scrap will decrease due to the growing penetration of EVs, rendering circularity of electronic components in the automotive sector of greater importance for palladium's security of supply.

Global trade

International trade statistics do not provide the required detail for tracing trade flows of PGM primary raw materials[17]. With regard to refined/processed raw materials, Russia is a key supplier of palladium to the rest of the world, accounting for 30% of global export value in 2020. Other large exporting countries in 2020 were the UK (17%), the EU (15%), South Africa (14%), and the USA (12%) (Figure 15). The export supply of unwrought palladium & powders is greatly concentrated, as these five countries typically account for 85-90% of the world's exports.

Figure 15 – Global exporters of unwrought palladium & powders in 2020 by value



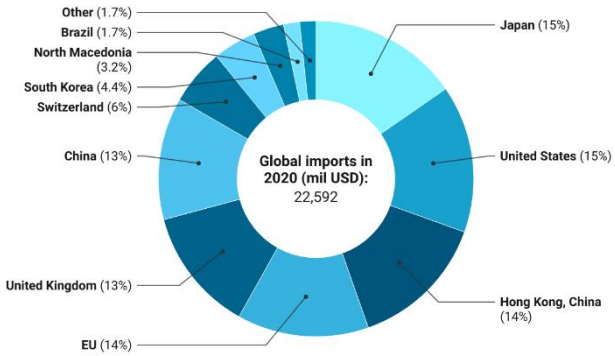
Source: JRC based on (WITS, 2022) (Eurostat Comext, 2022)

[16] Mined (or primary) supply figures represent estimates of sales by PGM mines, which are allocated to where the initial mining took place rather than the location of refining. It may differ from underlying mining production, because of changes in work-in-progress (pipeline) stocks or due to additional sales by the producers of metal held in refined inventory. Recycling addresses open-loop recycling only, closed loop recycling is excluded; in other words, secondary metal supplied to the market each year that may be used by any PGM-consuming sector.

[17] Ore concentrates and other intermediate products of PGM and Ni/Cu metallurgy

China is the leading importer of palladium in unwrought & powder form, with a share of 27% of global imports by value in 2020 (including Hong Kong SAR). Japan, the USA, the EU, and the UK were among the world's top palladium importers in 2020.

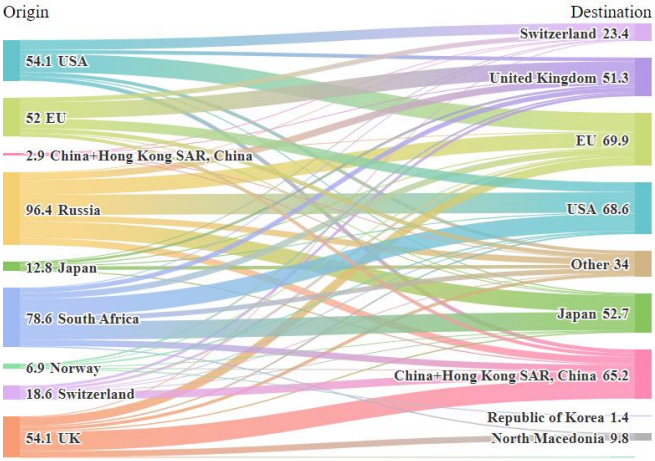
Figure 16 – Global importers of unwrought palladium and powders in 2020, by value



Source: JRC elaboration based on (WITS, 2022) (Eurostat Comext, 2022)

Hong Kong SAR, the UK, the EU, and Switzerland are significant hubs in the international trade of palladium refined products as large exporters and importers.

Figure 17 – Main flows in trade of unwrought palladium and powders, average 2017-2020, tonnes



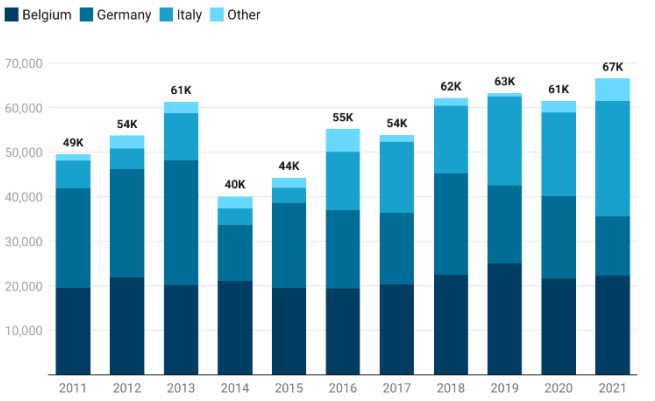
Source: JRC based on background data (CEPII, 2022)

EU IMPORT DEPENDENCY

EU production

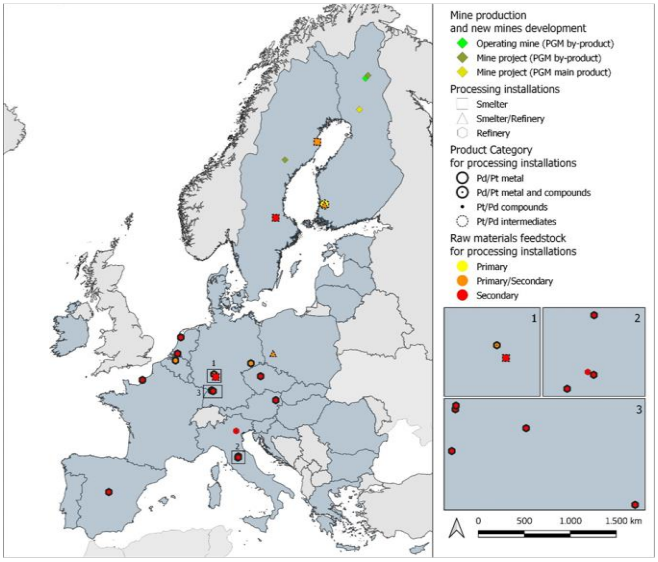
The small quantities of mined palladium in the EU (about 1 tonne annually in Pd content) originate almost entirely from Finland and barely contribute to domestic supply. On the other hand, EU refineries have a considerable output of refined PGM from primary and, mostly, from secondary feedstock materials. The EU annual output of palladium in unwrought & powder form is estimated to have ranged between approximately 40 and 67 tonnes in 2011-2021 (yearly average of 55 tonnes), with the highest estimate of production occurring in 2021. The map in Figure 19 shows a non-exhaustive list of the PGM-producing sites in the EU.

Figure 18 – Estimated[18] EU production of refined palladium products (unwrought & powders) by country, kilograms



Source: JRC based on (Eurostat Prodcom, 2023) (Eurostat Comext, 2022)

Figure 19 – Production sites of PGM in the EU



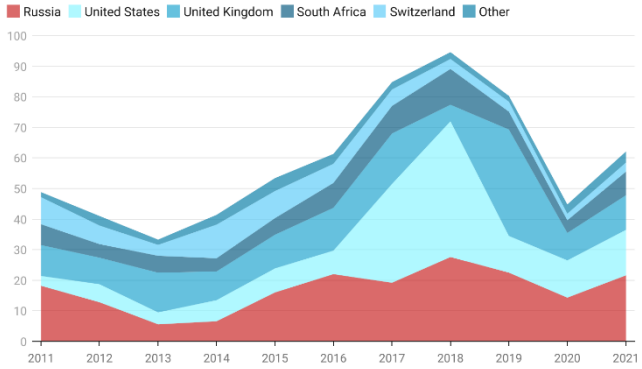
Source: JRC/RMIS data compilation

EU imports

EU imports of refined palladium (unwrought & powders) amounted to about 62 tonnes in 2021 (Figure 20), worth EUR 4.1 billion. The majority of refined palladium imported to the EU in 2021 came from Russia (36% in 2021 by value) (Figure 21). In 2011-2021, imports of unwrought palladium & powder products represented about half (51%) of the total estimated EU sourcing (production+imports). Russia covered 15% on average of the total EU sourcing (production+imports) in the same period for refined palladium (unwrought & powders). The USA and the UK are also among the top EU suppliers in recent years (Figure 20).

[18] Comprehensive production statistics for refined palladium metal are not available. The production in Germany in 2019-2021 is sourced from (Eurostat Prodcom, 2023); for 2011-2018 it was derived from aggregated data for all PGM reported by (Eurostat Prodcom, 2023). The production in Belgium is approximated on the basis of operating capacity (25 kt per year) and the assumption that it followed yearly the trend of global demand. Exports (EU-intra and EU-extra) are used as a proxy for the production in the rest of countries (Italy, Austria, Czechia, France, Netherlands, Spain) after accounting for re-exports. Palladium unwrought & powder comprises palladium metal and alloys in which palladium predominates by weight.

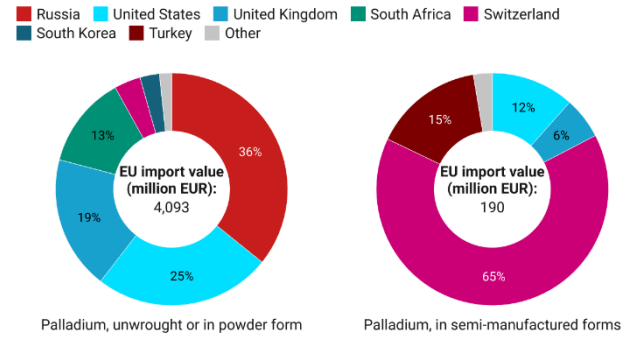
Figure 20 – Structure of EU imports of unwrought palladium & powders by origin, tonnes



Source: (Eurostat Comext, 2022)

Regarding the wrought palladium products (semi-manufactured forms), imports amounted to 7 tonnes in 2021, worth EUR 191 million, representing only 4% of total palladium import value in the EU (unwrought, powders and wrought). Switzerland is the main origin of EU imports for palladium in semi-manufactured forms (Figure 21). Concerning PGM waste & scrap, the USA, the UK, South Africa and Switzerland accounted for 75% of EU import value in 2021, with the majority shipped from the USA (38%)(Eurostat Comext, 2022). Russia is not a significant supplier to the EU for wrought palladium products and PGM waste & scrap.

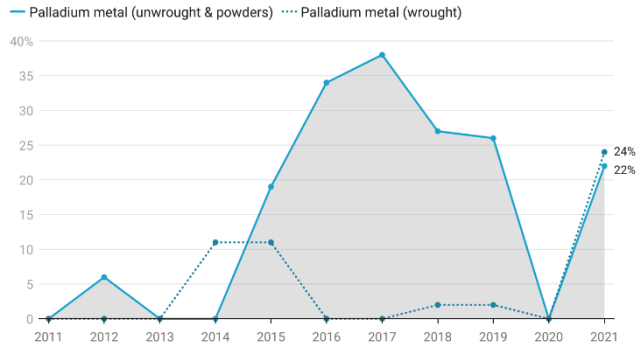
Figure 21 – EU import value of refined palladium (unwrought & powder) and semi-manufactured palladium by origin, 2021



Source: (Eurostat Comext, 2022)

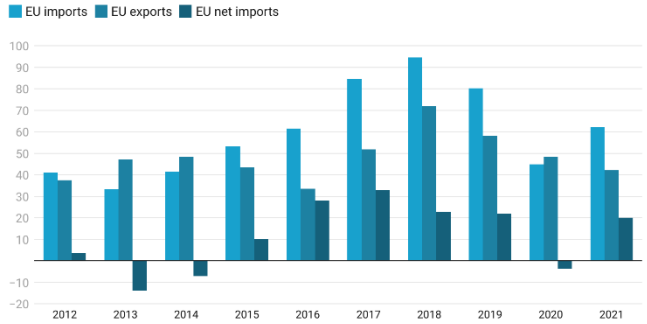
The EU's reliance on imports of primary raw materials cannot be estimated due to the absence of specific trade codes reflecting the PGM-bearing intermediate products marketed by primary producers. Nevertheless, it is nearly 100% as domestic mine palladium production is minor. Concerning refined raw materials, i.e. unwrought palladium and powders, the EU's reliance on imports rose after 2014 and ranged between 19% and 38% in 2015-2021 (Figure 22); in 2020, the EU was a net exporter of unwrought palladium and powders (Figure 23). With regard to wrought palladium products (semi-manufactured forms), which represent a much lower import value compared to refined products, the EU's import reliance is minor, with the exception of 2021 (Figure 22).

Figure 22 – Estimated EU import reliance[19] for palladium refined (unwrought & powders) and semi-manufactured[20] (wrought), %



Source: JRC based on (Eurostat Comext, 2022) (Eurostat Prodcom, 2023)

Figure 23 – EU trade of palladium in unwrought & powder forms, tonnes



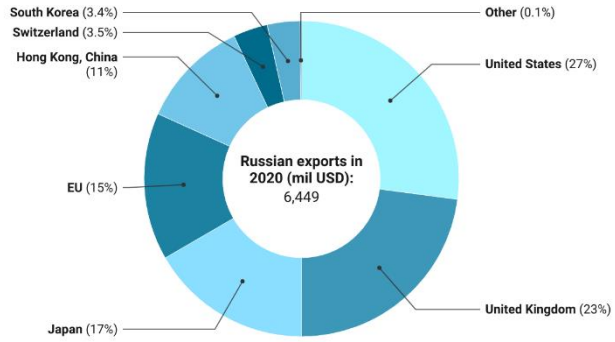
Source: JRC based on (Eurostat Comext, 2022)

TRADE FLOWS FROM RUSSIA

Global

Russian exports of unwrought palladium and powders are destined mostly for Western countries, which accounted for over 85% of the total Russian exports worth 6.5 billion USD in 2020 (Figure 24), about ten times higher than Russia's platinum exports in the same year. Among major palladium importers from Russia in 2020, the EU accounted for a 15% share of Russian exports.

Figure 24 – Destinations of Russian exports of unwrought palladium & powders in 2020 by value



Source: (WITS, 2022)

[19] 'Import Reliance' Indicator = (Imports – Exports) / Apparent consumption; Apparent consumption = Domestic production + Imports - Exports

[20] In the case of wrought products, the indicator is estimated on the basis of production value and trade value

EU

EU countries imported approximately 22 tonnes of unwrought palladium and powders from Russia in 2021; in 2018, the import volume peaked at 27 tonnes. On average, the EU imported unwrought palladium and powders worth EUR 1.1 billion annually over 2019-2021. The EU relied on Russia for 39% of its unwrought palladium and powders imports by value and 32% by quantity. The most significant consumers of Russian palladium are Germany and Italy, the two major EU importers (Figure 25).

Figure 25 – Import value of unwrought palladium & powders by Member State, annual average 2019-2021

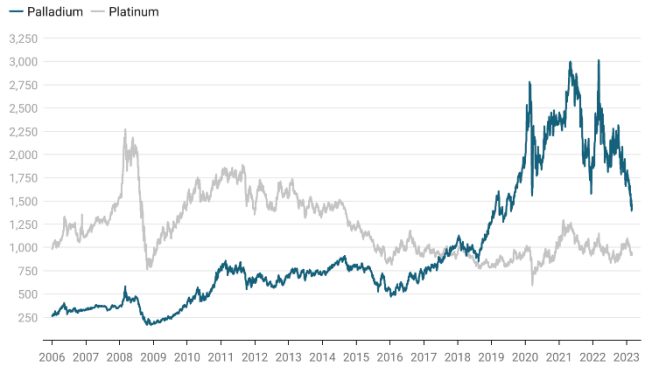
EU country	EU-extra imports (million EUR)	Imports from Russia (million EUR)	Imports from Russia (% of EU-extra imports)
	2,973	1,149	39
	1,711	736	43
	1,103	403	37
Other	159	10	6

Source: JRC based on data from (Eurostat Comext, 2022)

PRICES

Palladium's price has been extremely volatile in the last few years, as shown in Figure 26. Well before the Russo-Ukrainian war, palladium's price had been soaring. It exceeded platinum's price in October 2017 and rose to a record level of about USD 3,000 per troy ounce in May 2021, a three-fold increase since mid-2018.

Figure 26 - LBMA Palladium daily price evolution compared to platinum, Jan 2006 –Feb 2023, in USD/oz t[21]



Source: (LBMA, 2023)

Soon after Russia invaded Ukraine, palladium's price recorded a new all-time high over concerns about supply restriction from top exporter Russia. However, one year after Russia invaded Ukraine, it retreated to a multiyear low at the end of February 2023, considerably narrowing the gap with platinum's price. This indicates that fears of loss of Russian palladium supply were short-lived and consumers faced with no supply shortfalls or/and that concerns might have shifted to demand downside risks.

CONCLUDING REMARK

Russia is a key player in the global palladium market and has no equivalent in terms of production and export capacity in the short term. The reconfiguration of trade flows and the EU's autonomy from Russian palladium may be possible after 2025 as the transition to electromobility is projected to largely decrease demand and lead to growing market surpluses towards the end of the decade.

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[21] 1 troy ounce (oz t) = 31.10348 g

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