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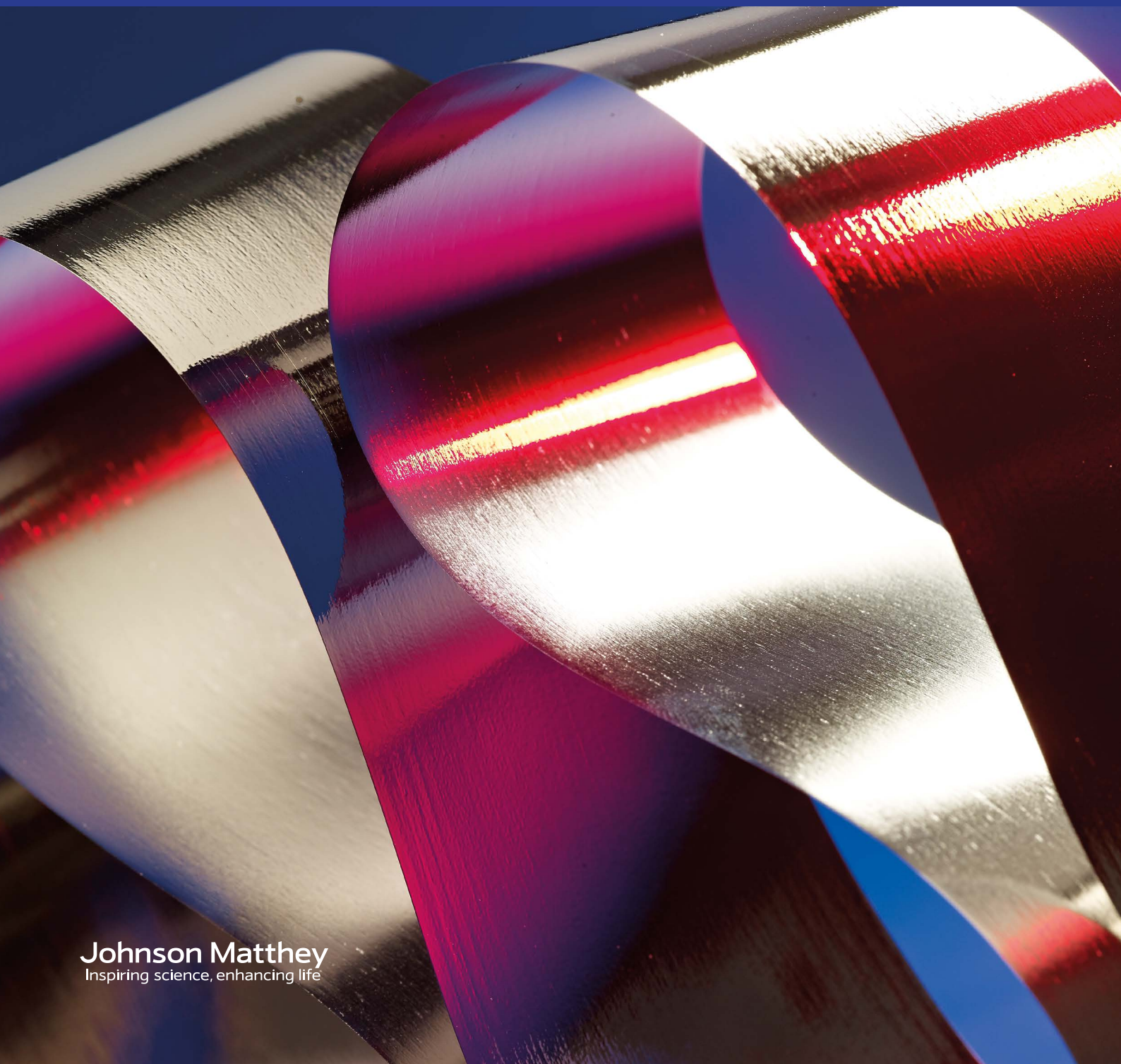
# PGM market report

## May 2024



Johnson Matthey
Inspiring science, enhancing life

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Johnson Matthey defines 'light duty' as cars and light trucks with a gross vehicle weight (GVW) of up to 3.5 tonnes, except in the USA, Canada and Mexico, where vehicles are considered 'light' if they have a GVW of up to 6 tonnes. Automotive production data is taken from S&P Global Mobility, Powertrain Production Forecast, February 2024 (vehicles with a GVW of up to 6 tonnes) and KGP-GlobalData Commercial Vehicle Powertrain Forecast February 2024 (vehicles with a GVW over 6 tonnes).

The PGM market report is published annually, in May each year.

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# Definitions

| | |
|---|---|
| **Europe** | EU+ (includes UK and Turkey but excludes Russia) |
| **Japan** | Japan only |
| **North America** | USA and Canada (excludes Mexico) |
| **China** | China only |
| **RoW** | Rest of World: all countries not captured in the above |
| **Primary supply** | Supply figures represent sales of **primary PGM** by producers and are allocated to the region where mining took place, rather than 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.<br><br>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).<br><br>**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.<br><br>**Jewellery demand** is allocated to the region where the finished jewellery is manufactured, not sold. |
| **Movements in stocks** | This figure gives the overall market balance in any one year and reflects the extent of stocks that must be mobilised to balance the market in that year. It is thus a proxy for changes in stocks held by fabricators, dealers, banks and depositories, but excludes stocks held by primary and secondary refiners and final consumers. A positive figure (market surplus) thus reflects an increase in global market stocks. A negative value (market deficit) indicates a decrease in global market stocks. |

# PGM summary

## Supply and demand in 2023

Platinum, palladium and rhodium recorded significant deficits in 2023

But palladium and rhodium prices fell dramatically, due to ample market liquidity and negative sentiment

PGM supplies were supported by heavy Russian sales into Hong Kong and mainland China

Other primary supplies were lacklustre, while secondary recoveries fell to a seven-year low

Global gasoline car output surged, lifting automotive PGM demand by 8%

Industrial platinum consumption was robust, with exceptionally strong demand from the glass sector

Glass demand for rhodium remained weak, with further sales of surplus metal by Chinese glassmakers

### Market balance

An anticipated recovery in primary and secondary PGM production fell short of expectations in 2023. Plant maintenance and electricity shortages hampered efforts to reduce work-in-progress at South African smelters and refineries, while the number of end-of-life vehicles entering scrapyards continued to decline, reducing PGM recoveries from automotive scrap by around 14%. Despite heavy selling of Russian PGM into the Chinese market, combined primary and secondary supply of platinum and palladium rose only slightly, while rhodium supply declined.

In contrast, automotive demand significantly outperformed earlier expectations, as global light vehicle production surged by nearly 10% to 88.9 million units – the highest level since 2018. Battery electric vehicles (BEVs) continued to make strong gains, but the roll-out of zero emission cars progressed more slowly than forecasters had initially anticipated. As a result, automakers augmented their output of gasoline cars (both hybrid and conventional) to meet strong consumer demand for vehicles.

A year ago, the gasoline car market was forecast to be flat in 2023, but ultimately production surged 9% to 68.7 million vehicles, beating earlier expectations by a remarkable 5.5 million units. This alone added around 600,000 oz to our automotive PGM demand estimates. Total automotive PGM consumption rose by 8% to reach 13 million oz in 2023, the second-highest total ever recorded (after 2019).

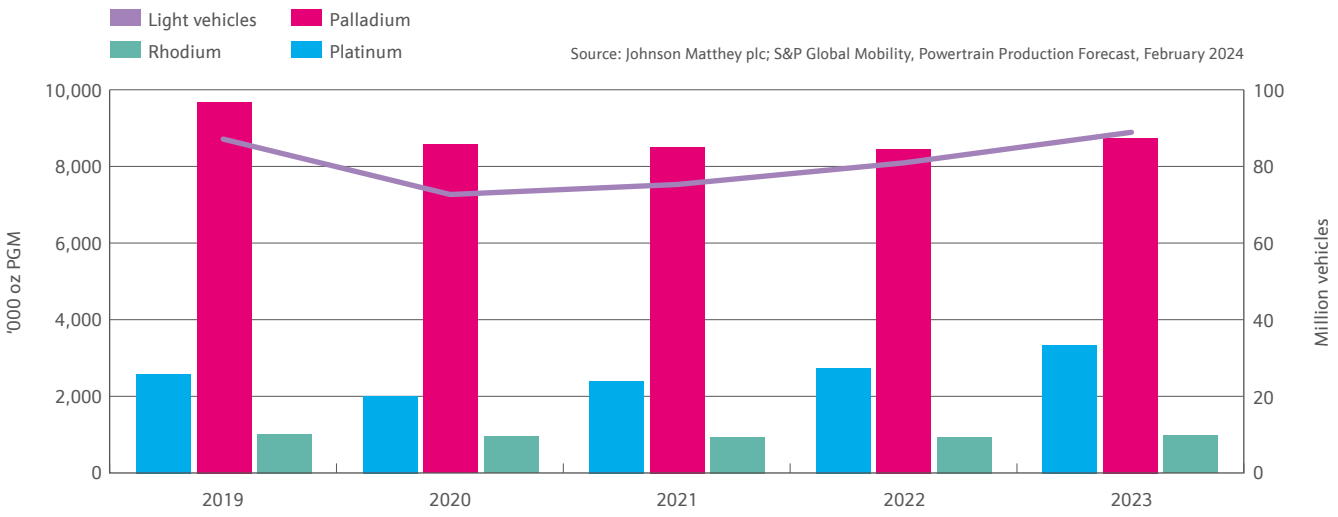


**Figure 1** Automotive PGM demand and light vehicle output

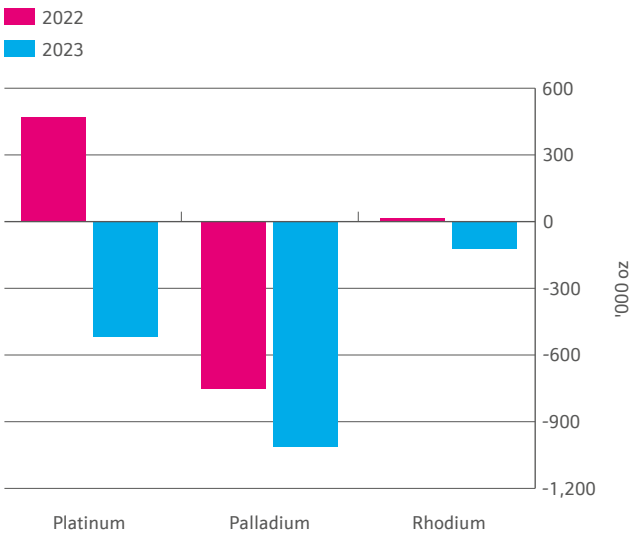


**Figure 2** PGM market balance

Industrial demand was also relatively robust. Glass demand significantly exceeded earlier expectations, as manufacturers built new display glass plants in China, while use of PGM in pollution control, biomedical and some smaller applications was buoyant. Chemicals demand for platinum and palladium fell short of recent highs, but remained elevated by historical standards, while lower prices supported purchases of rhodium catalyst by acetic acid and oxo alcohols producers in China. However, consumption of PGM in the electronics sector was unusually weak: shipments of end products such as mobile phones and PCs saw double-digit declines, while a slowdown in data centre upgrades hit hard disk demand.

Investment demand for platinum and palladium moved back into positive territory in the wake of significant liquidation of exchange traded funds (ETFs) in 2022. Meanwhile, jewellery demand saw only a modest overall decline as the rate of contraction in Chinese jewellery fabrication eased. Overall, platinum, palladium and rhodium all saw demand gains in 2023. With supplies failing to keep pace, all three metals recorded significant deficits.

## Price trends

These deficits were not reflected in price movements. During 2020-2022, exceptionally elevated prices for palladium and rhodium motivated long-term holders of market stocks to release metal. Consumers were also incentivised by this to acquire metal in excess of their immediate requirements to mitigate future price and supply risks. In addition, contractual obligations resulted in some industrial users continuing to take delivery of PGM in quantities that exceeded their actual requirements. The consequence was an accumulation of excess PGM stocks in the hands of industrial consumers and other short-term holders.

"As prices fell and supply risks dissipated, consumers became less willing to hold excess PGM inventory"

As prices fell, and anxiety about future supply risks dissipated, consumers became less willing to hold excess inventory; the result was a temporary reduction in PGM purchasing and, in some cases, the sale of metal back to the market. This process was exacerbated by price-driven shifts in demand, such as the substitution of palladium in gasoline autocatalysts and a reduction in the rhodium content of glassmaking

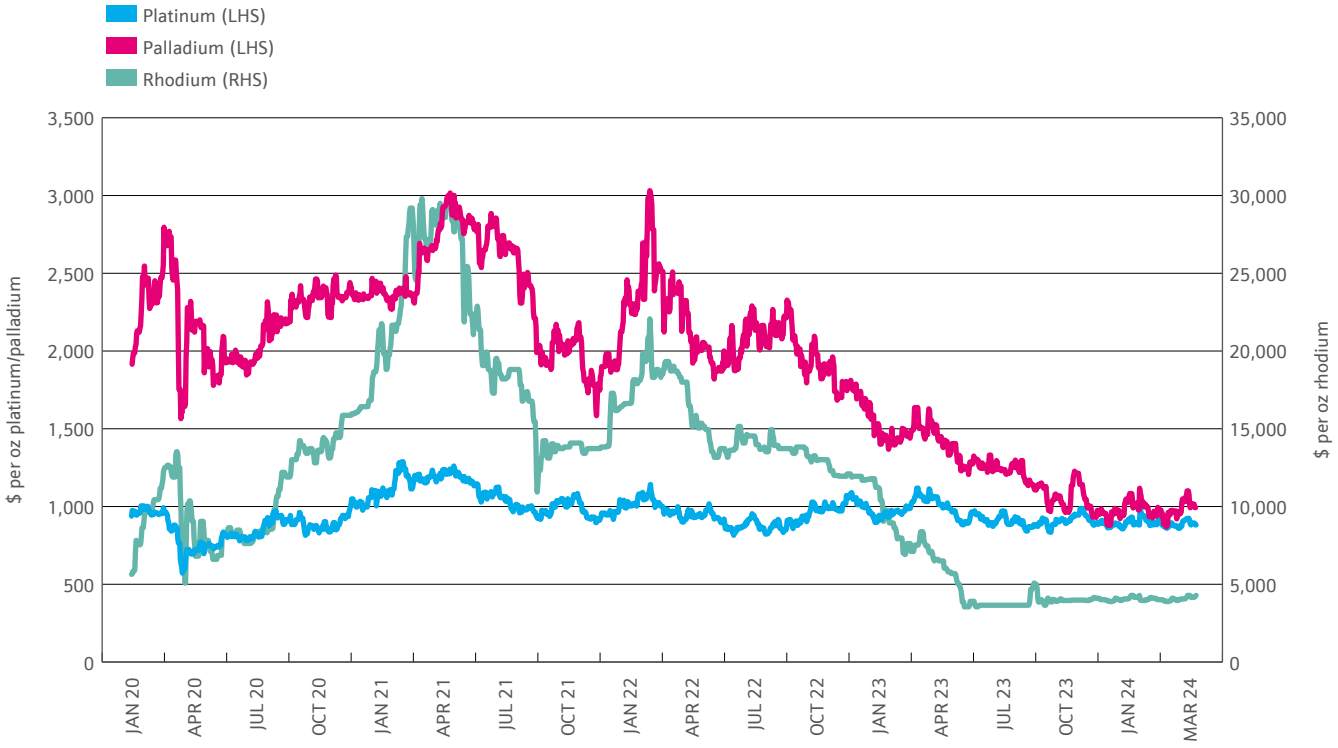


**Figure 3** Platinum, palladium and rhodium prices, January 2020 to March 2024

alloys, which have reduced the total stock of metal held in plant and work-in-progress by industrial consumers.

While we capture some industrial stockbuilding and destocking in our numbers, where hard evidence is available, our demand estimates primarily reflect the amount of PGM consumed in industrial processes and products in any given year. Thus, we show palladium and rhodium in deficit in 2023, because industrial use increased ahead of new supply, even though both markets saw significant improvements in availability.

The situation for platinum is somewhat different, as surpluses were recorded as recently as 2021–2022, adding to pre-existing market liquidity. More broadly, on a consumption basis (i.e., excluding investment metal, which is 'held' rather than consumed), the platinum market has been in surplus for many years. Thus, above-ground stocks of this metal exist to meet industrial requirements in years in which new supply falls short of demand. Ample physical availability kept platinum prices range-bound during the 2020–2022 period, when the other PGM were setting all-time records.

## "Shipments of Russian PGM to Hong Kong accelerated during 2023"

As well as increased liquidity, investor sentiment weighed heavily on prices in 2023, particularly for palladium and rhodium. Both metals are heavily exposed to the automotive sector, which in recent years has accounted for well over 80% of total demand. The market consensus is that rising BEV share will push these markets into persistent surplus in the medium term, and that there is currently no obvious replacement for automotive demand for these metals.

The combination of strong market liquidity and negative investor sentiment set the scene for dramatic falls in palladium and rhodium prices over the course of 2023. The situation was exacerbated by nervousness about the global economic outlook, a stronger US dollar and high interest rates which increased the opportunity cost of holding non-yielding assets such as precious metals. In the case of palladium, price weakness was intensified by the accumulation of a large speculative short position on NYMEX, while the rhodium price was periodically impacted by significant sales by Chinese glassmakers. The palladium price slumped from a high of $1,830 in January to a low of $941 in December, a decline of nearly 50%; although it briefly rallied above $1,200 at the year-end, these gains were quickly lost during January 2024. Meanwhile, rhodium lost around two thirds of its value, sliding from a high of $12,400 in January to a low of just $4,000 in July, and trading below $4,500 for most of the second half of the year. In contrast, platinum mainly remained range-bound between $900 and $1,000, as has been the case for much of the past five years.

### Russian PGM supply

Gains in primary PGM supplies in 2023 were primarily due to a sharp increase in exports of Russian metal, particularly to Hong Kong and mainland China. We estimate that Russian palladium supplies rose by 17% to 2.7 million oz, while platinum sales were up by more than 70%, to 780,000 oz.

Following the Ukraine invasion in February 2022, the imposition of sanctions by market authorities, combined with 'self-sanctioning' by customers, significantly reduced (and in some cases virtually eliminated) trade in PGM between Russia and most of its Western and Asian trade partners. This meant that significant quantities of Russian metal produced in 2022 remained unsold at the end of that year. (We note that following a reanalysis of trade flows and other information, we have made a downward revision to our estimate of Russian shipments in 2022.)

Starting in mid-2022, trade data shows an increase in direct shipments of PGM from Russia to Hong Kong, for onward delivery into mainland China. This flow of metal accelerated during 2023: direct exports of Russian platinum to Hong Kong rose by a multiple of six, to more than 600,000 oz, while those of palladium nearly trebled, exceeding 1 million oz.

Russian PGM was offered at discounts, resulting in all three automotive PGM trading below international price levels in China during the second half of 2022 and for much of 2023. These discounts allowed Russian metal to partly displace not only imports from other producing regions, but also PGM from domestic Chinese refineries.

Higher shipments of Russian platinum were facilitated by ongoing robust industrial demand for this metal in China; we believe that most of the Russian platinum produced but not sold in 2022 was shipped last year. However, Chinese palladium consumption has been on a declining trend since 2019 and fell to an eight-year low of 2.2 million oz in 2023. This may have

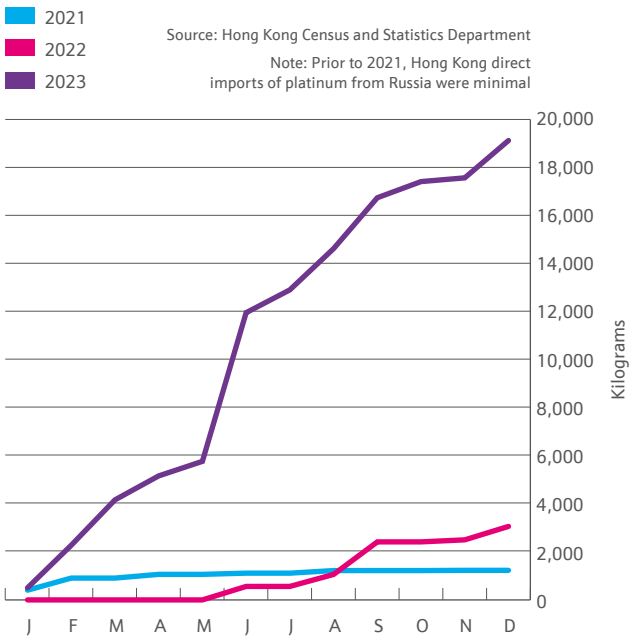


**Figure 4** Hong Kong: direct imports of Russian platinum

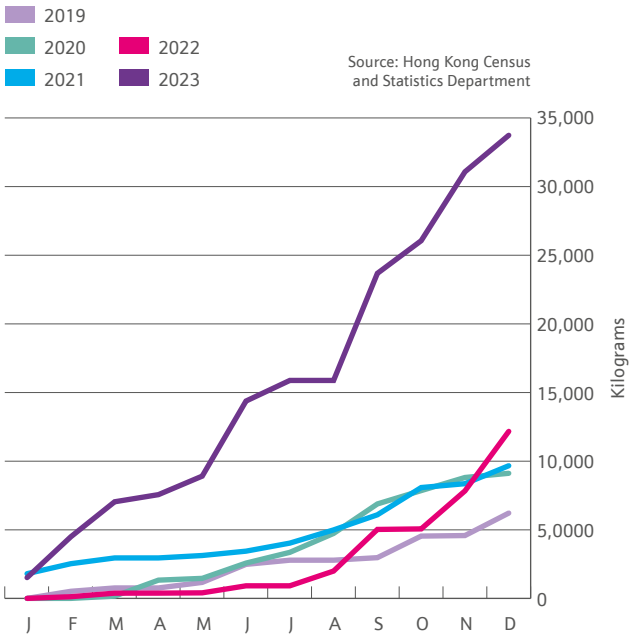


**Figure 5** Hong Kong: direct imports of Russian palladium

limited the appetite of Chinese buyers for Russian palladium, even at favourable prices, restricting sales of producer stocks.

Sales of Russian PGM to most other markets fell significantly, or even ceased entirely, partly due to the imposition of increased import tariffs by some jurisdictions, notably the UK and the USA. Dissuasive import taxes on all Russian PGM except palladium sponge were imposed by the US government starting in April 2023. US imports of Russian platinum dried up completely as a result, but trade data shows ongoing large shipments of palladium to US counterparties.

Due to the release of unsold metal from the previous year, our estimates of Russian PGM supplies in 2023 exceed reported production by Norilsk Nickel (Nornickel). Palladium output at Nornickel fell by 4%, to 2.7 million oz, due to a combination of plant maintenance and a fall in mined volumes of higher-grade ore; platinum output rose by 2%, to 664,000 oz (lower-grade disseminated ores at Norilsk often have a higher platinum-to-palladium ratio). The withdrawal of Western companies from the Russian market has obliged Nornickel to transition to alternative mining equipment, sourced from Chinese and domestic suppliers, and this has had a temporary impact on underground mining operations.

## South African and other supply

Primary supplies from other regions were marginally higher than the previous year. South African PGM supplies were supported by sales of refined metal from producer inventories, offsetting a build-up in 'pipeline' (work-in-progress) stocks at smelters and refineries. This pipeline build disproportionately affected platinum, rhodium and the minor metals; in contrast, there was a release of palladium work-in-progress at Anglo American Platinum, following the return to service of its Polokwane smelter after a furnace rebuild. (Polokwane treats concentrate from the large, palladium-rich Mogalakwena mine.)

Underlying mine output in South Africa was virtually unchanged last year. Despite a serious accident at its number 11 shaft in November 2023, Impala Platinum's Rustenburg mine reported a significant improvement in PGM production, and this helped to offset the closure of end-of-life mining infrastructure at some other western Bushveld operations. Financial pressures resulted in the premature closure of one mine, Sedibelo Platinum, which ceased operations at both its open pits during the second half of the year (however, the impact on refined output and supplies will only be felt in 2024).

North American PGM supplies rebounded in 2023, after a steep fall the previous year, when Sibanye-Stillwater's Montana operation was severely disrupted by regional flooding. Although the recovery at Stillwater was lacklustre, with mining hampered by damage to a shaft and severe skill shortages, the region's other PGM mine, Impala Canada, reported a 10% increase in palladium production. Output of by-product PGM from the region's large nickel-copper mines was little changed, with higher totals from Vale offset by a drop at Glencore following a 2022 strike at its Raglan mine.

"PGM recoveries from spent autocatalysts were 22% below the 2019 peak"

## Secondary supply

A year ago, we anticipated a modest improvement in vehicle recycling rates in 2023, on the basis that a rebound in new car sales would ultimately result in larger numbers of old vehicles being scrapped. However, this recovery failed to materialise. Vehicle scrappage rates continued to deteriorate last year; although the market appears to have stabilised during the second half, there was no sign of any material upturn in activity. We now estimate that recycling of PGM from spent autocatalysts fell by around 14% in 2023, to 3.7 million oz.

This is 22% below the peak 2019 level, when autocatalyst PGM recoveries approached 4.7 million oz – and this figure would probably have been higher had it not been for a shortage of refining capacity following refinery closures in Europe and the USA. The resulting capacity constraints gave rise to a backlog of untreated and partly treated scrap, which helped support secondary refinery outturns during 2020 and 2021, when Covid lockdowns periodically interrupted the delivery of end-of-life vehicles to scrapyards and hindered the collection and shipping of catalyst scrap.

By 2022, Covid disruption was dissipating and the scrap market returned to more normal business conditions. However, as the year progressed, the number of used vehicles entering scrapyards began to fall steeply. This trough in vehicle scrappage activity deepened during 2023, despite double-digit gains in new car sales in most major markets, which under normal circumstances would have been positive for the auto recycling industry.

It is now clear that shortfalls in auto sales between 2020 and 2022 have had severe and lasting impacts on the

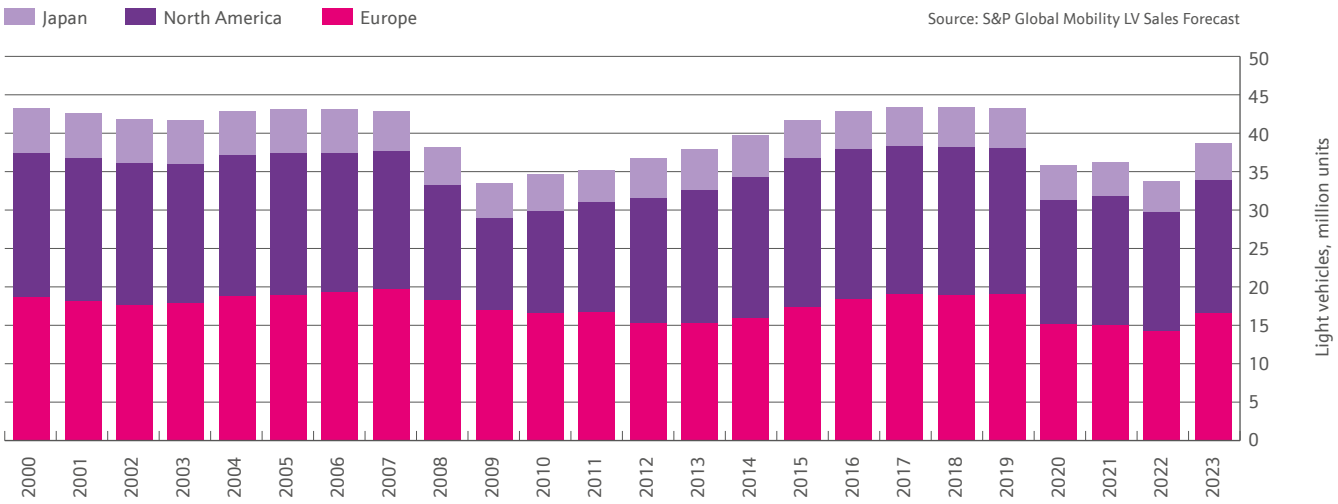


**Figure 6** Light vehicle sales in mature auto markets, 2000-2023

second-hand vehicle market. Compared to pre-Covid levels, the volume of non-realised car sales during this three-year period amounted to around 25 million units in the mature auto markets of Europe, North America and Japan. As a result, the flow of one-to-three-year-old vehicles onto the second-hand market has been severely curtailed.

This scarcity of nearly new cars, combined with higher borrowing costs and general cost-of-living pressures, has forced buyers to consider older vehicles than in the past. A budget that would have bought a three-year-old vehicle prior to Covid might now be sufficient to purchase a six- to eight-year-old car. This has had a knock-on impact across the entire second-hand market, leading to large increases in the value of used cars of all ages, delaying the scrapping of older cars, and increasing the average age of vehicles entering scrapyards.

In the oldest vehicle categories, the squeeze was exacerbated by fluctuations in auto sales dating back more than a decade. In developed markets, the peak age for vehicle scrappage has historically been around 15 years. At present, this corresponds to vehicles built around the time of the 2008 global financial crisis – a period when most mature auto markets saw new registrations contract sharply. Thus, the residual stock of older vehicles approaching the end of their lives is currently falling, at a time when the value of these vehicles on the second-hand market is rising, and they are being kept on the road for longer. This 'double whammy' triggered a collapse in the number of vehicles entering scrapyards in the second half of 2022 and during 2023.

Exceptionally high palladium and rhodium prices were broadly supportive of PGM recoveries during 2020–2022, with the processing of high-value gasoline catalysts being expedited through the recycling network. Prices for these metals fell precipitously in 2023, but we do not believe that this had a significant impact on scrappage volumes in the mature automotive markets, where 'hoarding' activity appears to have been relatively limited. ('Hoarding' occurs when market participants, typically at the bottom of the value chain, deliberately hold back scrap material in the hope that its value will increase in future).

Declining PGM prices had more important consequences for the developing Chinese market. Collectors adapted their business practices to mitigate the downside price risk, for example by offering only a down payment on the contained metal value of catalyst scrap (with the balance being paid after refining and sale), or by buying at a significant discount to market prices; some collectors even temporarily discontinued scrap purchasing. This resulted in market participants at the bottom of the supply chain holding onto scrap material for much longer than usual and led to a dramatic decline in catalyst scrap intakes at refineries during the first quarter of 2023.

Under normal circumstances we would have anticipated a rapid return to more normal activity levels in China, as scrap collectors and recyclers became accustomed to lower prices. However, as the year progressed, other factors impeded a recovery in volumes, including concerns over scrap provenance, and a government clamp-down on informal collectors operating without the necessary hazardous waste permits. This has increased the cost of collecting and transporting autocatalyst scrap and has made the business less attractive to smaller players. The availability of ample quantities of Russian palladium, offered on the Chinese market at a discount to market prices, also affected the economic incentives driving secondary recovery of PGM. Overall, we estimate that the volume of autocatalyst scrap treated by Chinese recyclers last year fell by around 20%.

## Automotive demand

Automotive PGM consumption jumped by 8% to reach 13.1 million oz in 2023, as both the light and heavy duty sectors staged a global recovery. This was the highest level since 2019, and only the second time that measured PGM demand in this sector has exceeded 13 million oz.

We note that our estimates are based on the amount of PGM used in autocatalysts fitted to vehicles produced in each year (as well as in catalysts for fuel cell electric vehicles, FCEVs, although this number is currently small). We do not measure PGM purchases by automakers, as this data cannot reliably be obtained at the global market level; however, in any single year, purchases

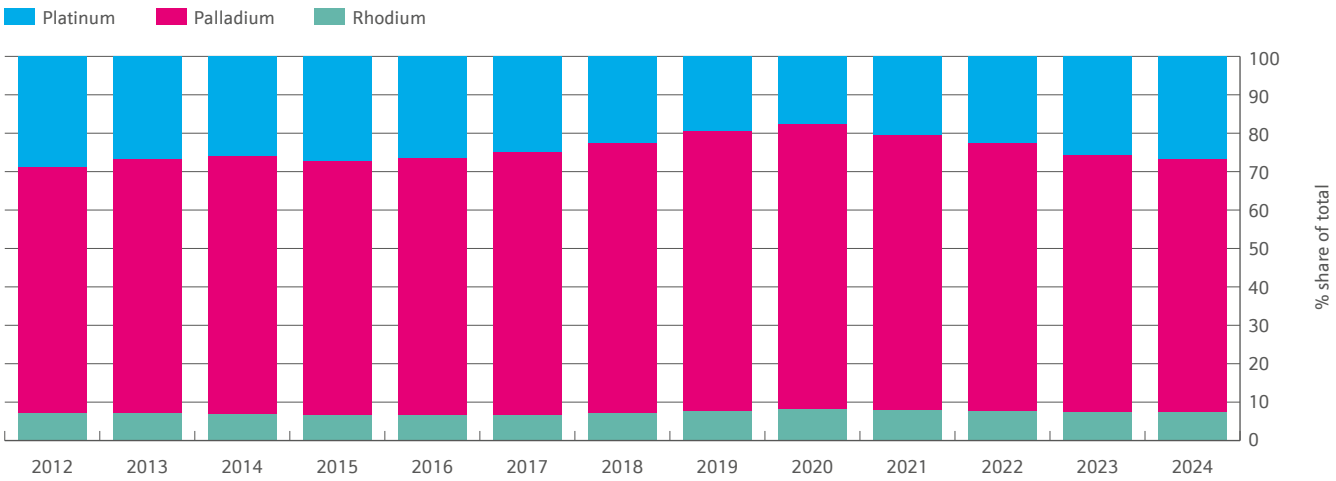


**Figure 7** Share of automotive PGM demand by metal

may differ, sometimes significantly, from actual consumption on autocatalysts. Thus, while we estimate that PGM used on vehicles last year was only 2% below the 2019 level, it is likely that actual purchasing by automakers was significantly lower than the 2019 peak. Due to a combination of production disruption and supply concerns, some companies accumulated surplus inventory of PGM during the 2020–2022 period. As prices fell and supply risks dissipated, these excess stocks are gradually being drawn down.

Light vehicle output rose by nearly 10%, with robust growth in all regions. China, Europe and Japan all recorded double-digit annual gains, while the large US market posted an 8% increase, despite a six-week strike at the three major domestic automakers. Global production of vans, buses and trucks climbed by 12%, propelled by an exceptionally strong performance in Europe (+15%) and China (+25%).

While the zero-emission segment posted the fastest growth rates, expectations that BEVs would account for virtually all last year's gains in vehicle output proved unfounded: production of light and heavy duty ICE vehicles rose by 8% and 11% respectively. Only the light duty diesel sector experienced any weakness, with global volumes down marginally year-on-year, reflecting changes in consumer preferences in Europe and India.

PGM consumption on light vehicles rose at a slightly lower rate than car output, mainly due to aggressive thrifting in China, where improvements in engine and catalyst technology enabled automakers (particularly domestic companies) to reduce average loadings on their vehicles. This was despite the introduction of Real Driving Emissions (RDE) testing in July 2023 under China 6b legislation. The advent of RDE testing in China has not had any material impact on loadings in this region; in contrast, the implementation and subsequent tightening of RDE regulations in Europe between 2017 and 2023 resulted in a rise in gasoline loadings of more than 60%.

Although type-approval emissions limits are stricter under China 6b than current Euro 6 standards, RDE legislation in China uses relatively lenient 'conformity factors' (CF: the permitted error margin when measuring emissions under real driving conditions) for both $NO_x$ and particle number (PN) emissions.

At 2.1, Chinese CFs are significantly higher than those applied under European regulations (currently 1.1 for $NO_x$, and 1.34 for PN). In addition, unlike in Europe, there is no cold-start requirement for Chinese RDE testing. One of the main reasons for higher loadings under Euro 6d RDE regulations is the need to achieve good $NO_x$, carbon monoxide and hydrocarbon conversion at low temperatures, such as during cold-start and low-speed city driving. If the test cycle excludes the coldest part of engine (and therefore catalyst) operation, as is the case in China, this permits the use of lower PGM loadings.

## "Chinese PGM loadings fell, despite the advent of Real Driving Emissions testing"

Only in North America did tightening legislation have a material impact on catalyst PGM loadings in 2023, as the phase-in of Federal Tier 3 legislation continued. Unlike Chinese and European standards, US Federal legislation does not impose a single set of limits; instead, it requires automakers to certify their vehicles into different emissions 'bins' in order to meet an overall emissions target. With the phase-in process nearing its conclusion (in 2025), an increasing percentage of vehicles met the strictest emissions standards last year.

Platinum captured a disproportionate share of overall PGM demand growth in light vehicles last year, as substitution programmes initiated in the 2019–2022 period were implemented. However, platinum remained a relatively minor component of gasoline demand, accounting for little more than 10% of total PGM used on gasoline catalyst systems outside of North America. Its share is a little larger in the USA, where higher average vehicle weights and catalyst loadings created a greater incentive for substitution. Although Chinese car companies were among the first to adopt platinum-containing catalysts, interest in substitution has subsided as the price differential between platinum and palladium has narrowed.

In the heavy duty sector, PGM use rose faster than vehicle volumes. This was not due to any specific legislative drivers,

but rather due to a sharp increase in production of large trucks powered by compressed natural gas (CNG). This was particularly evident in China, where low gas prices helped stimulate this market segment. These CNG vehicles use gasoline-type catalyst technology but - despite recent thrifting efforts - they typically require much higher PGM loadings than other powertrains.

Virtually all the PGM in our automotive demand estimates derives from autocatalysts on ICE vehicles. Our numbers also include platinum consumption in fuel cell vehicles, but this is currently minimal. Lack of subsidy support and a persistent shortage of hydrogen refuelling infrastructure appears to have choked production and sales of light duty FCEVs, which fell to little more than 10,000 units in 2023. Heavy FCEVs are faring better, with production rising by nearly 50% last year, but absolute volumes remain very small.

## Jewellery demand

Platinum jewellery fabrication fell by a further 2% to 1.36 million oz in 2023, the lowest level since the late 1980s. Weakness in the Chinese market has intensified over the past four years, with platinum losing its reputation as the most precious jewellery metal (following a prolonged period of weak prices) and consumer tastes moving decisively in favour of gold. Many Chinese jewellery makers have repurposed their platinum fabrication facilities to make gold jewellery, although some have retained smaller teams which specialise in platinum.

The Japanese market has also seen a shift towards gold jewellery, while demographic changes have also been negative for platinum. As the population ages, the number of marriages is falling, affecting demand for platinum in its traditional stronghold, bridal jewellery.

Elsewhere, fabrication of platinum jewellery saw a strong post-Covid rebound in demand, as marriages which were postponed during lockdown periods took place, and luxury jewellery and watch sales surged. However, this recovery began to run out of steam in 2023, with economic headwinds affecting consumer spending power, particularly in Europe.

## Industrial demand

Use of PGM in industrial applications was relatively robust during 2023, although weakness in the global electronics industry continued to weigh upon palladium in particular. Industrial demand for the latter metal has fallen steadily over the last two decades, largely due to price-stimulated substitution in electronics and dental applications.

## "Industrial platinum demand was close to all-time highs"

In contrast, industrial platinum consumption has been steady at around 2.8 million oz over the past three years – close to historical highs, despite geopolitical and economic headwinds. Demand has been supported by exceptionally strong purchasing by the Chinese chemicals and glass sectors. Although platinum use in the chemicals industry eased somewhat in 2023, the glass sector saw further large capacity expansions by both glass fibre and display glass producers.

During 2021–2022, rhodium demand was depressed by heavy sales back to the market by glassmakers, in the wake of price-driven reductions in the rhodium content of glass fibre alloys. These sales continued during 2023, but at a lower rate, enabling a small recovery in purchasing by the glass sector. Lower prices were also positive for demand for rhodium process catalysts used in some chemical processes.

Ruthenium and iridium demand remained buoyant last year. Ongoing investment in caprolactam production in China continued to boost purchasing of ruthenium process catalysts, while iridium saw firm demand from electrochemical applications such as ballast water treatment, copper foil production and PEM electrolysis.

*See page 23 for an in-depth focus on industrial PGM demand.*

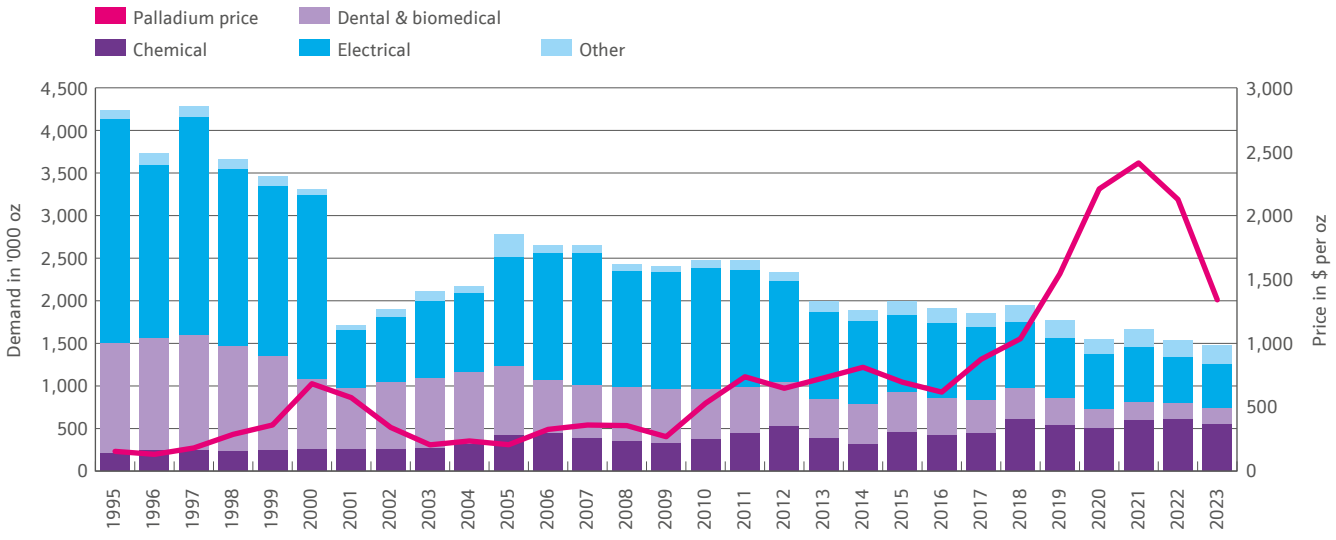


**Figure 8** Long-term trend in industrial palladium demand and price

# PGM outlook

## Supply and demand in 2024

**Deficits in palladium and rhodium will shrink this year, as gasoline car output declines**

**Lower primary supplies will push the shortfall in platinum to nearly 600,000 oz**

**Automotive PGM consumption will fall by 5% to 12.4 million oz**

**Recycling should see modest growth, as Chinese auto scrap collectors process backlogs**

**Despite fundamental deficits, the PGM markets remained highly liquid during early 2024**

"PGM supply shortfalls will persist in 2024, despite lower gasoline car output and higher recycling"

### Market balance

All three autocatalyst PGM are expected to remain in deficit in 2024, despite expectations of a 5% decline in light duty ICE vehicle production, a modest upturn in autocatalyst recoveries, and continued sales from Russian producer stocks.

The shortfall in the palladium market is expected to shrink significantly, to around 360,000 oz in 2024. Demand is forecast to fall by 6% to 9.7 million oz, the lowest level since 2016. Although industrial consumption will hold up well, supported by some modest gains in the electronics and pollution control sectors, automotive use will slip to 8.1 million oz, an eight-year low. This reflects expectations of a 4% contraction in gasoline car output, amplified by continued heavy thrifting by Chinese automakers. On the supply side, a 4% gain in secondary palladium recoveries is predicted to offset a slight decline in primary metal sales.

Our demand estimates allow for small additions to ETF holdings this year, based on modest buying by US investors during the first quarter; we take a neutral stance on investment over the remainder of the year. The amount of palladium held in ETFs is now relatively small, at below 600,000 oz, down from a peak of nearly 3 million oz in 2014–2015. In theory, heavy ETF redemptions could balance the market this year, but this would require the sale of more than half of remaining holdings (which proved remarkably 'sticky' at much higher prices during 2021–2023).

There are two other areas of uncertainty upon which the palladium market balance will ultimately hinge this year. The first of these is vehicle output. While the auto sector undoubtedly

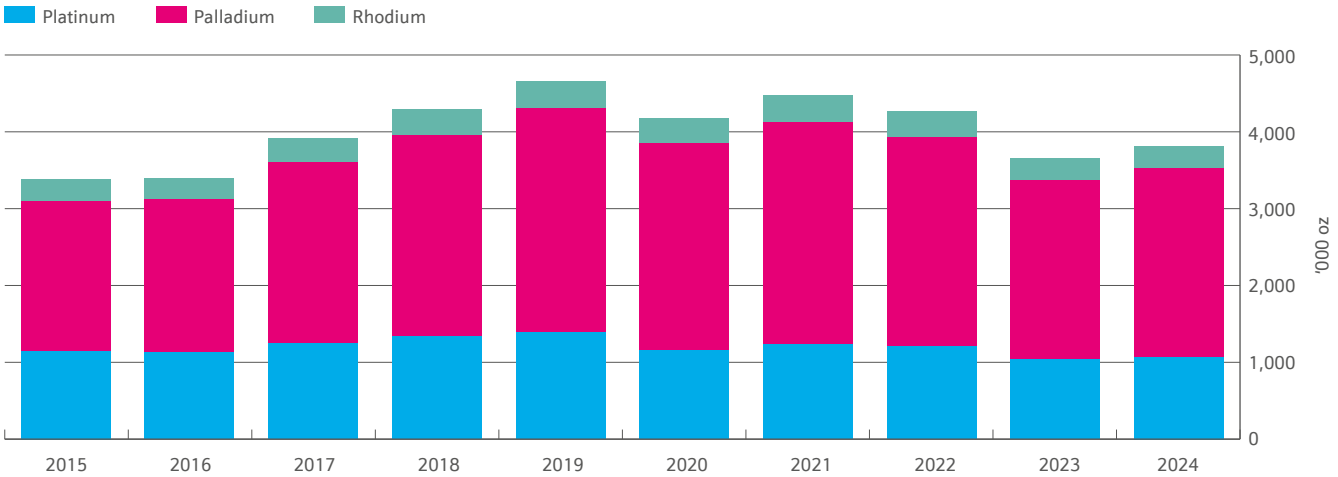


**Figure 9** Global recoveries of platinum, palladium and rhodium from automotive scrap

| Supply '000 oz | 2022 | 2023 | 2024 |
|---|---|---|---|
| South Africa | 3,965 | 4,001 | 3,979 |
| Russia | 450 | 780 | 660 |
| Others | 971 | 1,010 | 1,042 |
| **Total primary supply** | **5,386** | **5,791** | **5,681** |
| Secondary supply* | 1,517 | 1,300 | 1,335 |
| **Total combined supply** | **6,903** | **7,091** | **7,016** |

| Demand '000 oz | 2022 | 2023 | 2024 |
|---|---|---|---|
| Automotive | 2,747 | 3,342 | 3,299 |
| Jewellery | 1,391 | 1,361 | 1,343 |
| Industrial | 2,858 | 2,860 | 2,852 |
| Investment | -565 | 46 | 120 |
| **Total demand** | **6,431** | **7,609** | **7,614** |
| Movements in stocks | 472 | -518 | -598 |

* Secondary supply comprises open-loop recycling from the automotive, jewellery and electronics industries

**Table 1** Platinum supply and demand

faces some challenges – including a slowdown in new orders, rising inventories of completed vehicles, and a risk of component shortages due to Red Sea shipping disruption – industry forecasts have been repeatedly upgraded in recent months. The gasoline car sector in particular has outperformed expectations. Given recently announced delays to electrification programmes at several large automakers, it is possible that the ICE vehicle output will hold up better than anticipated in 2024. If gasoline car production were to stabilise at 2023 levels, this would add around 200,000 oz to our palladium demand forecast.

Auto recycling is the second major source of uncertainty. Following distortions to new and used vehicle markets over the last four years, there is now a large backlog of older vehicles that are still in service, but which under normal circumstances would already have been retired. It is difficult to foresee to what extent, and how quickly, vehicle scrappage rates will normalise. There may be some scope for recycling to bounce back more strongly than is shown in our numbers, but there is also a risk that it will disappoint, in view of an anticipated slowdown in new vehicle sales growth this year, ongoing tightness in used car markets and cost-of-living pressures that are compelling car owners to keep vehicles on the road for longer than normal.

The deficit in the platinum market is forecast to exceed half a million ounces again in 2024. Demand is expected to stabilise at around 7.6 million oz, with small decreases in automotive and jewellery balanced by an uptick in investment. Industrial consumption will be virtually unchanged. On the supply side, a fall in Russian shipments (following unusually large producer stock sales in 2023) should be offset by modestly higher recoveries from auto recycling, and slightly increased primary supplies from Zimbabwe and North America. South African platinum supply is forecast to be virtually flat, with releases of work-in-progress from producers' refining pipelines largely compensating for a small decline in underlying mine output.

Our demand estimates allow for positive platinum investment of 120,000 oz in 2024, much of this in the form of coins and small bars, including new platinum products celebrating the Chinese Year of the Dragon issued by the Perth Mint in Australia and the People's Bank of China. Net investment in the form of retail bar sales in Japan, and via exchange traded funds in other regions, was minimal during the first quarter of 2024.

Platinum ETF holdings totalled nearly 3 million oz as of the end of March 2024, while Japanese retail investors also hold large quantities of metal purchased in previous years, so it is theoretically possible for disinvestment to balance the market, as happened in 2022 (when rising interest rates reduced the attractiveness of non-yielding assets, and dollar strength provided some profit-taking opportunities for platinum investors in other currencies). Historically, liquidation of large bar holdings in Japan has been favoured by sharp upward movements in the yen-denominated platinum price, but it is harder to anticipate the reaction of ETF investors.

## "Delays to electrification programmes at some automakers could support ICE vehicle production this year"

The risks to platinum supply are probably weighted to the downside, in view of weak PGM prices: many producers are under financial pressure, and further announcements regarding cuts to capital spending, delays to projects or even outright shaft closures cannot be ruled out.

As noted above, there could be upside to auto demand, but any upgrades to light vehicle production forecasts are likely to favour gasoline vehicles rather than diesel cars (the

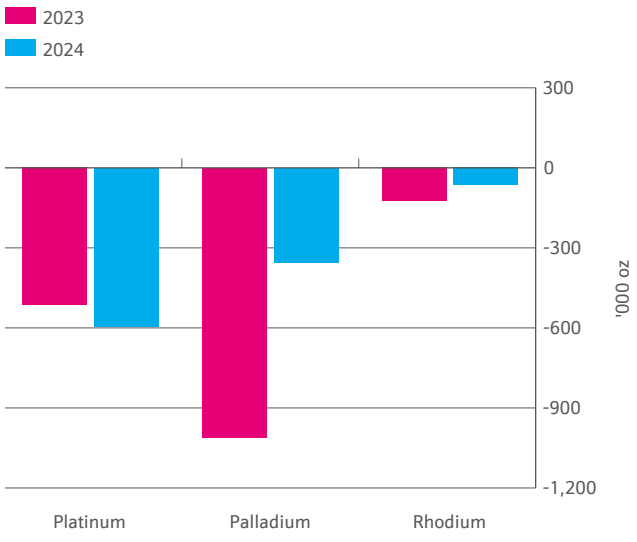


**Figure 10** PGM market balance

market for which is now in seemingly inexorable decline) and would therefore be more favourable for palladium than for platinum. The latter has increased its share of gasoline catalyst demand in recent years, but PGM use in three-way catalysts is still dominated by palladium.

We forecast another deficit in the rhodium market, despite a 6% decline in automotive demand, some recovery in autocatalyst recycling, and a modest rebound in South African supplies as a backlog of semi-processed metal is refined and sold. While this will help reduce the extent of the deficit, it is unlikely to be enough to erase it completely.

Consumption of rhodium in industrial applications is forecast to improve by 9%, reflecting a particularly strong outlook for rhodium catalyst sales to the chemicals industry. However, rhodium requirements in the glass industry will remain weak, with Chinese glass fibre producers expected to make further sales of surplus metal back to the market. Overall, our forecast shows a 4% decrease in combined auto and industrial consumption of rhodium in 2024. Uncertainties primarily relate to auto demand, as discussed above, and the rate at which glassmakers will sell excess rhodium.

Both ruthenium and iridium are forecast to see demand gains this year. There will be unusually strong consumption of ruthenium catalysts in a wide range of chemical processes, particularly in China, while electrical demand should benefit from a recovery in hard disk volumes. Consumption of iridium is expected to be firm in all its main applications, reflecting ongoing growth in a range of electrochemical processes linked to the energy transition and environmental protection, and a recovery in electronics use following weakness over the past two years. This demand growth should be met by increased supply, as work-in-progress inventory in South Africa is gradually refined and sold. Market stocks of ruthenium remain elevated in China following very large imports in 2021, while there are also some remaining producer stocks in South Africa which could be mobilised to meet demand if required.

"Chinese glass fibre companies continue to sell surplus rhodium back to the market"

## Price trends

Despite fundamental supply deficits, the PGM markets were highly liquid during the first quarter of 2024, with lease rates continuing to trend lower and prices remaining generally subdued. Following a December 2023 rally, palladium fell back below $1,000 during January, before tumbling to a five-year low of $866 in mid-February, when it briefly traded at a discount to platinum for the first time since April 2018. It climbed back towards $1,100 during March, but again retreated below the $1,000 level at the month end. Speculator sentiment towards palladium remains negative: the net speculative short position on NYMEX was above 1 million oz for most of the first quarter of 2023, peaking at 1.3 million oz in mid-February.

Platinum prices remained weak in early 2024, subsiding from $1,000 on 1st January to trade either side of $900 for most of the first quarter. Rhodium traded steadily at around $4,500 for much of this period, before edging above $4,700 in late March.

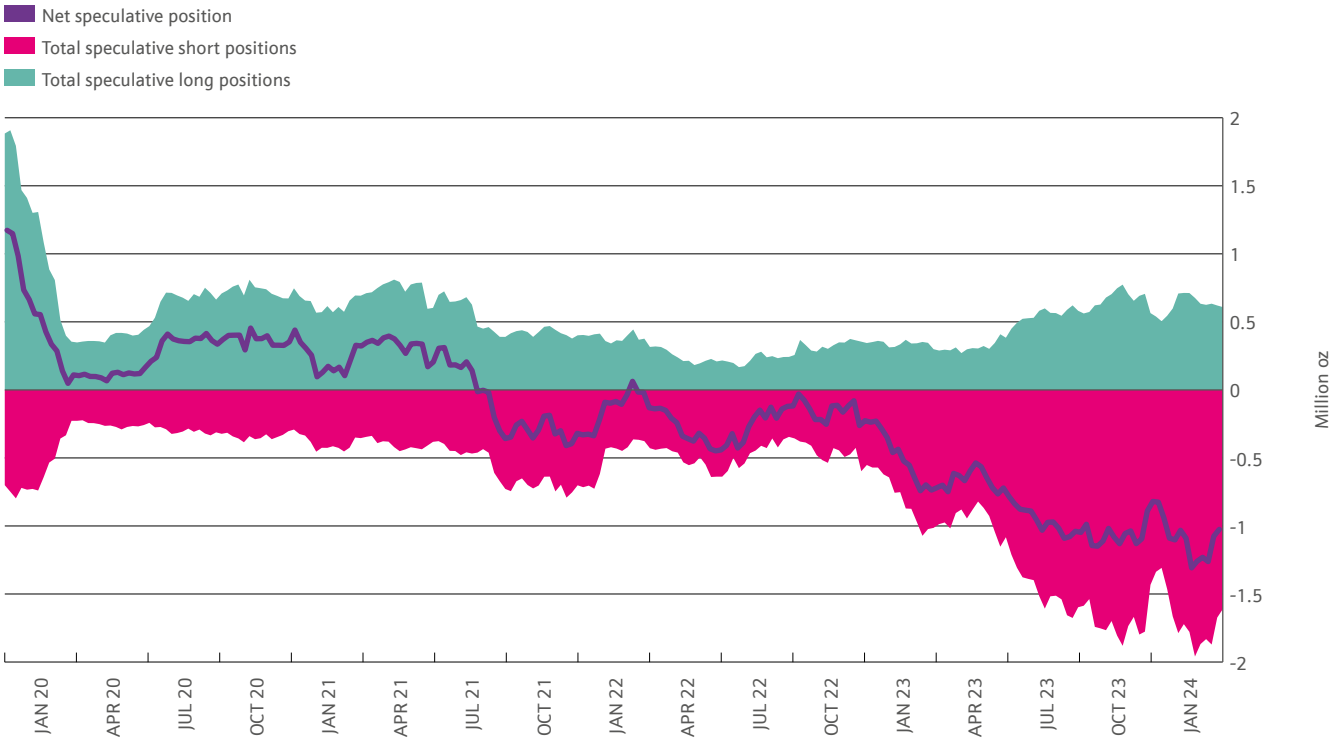


**Figure 11** Palladium: speculative position on NYMEX

## Primary supply in 2024

We do not expect any major changes in combined primary and secondary PGM supply this year, with a modest reduction in Russian sales likely to be offset by a small improvement in recoveries from automotive scrap. South African shipments are forecast to be broadly flat: underlying mine output is set to decline slightly, but producers are expected to treat a backlog of work-in-progress that has built up since 2022 due to furnace maintenance and reductions in electricity supply ('load curtailment'). At the end of last year, we estimate that this backlog amounted to at least half a million ounces of PGM, but we do not expect all this metal to be refined in 2024. More smelter repairs are scheduled this year, while load curtailment continues to create some operational challenges, albeit to a lesser extent than last year.

"South African PGM producers are restructuring in response to weak PGM prices"

There is a small number of expansion projects currently underway in South Africa, including the redevelopment of formerly mothballed mines at Eland (Northam Platinum) and Bokoni (African Rainbow Minerals: ARM), and a large Merensky expansion at the Two Rivers mine (an Impala Platinum/ARM joint venture). However, these projects are not expected to make a significant contribution to supplies this year and could be subject to delay or a reduction in their scope due to low PGM prices. Outweighing any gains from these projects, the closure of the Pilanesberg mine (Sedibelo Platinum) in the second half of 2023 will impact production this year, while we expect another decline at the Kroondal mine (Sibanye-Stillwater), which has limited remaining ore reserves. We expect mine output of PGM in concentrate to fall by around 3% this year.

All the major South African PGM producers have announced restructuring programmes in response to weak PGM prices. These primarily target cost and head-count reductions, along with the deferral of replacement and expansion CAPEX, rather than near-term closures of existing assets. The immediate impact on PGM output will therefore be limited, although cuts to CAPEX will inevitably degrade longer-term production capacity in the South African platinum industry.

Guidance from Norilsk Nickel suggests that refined platinum and palladium output from the company's large Norilsk-Talnakh mining complex in northern Siberia will fall by between 9% and 15% this year, due to scheduled furnace repairs that were postponed from 2023. Palladium production is expected to be between 2.3 and 2.45 million oz, while platinum output will be in a 567,000–605,000 oz range. However, we believe that the company holds some unsold stocks, particularly of palladium, and this could supplement sales of fresh mine production.

Elsewhere, there is potential for a modest improvement in PGM output in 2024. In Zimbabwe, both Unki (Anglo American Platinum) and Zimplats (Impala Platinum) have recently increased capacity at their concentrators. However, with the recent cancellation of the North Hill replacement project at Mimosa (an Impala Platinum/Sibanye-Stillwater joint venture), it appears that a long period of growth in Zimbabwean PGM supplies may be approaching an end.

| Supply '000 oz | 2022 | 2023 | 2024 |
|---|---|---|---|
| South Africa | 2,276 | 2,347 | 2,305 |
| Russia | 2,300 | 2,700 | 2,600 |
| Others | 1,450 | 1,500 | 1,549 |
| **Total primary supply** | **6,026** | **6,547** | **6,454** |
| Secondary supply* | 3,193 | 2,807 | 2,919 |
| **Total combined supply** | **9,219** | **9,354** | **9,373** |
| | | | |
| **Demand '000 oz** | **2022** | **2023** | **2024** |
| Automotive | 8,460 | 8,745 | 8,145 |
| Jewellery | 88 | 86 | 85 |
| Industrial | 1,536 | 1,479 | 1,472 |
| Investment | -109 | 61 | 29 |
| **Total demand** | **9,975** | **10,371** | **9,731** |
| Movements in stocks | -756 | -1,017 | -358 |

* Secondary supply comprises open-loop recycling from the automotive, jewellery and electronics industries

**Table 2** Palladium supply and demand

We also forecast small gains in North America this year, reflecting our expectation of slightly higher PGM by-product from the region's nickel mines. At Sibanye-Stillwater's US operation, production is expected to rise only marginally this year, with expansion on hold, and the mine focussing on reducing costs and increasing operational flexibility. It is loss-making at the PGM prices prevailing in the first quarter of 2024 and will need to make substantial cuts in unit costs if it is to return to profitability.

## Outlook for secondary supply

Our secondary supply estimates for 2024 allow for a modest recovery in autocatalyst recoveries. Automotive scrap intakes at collectors and refiners were weak last year, especially in Europe and North America (by far the largest recycling markets). While it is too early to be confident of the timing of any return to growth, recent declines in used car prices (in the wake of strong gains in new registrations in 2023) may herald a gradual return to more normal market conditions. In addition, we expect hoarding of untreated scrap in China to begin to unwind.

As discussed on page 9, significant quantities of automotive scrap accumulated at scrap yards and smaller collectors in China during 2023, due to a combination of falling PGM prices, concerns over scrap provenance and a government crackdown on unlicensed collectors. The gradual return of this material to the market should boost Chinese recycling

| Supply '000 oz | 2022 | 2023 | 2024 |
|---|---|---|---|
| South Africa | 570 | 559 | 574 |
| Russia | 54 | 70 | 59 |
| Others | 69 | 72 | 71 |
| **Total primary supply** | **693** | **701** | **704** |
| Secondary supply* | 334 | 285 | 295 |
| **Total combined supply** | **1,027** | **986** | **999** |

| Demand '000 oz | 2022 | 2023 | 2024 |
|---|---|---|---|
| Automotive | 946 | 989 | 931 |
| Other | 64 | 122 | 133 |
| **Total demand** | **1,010** | **1,111** | **1,064** |
| Movements in stocks | 17 | -125 | -65 |

* Secondary supply comprises open-loop recycling from the automotive industry

**Table 3** Rhodium supply and demand

volumes during 2024, although there remain some headwinds relating to domestic movement of scrap, which is classified as hazardous waste. Historic growth in vehicle sales and catalyst fitment should also underpin the market.

It is more difficult to be confident of the near-term trajectory of recycling in the mature automotive markets. Hoarding is thought to have been more limited in these regions during 2023 and is unlikely to play a decisive role in recycling levels this year. Any significant recovery will therefore require an underlying increase in the number of end-of-life vehicles reaching scrap yards. We do not yet have any firm evidence for a turnaround in vehicle scrappage rates, but the gradual decline in used car prices over the past year should ultimately reduce the economic incentive to delay the retirement of older vehicles.

## "In mature auto markets, average vehicle lifetimes have been rising for many years"

There remains significant uncertainty over the rate at which scrap intakes might improve, because this depends largely on whether recent extensions of the lifespan of vehicles will eventually be reversed, and how quickly. Average vehicle lifetimes in developed auto markets have been rising for many years; for example, the average age of cars on the road in the European Union reached 12.3 years in 2022[1], the last year for which data is available. This was up from around 11.5 years in 2019, and under nine years prior to the 2008 Global Financial Crisis.

A number of factors have contributed to lengthening lifetimes, including improved durability, rising vehicle ownership in lower-income countries (where vehicles are kept on the road for longer), and periodic falls in new registrations, which ultimately create a bottleneck in the supply of used vehicles. A plunge in car output over the 2020–2022 period was the direct cause of the current lack of one-to-three-year-old vehicles on the second-hand market, while weak sales in the years following the Global Financial Crisis means there is now a shortage of older vehicles for car buyers on a low budget.

There is now a significant backlog of older vehicles still on the road which in normal circumstances would have been scrapped. However, used vehicle markets remain tight, financing costs are high, and many car buyers face severe cost-of-living pressures. On balance, we think there are reasonable prospects of a small improvement in recycling rates in the mature auto markets in 2024, but there is both upside and downside risk to our forecast.

## "Industry forecasters are trimming their near-term forecasts of BEV penetration"

### Outlook for auto production

Following a 10% rise last year, global output of light vehicles is forecast to contract marginally this year to 88.3 million units. This reflects an ongoing tension between rising vehicle prices and elevated credit costs, and reduced consumer spending power due to the cost-of-living crisis in many Western markets. As a result, inventories of finished vehicles have risen, while order backlogs are shrinking, setting the scene for slightly weaker auto output this year, despite expectations of low single-digit growth in global LV sales.

Battery electric models are primed to make further market share gains at the expense of ICE vehicles. Globally, BEV output is forecast to rise by 29% to 13.5 million units, accounting for 15% of all light vehicles, up from 12% in 2023. Automakers in China will continue to dominate the BEV sector, accounting for 60% of fully electric cars produced worldwide.

Although the prospects for the BEV sector remain positive, industry forecasters are now trimming their near-term

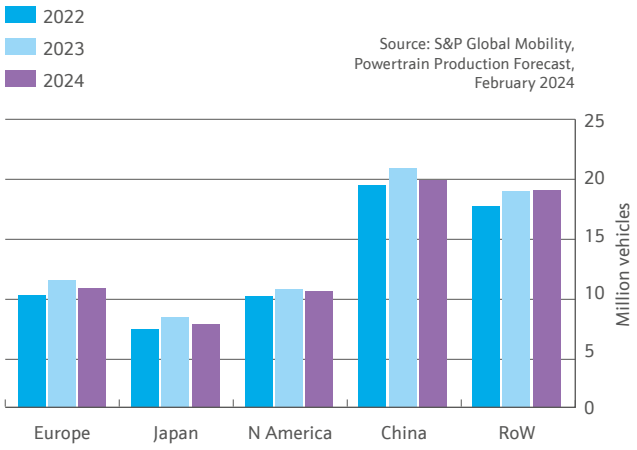


**Figure 12** Light duty gasoline vehicle production by region

[1]https://www.acea.auto/files/ACEA-Report-Vehicles-on-European-roads-.pdf

outlooks, as headwinds begin to emerge. This has been particularly noticeable in North America and Europe, where automakers face stern competition from cheaper Chinese imports. Mass-market uptake of BEVs faces a range of obstacles in many large Western markets, including the withdrawal or reduction of subsidies, high prices, poor resale values and lack of charging infrastructure. This has led some large OEMs including Ford, GM, Toyota and Mercedes Benz to backtrack on their near-term electrification targets.

Global production of gasoline and diesel cars is forecast to total 74.8 million units in 2024 – a decline of 5% on last year, but still significantly above the levels seen in the 2020–2022 period. The light gasoline sector is expected to contract by 4%, significantly outperforming the diesel segment, which is set to see a double-digit decline.

ICE vehicle output proved more resilient in 2023 than initially expected, and industry predictions for 2024 have also seen upgrades, particularly in China, where the light gasoline sector is being supported by strong demand from domestic consumers for plug-in hybrid and extended-range electric vehicles (PHEV and EREV – see page 20 for further information). Unlike conventional hybrids, these vehicles can be operated using the battery alone for significant distances, offering emissions-free driving over ranges of up to 100 kilometres, but without the 'range anxiety' associated with fully electric vehicles. Like battery electric models, they are considered New Energy Vehicles (NEV) for Chinese government policy purposes and are exempt from purchase tax in 2024–2025. However, growth is now less dependent upon incentives, and is being driven mainly by underlying consumer demand. Prices for plug-in cars have fallen significantly over the past year, enhancing their appeal as a longer-range, cheaper alternative to a BEV, with lower running costs than a conventional ICE vehicle.

"Plug-in hybrids have seen explosive growth in China over the past three years"

In 2023, all the growth in the Chinese light duty gasoline sector came from plug-in vehicles, production of which has seen explosive growth over the past three years. PHEV output in China more than quadrupled between 2021 and 2023, reaching 2.2 million units last year; extended-range vehicles saw volumes rise seven-fold to nearly 700,000 over the same period. Combined PHEV and EREV output is predicted to exceed 4 million units this year, a gain of 40%. In contrast, the market for conventional ICE vehicles and non-plug-in hybrids is set to contract by 12%.

In other major auto markets, conditions are currently less positive for plug-in hybrids. PHEVs have seen some success in Europe, with output reaching 1 million units in 2023, but European legislation is increasingly unfavourable towards these vehicles (see page 20) and government subsidies and incentives are less generous than for BEVs. In other markets, volumes are currently negligible. Total output of plug-in hybrid vehicles outside China is forecast to rise by 7% to 1.8 million

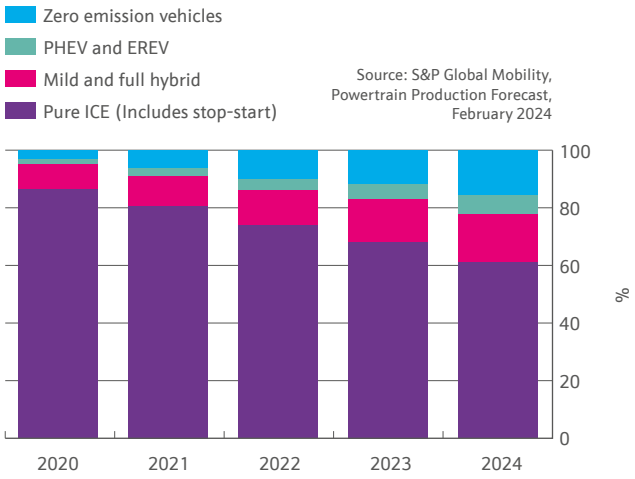


**Figure 13** World light duty market share by degree of electrification

units this year but volumes are not large enough to materially impact wider trends in the light duty gasoline market.

In the heavy duty sector, global production is expected to rise by 5% to 5.1 million vehicles, with China accounting for virtually all of this growth. The vast majority of heavy vehicles still have ICE powertrains: globally, diesel powertrains account for a market share of over 85%. However, the battery electric segment is growing, again mainly in China, where output of heavy electric trucks and buses is forecast to rise by over 40% to around 275,000 units this year.

## Trends in automotive PGM use

Falling production of light duty ICE vehicles will inevitably be reflected in automotive PGM demand, which is forecast to contract by 5% to 12.4 million oz this year. Platinum will again perform better than the other metals, with consumption down just 1%, supported by relatively firm demand in the heavy duty sector, and another modest increase in platinum-for-palladium substitution. While some automakers are reconsidering their substitution programmes, in view of recent declines in palladium prices, this is not expected to impact catalyst fitment programmes this year.

Palladium and rhodium demand is forecast to fall by around 7%, as the impact of lower gasoline vehicle output is amplified by a drop in PGM loadings in all regions except North America and India. In particular, we expect to see further thrifting of gasoline loadings by automakers in China this year, despite 2024 being the first full year of China 6b with RDE (the new regulations having been implemented in mid-2023). Although PGM prices and hence catalyst costs have fallen sharply over the past year, automakers are still striving to find cost savings and improve profitability on their conventional ICE models, partly because of intense price competition and low margins in the NEV segment.

As discussed on page 10, thrifting in China is being facilitated by a combination of relatively lenient RDE test conditions, more rapid certification of aftertreatment systems, and developments in engine and catalyst technology. For example, some domestic Chinese automakers use 'zoned' catalysts with

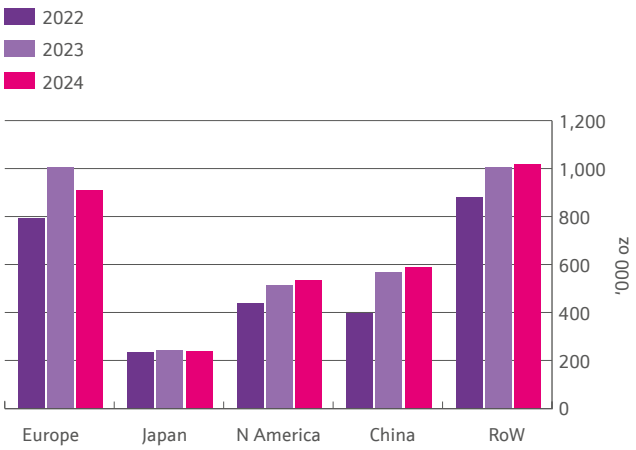


**Figure 14** Automotive demand for platinum by region

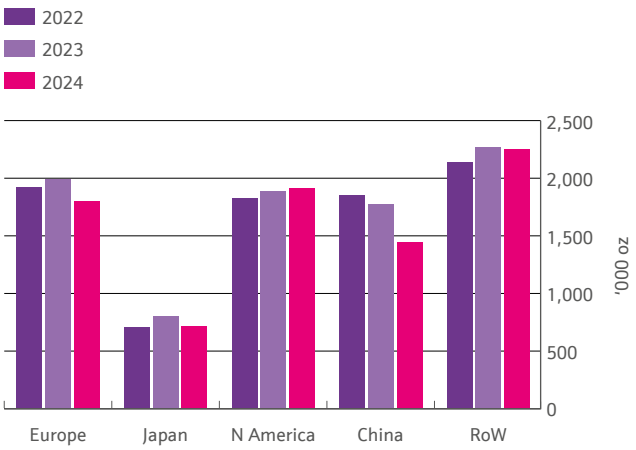


**Figure 15** Automotive demand for palladium by region

higher PGM loadings near the front of the catalyst (and lower loadings elsewhere): this accelerates the onset of catalyst activity ('light off') when the engine is switched on and permits a reduction in overall PGM loadings. This technology is less popular in other major auto markets, where type-approval test conditions and ageing cycles are typically harsher.

At present, average loadings on plug-in hybrids are slightly higher than those used on equivalent ICE vehicles. Many PHEV and EREV models in China use older engine platforms, which typically require catalysts with a higher PGM content. However, automakers with more sophisticated PHEV technology and dedicated engine platforms are able to achieve emissions control with lower loadings.

## "Loadings on PHEVs are slightly higher than on conventional gasoline models"

Only in North America is legislation currently driving any significant increase in the PGM content of catalyst systems. The phase-in of Federal Tier 3 legislation (2017–2025) has given rise to a gradual increase in PGM loadings over recent years, as more vehicles are certified into the lowest emissions categories. This has also benefited PGM demand in Mexico, counted in our Rest of World numbers.

In contrast, Europe is expected to see some modest thrifting in 2024. The latest Euro 6 update, known as Euro 6e, was implemented in September 2023; it reduces permitted error margins (formerly known as 'conformity factors') for $NO_x$ and particle number during RDE testing. However, most European models were already capable of meeting Euro 6e standards, so automakers have been able to pursue catalyst optimisation programmes despite the new legislation. Optimisation (and the resulting thrifting) has been more noticeable for gasoline vehicles than for diesel: automakers are devoting fewer technical resources to diesel powertrains, due to the contraction of this market. In 2024, European diesel car output is set to fall by 14% to just 3.6 million units, accounting for 22% of the region's light duty market.

PGM demand from the heavy duty diesel sector has also been affected by post-China 6 thrifting. Truck manufacturers in this region have concentrated their catalyst optimisation programmes on the heaviest categories: trucks with a gross vehicle weight (GVW) of over 15 tonnes, which have the highest PGM loadings. As current thrifting programmes conclude, we expect truck makers to shift their focus to smaller trucks in the 6–15 tonne GVW category.

In contrast, US heavy duty diesel loadings are trending upwards. The introduction of California's Heavy-Duty Low $NO_x$ Omnibus regulation (in California and other low-emission states) will be positive for heavy duty PGM demand this year. Once fully implemented (over two stages, in 2024 and 2027) this legislation will reduce permitted $NO_x$ emissions from heavy duty vehicles by 90%.

### Fuel cell electric vehicles

Industry forecasts suggest that fuel cell vehicle production will improve modestly this year, after a disappointing performance in 2023. To date, most series production of fuel cell models has been of passenger cars manufactured in Japan and Korea. However, sales have fallen far short of expectations: government policy has been unfavourable for light duty FCEV in most jurisdictions, while the development of hydrogen refuelling networks remains inadequate. Output of fuel cell passenger cars is expected to recover somewhat this year, but will remain very small, at no more than 15,000 units.

Developments in the commercial FCEV sector are more positive. This year should see the launch of a range of light fuel cell vans in Europe, based on an alternative 'plug-in hybrid' approach. All fuel cell vehicles are hybrids, in that they contain a battery, but these vans have larger batteries than conventional FCEVs, and a plug, enabling them to be driven as battery electric vehicles for short distances (typically 50–100 kilometres, depending on the model and the size of the battery). During longer journeys, the fuel cell drives the wheels and recharges the battery.

Several Chinese automakers are launching and ramping-up production of fuel cell vans with batteries large enough to power short trips. This technology enables automakers

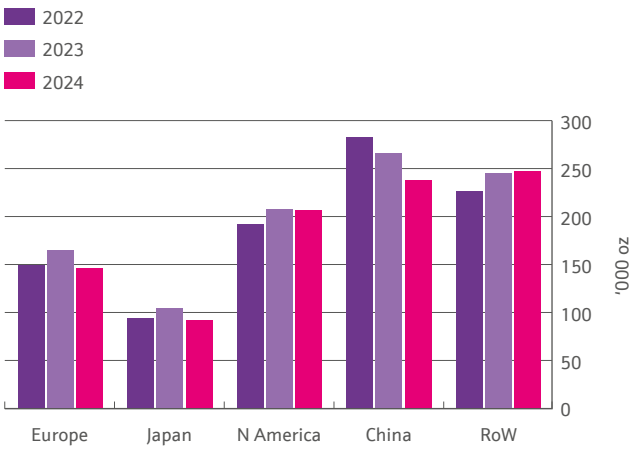


**Figure 16** Automotive demand for rhodium by region

to offer zero-emission light commercial vehicles with a long range but without the cost and weight disadvantage of a large battery pack. Globally, production of fuel cell vans could triple to around 6,000 units this year.

Production of heavier fuel cell vehicles is also beginning to ramp up, albeit from very low levels. At present, manufacturing is concentrated in China, where truck and bus makers will produce around 6,000 fuel cell vehicles with a gross vehicle weight of over six tonnes this year.

"Platinum use in glassmaking will remain at historically exceptional levels"

## Industrial demand

Despite ongoing weakness in the world economy, global demand for PGM in industrial applications is forecast to remain robust in 2024, rising 2% to nearly 5.8 million ounces. Chemicals consumption could reach record levels, reflecting unusually high ruthenium requirements in the Chinese chemicals industry, and ongoing strong demand for other metals (albeit, for platinum and palladium, slightly below recent peaks). In the electronics sector, expectations of a modest upturn in consumer demand should translate to increased use of PGM in conductive pastes used in a variety of electronic chips and in plating of connectors and lead-frames. Renewed investment in data storage capacity should also be positive for hard disk demand. We also anticipate further growth in electrochemical uses of PGM, driven by environmental protection and hydrogen applications, particularly benefiting platinum and iridium. However, glass demand is set to fall, as investment in new display glass capacity ebbs after a surge in 2022–2023 and as rhodium sales back to the market continue. Platinum use in glassmaking will nevertheless remain at historically exceptional levels, but rhodium requirements will again be weak.

A more detailed discussion of the outlook for industrial demand can be found on page 23.

## Outlook for jewellery fabrication

Fabrication of platinum jewellery is forecast to decline by 1% to 1.34 million oz this year, with the rate of contraction in the Chinese market continuing to ease. Following several years of depressed demand, the platinum jewellery making business has seen extensive rationalisation at the fabricator level, leaving platinum manufacturing concentrated among a smaller number of jewellery firms in the Shenzhen area. This process of consolidation may now be approaching an end, amid signs that the market is beginning to stabilise.

The Chinese gold jewellery market was strong in early 2024, but the industry expects a steep rise in the gold price in March to be negative for consumer demand. Exceptionally high gold prices could also result in retailers switching out some gold jewellery stock for cheaper platinum jewellery, to reduce their inventory costs, as happened in the second half of 2020. This has the potential to support platinum fabrication during 2024, but without an increase in underlying retail demand for platinum jewellery, any improvement would be temporary.

In North America, a run of post-Covid gains in jewellery fabrication is set to end this year. Retail sales of platinum jewellery have weakened moderately since mid-2023, reflecting cost-of-living and interest rate pressures on American consumers.

# Focus on PHEVs and EREVs

Production of plug-in hybrid electric vehicles (PHEVs) in China has seen explosive growth over the past three years, rising from under half a million units in 2021 to 2.2 million vehicles in 2023; output will approach the three million level this year. Extended range hybrid electric vehicles (EREVs) are a newer phenomenon: Chinese production began to ramp up over the past eighteen months and is set to reach 1.1 million units this year. Elsewhere, only the European region sees material production of PHEVs (just over one million vehicles annually) while EREVs are almost unknown.

Globally, over a quarter of all new gasoline vehicles are now hybrids: they have both an internal combustion engine and an electric motor powered by a rechargeable battery. Conventional hybrids have small batteries that are recharged while the vehicle is moving; the electric motor is designed to drive the wheels at low speeds, but the vehicle cannot be driven for any significant distance on electrical power alone. In contrast, PHEVs and EREVs are equipped with much larger batteries, recharged both during driving (via regenerative braking and from the engine) and from an external charging point when not in use. They are designed to be driven as electric vehicles over much longer distances: a PHEV typically has an 'electric range' of between 30 and 80 kilometres, while some EREV models have an all-electric range as high as 200 km. In addition, the presence of an internal combustion engine extends the vehicle's operating range significantly further: combined ICE and electric range is typically at least 500 km.

Although similar in concept, PHEVs and EREVs operate very differently: the former is a true hybrid vehicle with dual powertrains, while the latter can be thought of as an electric vehicle with an on-board generator.

In a PHEV, both the electric motor and the engine drive the wheels directly – known as 'parallel hybrid' operation. If additional power is required (for example during rapid acceleration), or if the battery is running low, the vehicle can also be powered by the internal combustion engine. In contrast, EREVs are designed as 'series hybrids': only the electric motor is used to drive the wheels. The gasoline engine serves exclusively to generate electricity, charging the battery if it runs low during driving.

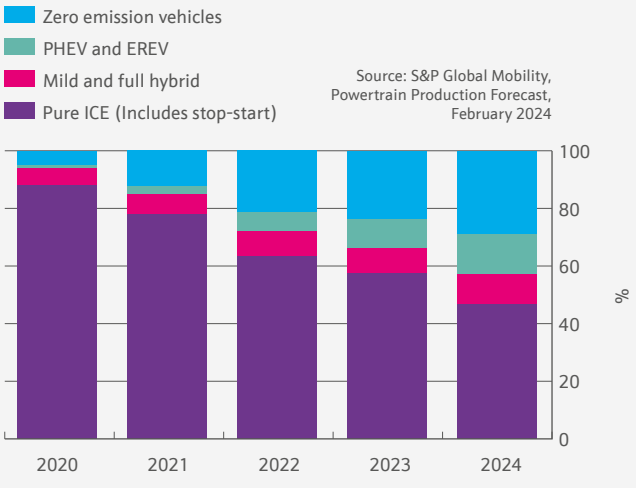


**Figure 17** Chinese light duty market share by degree of electrification

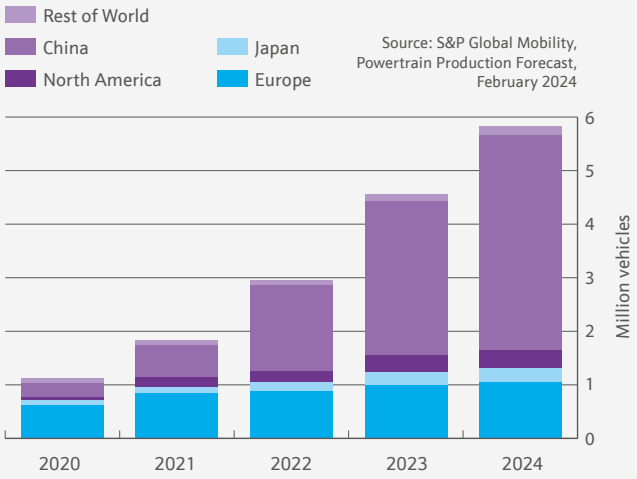


**Figure 18** World production of light duty PHEVs and EREVs, by region

Because electric range is closely related to battery size, both PHEVs and EREVs usually have much smaller batteries than fully electric vehicles (but much larger than conventional hybrids). Most modern BEVs have batteries with a capacity of at least 70 kWh, and this figure can rise to 100 kWh for larger, heavier vehicles. Hybridisation significantly reduces the size of the battery required, with EREV batteries typically in the 30 to 50 kWh range, and PHEV often below 20 kWh. This represents a significant saving in terms of battery cost and weight, although this is of course partly offset by the need for a gasoline engine. However, many plug-in models use existing engine platforms, and therefore benefit from economies of scale and low technology costs.

While plug-in vehicles are clearly a transition technology, they are set to play an important role in the Chinese market over the next few years: they address consumer enthusiasm for cleaner vehicles with lower running costs, while overcoming some of the hurdles to vehicle electrification, such as range limitations and lack of charging infrastructure. It remains to be seen whether there is potential for greater uptake in other regions.

In Europe, legislation is becoming less favourable for plug-in vehicles. Because PHEVs can be driven in either battery or ICE mode, a 'utility factor' (UF) is applied for the purposes of calculating fuel economy and $CO_2$ emissions, to account for the proportion of journeys that are powered by electricity alone. Currently, UFs are based on the assumption that electric driving accounts for 70-85% of PHEV use. However, this is not representative of real driver behaviour in Europe. Under Euro 6e legislation, introduced in September 2023, the UF will be reduced to 50% from 2025 (for private cars; for company cars the measure will be enforced from 2027). This is expected to disincentivise growth in PHEV sales in Europe.

There may be more scope for increased PHEV share in North America. In March 2024, the Environmental Protection Agency (EPA) finalised its 'Tier 4' ruling specifying new Federal emissions legislation to be phased in between 2027 and 2032. Compared to EPA's original proposal made in April 2023, the final ruling is more favourable for plug-in vehicles. The agency's central analysis case projects that BEVs will account for 56% of sales by 2032 and PHEVs for 13%, but it has also outlined alternative 'pathways' to meeting the legislation, which could see PHEV share climb as high as 36%.

# Update on Euro 7 legislation

| | Toxic pollutant limit values | Particle number | Test procedures | Durability | Other |
|---|---|---|---|---|---|
| **Light duty gasoline** | Identical to Euro 6e | Move from PN23 to PN10 measurement procedure[1] | Identical to Euro 6e | Extended to 160,000 km or 8 years[2] | New limits for brake and tyre particle emissions; new battery durability standards |
| **Light duty diesel** | Identical to Euro 6e | As above | As above | As above | As above |
| **Light commercial vehicles** | Identical to Euro 6e; retains less stringent standards for heavier LCVs | As above | As above | As above | As above |
| **Category 1 heavy vehicles[3]** | Limits significantly tightened; $NH_3$ and $N_2O$ regulated for the first time | As above | Minor changes vs Euro VI-E | Extended to 300,000 km or 8 years[4] | As above |
| **Category 2 heavy vehicles[3]** | As above | As above | As above | Extended to 700,000 km or 12 years[4] | As above |

No change  Small change  Significant change

[1]European emissions legislation limits not only the mass of particulate matter but also the number of particles (PN). Euro 6 legislated PN down to a particle size of 23 nanometres (PN23). Euro 7 will reduce the cut-off to 10 nanometres (PN10).

[2]Additional lifetime durability requirement for LV to 200,000 km/10 years, with 1.2 durability multiplier for gaseous pollutant emissions.

[3]Category 1 heavy vehicles are trucks with gross vehicle weight <16 tonnes, and buses with GVW <7.5 tonnes. Heavier trucks and buses are in Category 2.

[4]Additional lifetime durability for heavy vehicles to 375,000 km/10 years (Cat. 1) and 875,000 km/ 15 years (Cat. 2).

**Table 4** Comparison of final Euro 7 legislation with Euro 6/Euro VI

## Compromise Euro 7 legislation approved by the European Parliament

Following negotiations between the European Commission (EC), European Parliament (EP) and the European Council (EUCO: the council of heads of member states), the final form of Euro 7 has been significantly diluted compared to the initial proposals. The original text, issued in November 2022, envisaged imposing the lowest existing limits on all light vehicles regardless of fuel type or drivetrain, with enforcement starting in July 2025 and no phase-in period. However, under the compromise text agreed last December and approved by the European Parliament in March 2024, toxic pollutant limit values for Euro 7 will be unchanged from Euro 6 for light vehicles, albeit with more stringent durability requirements and tighter particle number standards, and their introduction will be delayed by at least 18 months versus the initial timeline. For buses and trucks, standards will tighten compared to Euro VI (both for exhaust emissions measured in laboratories, and under real driving conditions), and durability requirements will increase, but implementation will be later than originally envisaged.

Following approval by the EP, the legislation will now be formally approved by EUCO, and should enter into force by mid-2024. This sets the clock ticking on implementation of the new rules:

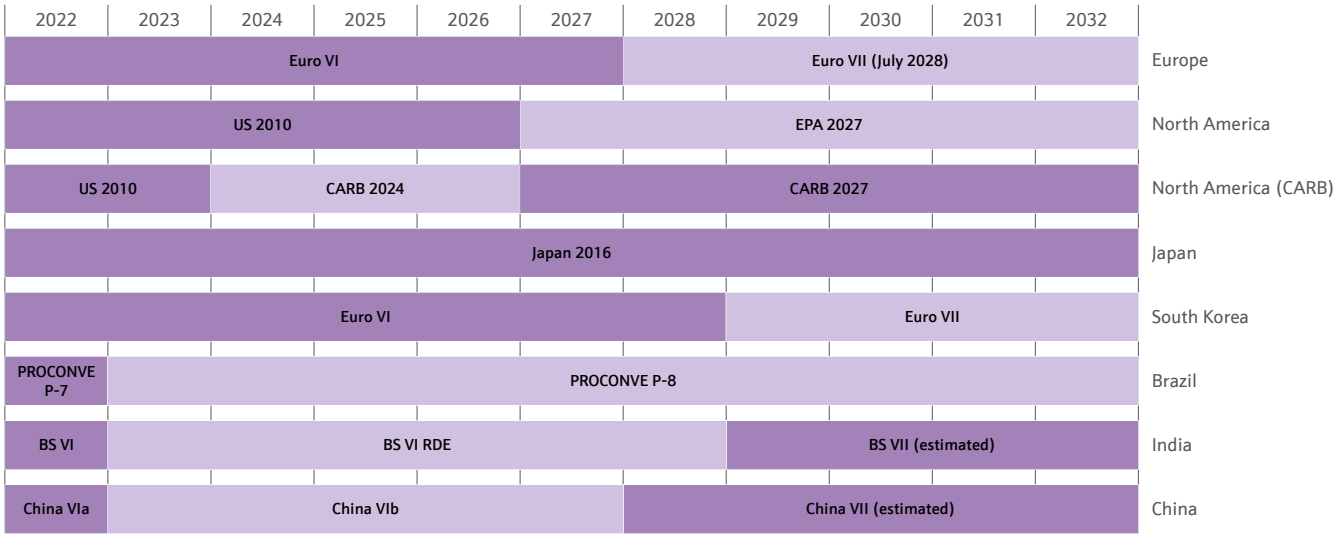


**Figure 19** Emissions legislation for heavy duty vehicles

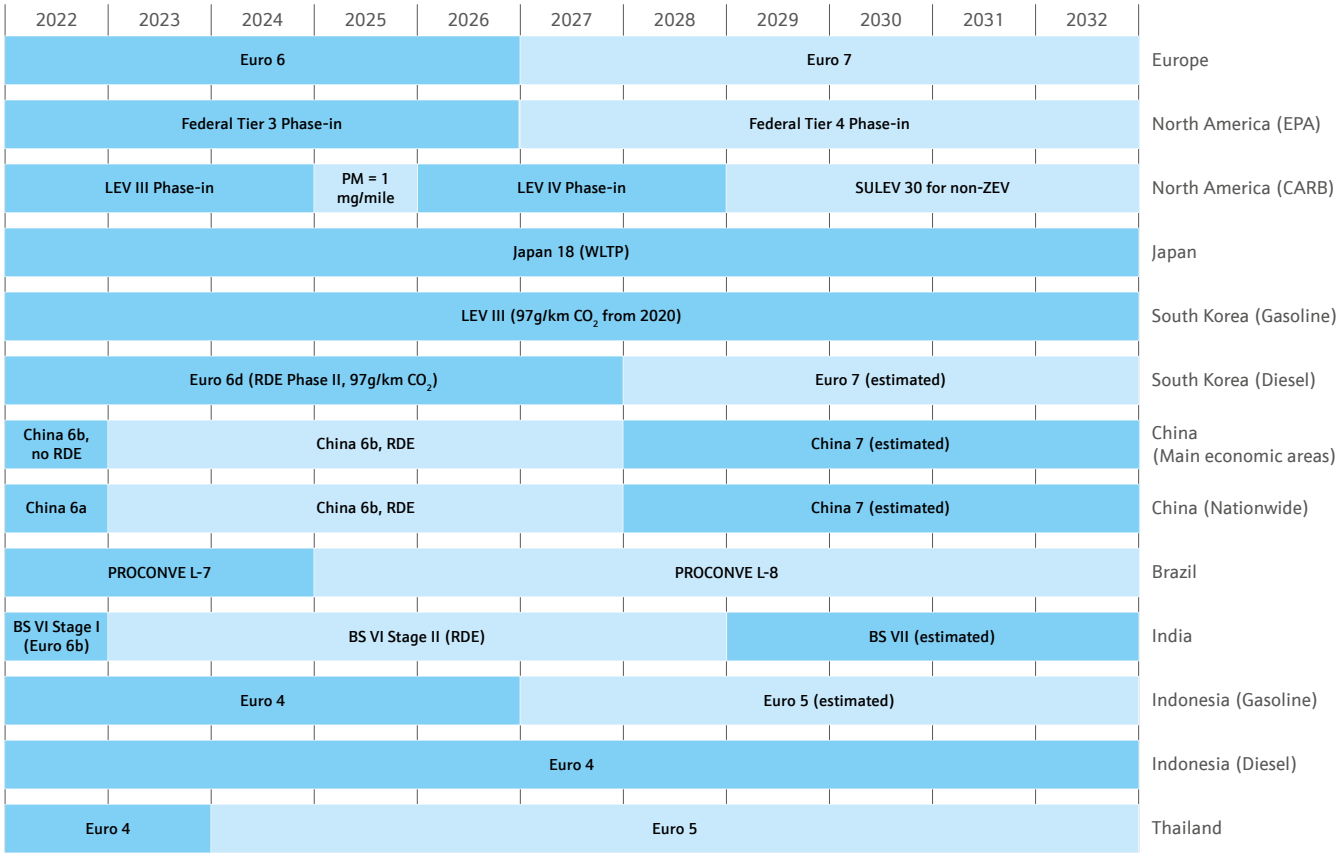


**Figure 20** Emissions legislation for light duty vehicles

30 months after entry into force for light vehicles, and 48 months for heavy vehicles. Thus, application of Euro 7 is set for around January 2027 for new light duty models (January 2028 for all light vehicles), and from mid-2028 for heavy vehicles.

## What does this mean for PGM demand?

With final light duty emissions limits unchanged versus Euro 6, there is more limited scope for an uplift to PGM loadings. However, there is still significant uncertainty over catalyst fitment for Euro 7. The tight timetable of the original proposal – which envisaged enforcement from mid-2025 – means that most automakers have already undertaken the necessary technical development and approved their Euro 7 catalyst strategy. For gasoline engines, these new catalyst systems typically have either an additional catalyst brick, or higher loadings on existing bricks. In contrast, Euro 7 light duty diesel systems are not expected to require additional PGM, although SCR volume will be increased on some models, for improved $NO_x$ control. (SCR technology does not use PGM, but all European diesels continue to require PGM-containing catalyst bricks to convert other pollutants).

At the time of writing, it appears that some companies still plan to proceed with existing Euro 7 catalyst programmes. With technical and financial resources being diverted towards vehicle electrification, spending on catalyst development has been cut, limiting automakers' ability to redevelop and recertify new catalyst systems ahead of Euro 7. In this case, we would expect technical resources to be focussed instead on post-2027 thrifting programmes. However, some automakers will be able to meet the new regulations with existing Euro 6e catalysts, and this would of course curb any increase in overall PGM loadings.

This has some implications for future platinum-for-palladium substitution. Some car manufacturers had planned to adopt catalysts with a higher platinum content in their Euro 7 systems, but the delay in the introduction of Euro 7 may give them time to review their substitution strategy.

For heavy vehicles, the longer implementation schedule means that many truck makers have yet to finalise their Euro 7 catalyst decisions. For these vehicles, Euro 7 legislation does include more stringent emissions limits. These will mainly be met by increasing SCR catalyst volume, but some additional PGM will be required to improve cold start emissions performance and enhance catalyst durability.

# Focus on industrial PGM demand

## Current and future drivers of industrial demand for PGM

**Industrial PGM demand will rise 2% in 2024, despite geopolitical and economic headwinds**

**PGM use in chemicals could set a new high this year, on strong ruthenium demand in China**

**Renewed investment in data storage will boost electronics demand**

**Platinum use in glassmaking will remain at historically exceptional levels**

**Over the past decade, Chinese industrial policy has been highly positive for PGM demand**

**Future PGM demand growth will be galvanised by environmental and hydrogen applications**

Industrial demand for PGM (including ruthenium and iridium) has been robust in the post-Covid period, exceeding 5.6 million oz in each of the last three years, despite volatile prices, ongoing Covid-related impacts, supply chain disruption, war in Ukraine, and general economic headwinds. High prices have stimulated thrifting in some palladium and rhodium applications, but platinum demand has been exceptionally robust, and consumption of ruthenium and iridium has also been firm. PGM consumption in industrial applications totalled 5.7 million oz in 2023, unchanged on the previous year.

Demand is forecast to rise by 2% this year, to around 5.8 million oz. All the metals will see higher consumption in electronics in 2024, reflecting a modest upturn in consumer demand for electronic devices, and renewed investment by the data storage sector. We also anticipate further growth in electrochemical uses of PGM, driven by environmental protection applications, particularly benefiting platinum and iridium. Consumption of PGM by the chemicals sector could reach record levels, reflecting exceptional demand for ruthenium process catalysts in China, and ongoing strong demand for other metals (albeit, in the case of platinum and palladium, slightly below recent peaks). However, use of PGM in glassmaking is set to fall, as investment in new display glass capacity ebbs after a surge in 2022–2023, and as rhodium sales back to the market continue. Platinum use in the glass industry will nevertheless remain at historically exceptional levels.

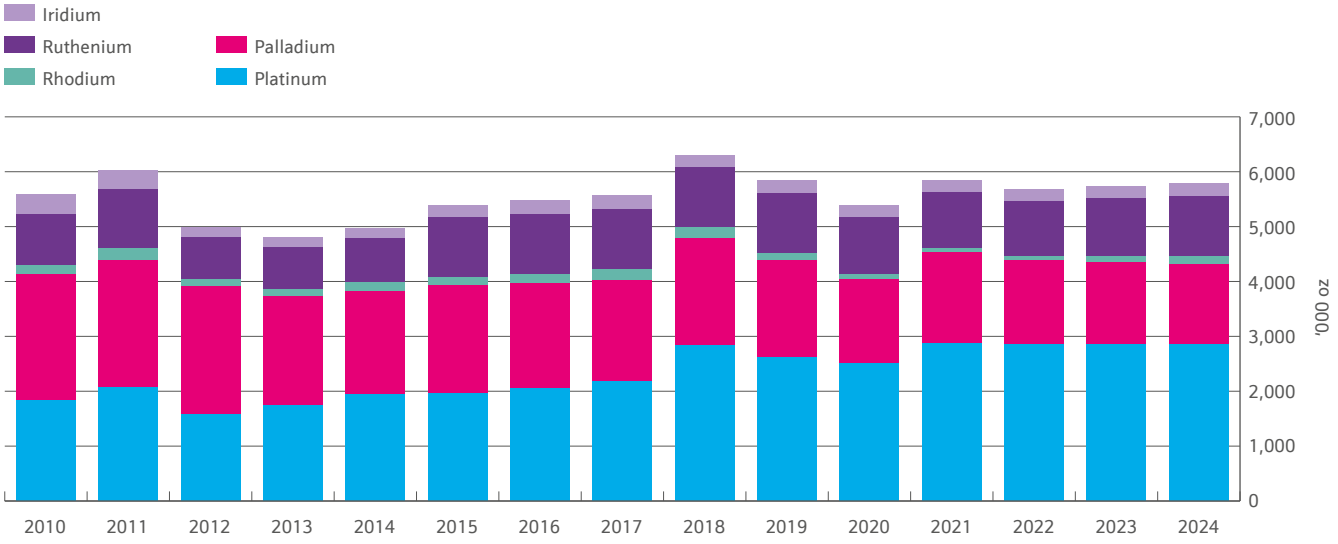


**Figure 21** Industrial PGM demand by metal

This section looks at three of the most important drivers for industrial PGM demand: Chinese industrial policy; environmental protection and the energy transition; and the 'high tech' sector.

## Chinese industrial policy: creating the largest industrial market for PGM

China has played a key role in supporting industrial PGM demand in recent years. Since Covid, it has consistently accounted for nearly 40% of world PGM demand in industrial products and processes, up from just over 20% a decade ago. This massive expansion in demand was driven by government policy emphasising industrial modernisation and domestic self-sufficiency, which formed a key part of the thirteenth Five Year Plan (5YP: 2016 to 2020) and which continues to support PGM demand today.

In particular, the 13th 5YP was a very significant driver of demand for PGM catalysts for integrated petroleum refinery complexes incorporating downstream synthesis of chemicals such as paraxylene (PX; uses a platinum catalyst) and purified terephthalic acid (PTA; uses a palladium catalyst). Investment in these refinery complexes peaked in the 2019–2022 period; the pace of new capacity construction is now starting to slow, and Chinese purchases of platinum and palladium catalysts used in petroleum reforming, PX and PTA synthesis declined in 2023. However, chemicals companies continued to add capacity for a range of other downstream chemicals, generating strong demand for ruthenium catalysts used to produce caprolactam (a key feedstock for nylon production) and rhodium catalysts for acetic acid and oxo alcohols synthesis. As a result, Chinese consumption of PGM in process catalysts was at record levels last year.

We could see PGM demand in the chemicals sector set a new all-time high this year, once again supported by heavy consumption of ruthenium in process catalysts. In-use losses of ruthenium from the caprolactam process tend to be significantly higher than for other process catalysts. This means that 'top-up' requirements (to replace lost metal) represent a much larger proportion of ongoing demand than is the case for other chemical processes. With investment in new caprolactam capacity also underway, we could see ruthenium chemicals demand hit record levels.

> "China accounts for nearly 40% of world PGM demand in industrial products and processes"

| Demand '000 oz | 2022 | 2023 | 2024 |
|---|---|---|---|
| Chemical | 695 | 647 | 643 |
| Dental & biomedical | 251 | 264 | 273 |
| Electrical | 247 | 195 | 221 |
| Glass | 708 | 776 | 721 |
| Petroleum | 240 | 174 | 180 |
| Pollution control | 234 | 275 | 279 |
| Other | 483 | 529 | 535 |
| **Total demand** | **2,858** | **2,860** | **2,852** |

**Table 5** Global industrial demand for platinum

Demand for rhodium catalysts in acetic acid is also set to remain strong. Two alternative PGM catalysts can be used in acetic acid synthesis: either rhodium (the Monsanto process) or ruthenium-iridium (the Cativa process). Following falls in the rhodium price, the Monsanto process has regained favour for new expansions in China.

## PGM for environmental protection: not just autocatalysts

Both inside and outside China, environmental protection has been another important driver for PGM demand in recent years. PGM are used in a range of industrial applications which are fundamental for improving energy efficiency, reducing $CO_2$ emissions, and safeguarding the environment. These include glass fibre (widely used for vehicle light-weighting,

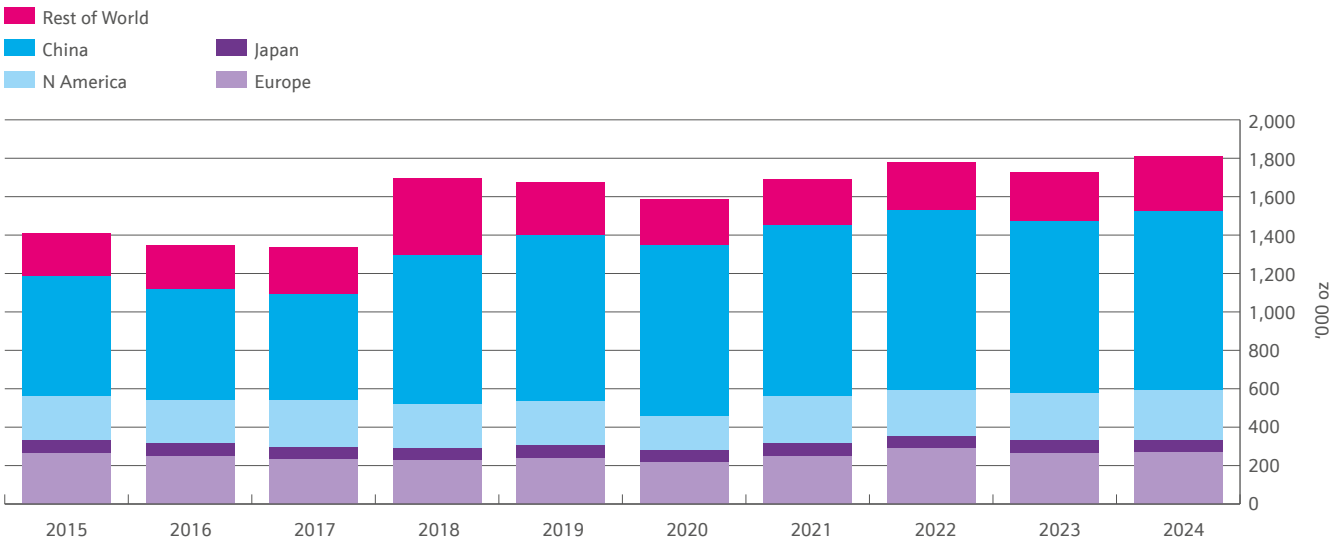


**Figure 22** PGM demand in chemical applications, by region

| Demand '000 oz | 2022 | 2023 | 2024 |
|---|---|---|---|
| Chemical | 67 | 81 | 92 |
| Electrical | 5 | 6 | 6 |
| Glass | -24 | 18 | 18 |
| Other | 16 | 17 | 17 |
| **Total demand** | **64** | **122** | **133** |

**Table 6** Global industrial demand for rhodium

and renewable energy applications such as wind turbines and solar panels), biofuels and synthetic fuels (to partly replace conventional oil-based fuels in aviation, for example), copper foil manufacture (for lithium-ion batteries), catalysts to control pollution from non-road and stationary engines, and hydrogen-related applications such as fuel cells and PEM electrolysis.

### Glass fibre: an important material for the renewable energy sector

In terms of PGM demand, by far the largest of these applications is glass fibre, where platinum-rhodium alloys are used in equipment (known as 'bushings') through which molten glass is extruded to form fine filaments. Since 2018, there has been exceptionally heavy investment in glass fibre capacity, mainly in China, propelled by growing use of glass fibre in a wide range of applications, and in particular the booming renewable energy sector (very large quantities of glass fibre are required to manufacture blades for wind turbines).

PGM demand from the glass fibre industry peaked at around 700,000 oz in 2021 (when some glass companies acquired additional platinum ahead of future capacity expansions), retreated briefly the following year, then rebounded strongly in 2023 as producers geared up for a new round of expansions. We expect heavy purchasing of platinum for glass fibre to continue this year.

Although glass fibre is currently in oversupply and profitability is under pressure, Chinese fibre producers regard this situation as temporary. In particular, they are optimistic that demand from renewable energy applications will continue to expand, with glass fibre now beginning to replace aluminium in frames for photovoltaic installations. The construction of one gigawatt of wind power may consume as much as 10,000 tonnes of glass fibre, while PV frames in solar farms could require more than 3,500 tonnes of glass fibre per gigawatt of capacity. The need for massive global investment in renewable electricity generation should therefore support PGM use in the glass sector for many years to come.

> "PGM are fundamental in many applications that help safeguard the environment"

While both platinum and rhodium are used in glass fibre production, demand for these metals does not necessarily rise or fall in tandem. Bushings made from alloys with a higher rhodium content (up to 20%) provide some technical advantages: in particular, they are more resistant to erosion by the molten glass, and therefore have a longer operating life. However, at high rhodium prices, it may make economic sense to reduce the rhodium content of glassmaking alloys (and increase their platinum content), because lower metal costs outweigh operational sacrifices.

Historically, a 10% rhodium content was considered to be the lower technical limit, but since 2020, Chinese glassmakers have moved to alloys containing much less rhodium, and have even adopted rhodium-free alloys for some applications. This has freed up some metal, reducing 'top-up' purchasing by Chinese manufacturers, and resulting in the sale of some unneeded rhodium back to the market. Most of these sales were made at high prices during 2021–2022, but selling activity continued during 2023 and into this year, albeit at a reduced level.

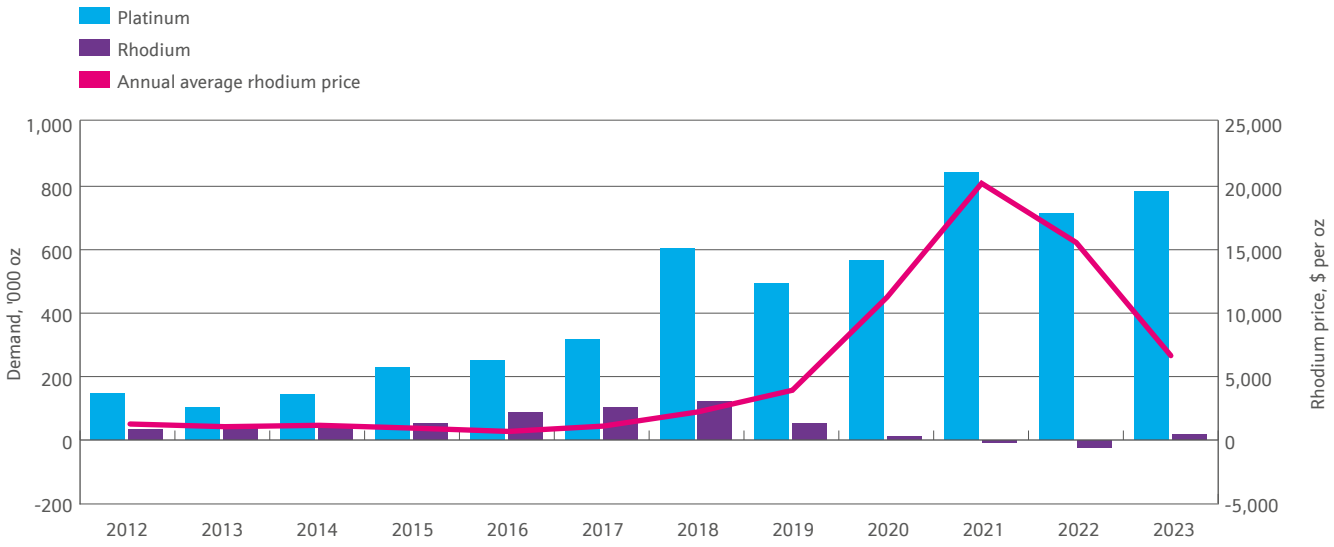


**Figure 23** Platinum and rhodium demand in the glass industry

| Demand '000 oz | 2022 | 2023 | 2024 |
|---|---|---|---|
| Chemical | 393 | 427 | 508 |
| Electrical | 369 | 309 | 323 |
| Electrochemical | 131 | 133 | 132 |
| Other | 134 | 139 | 142 |
| **Total demand** | **1,027** | **1,008** | **1,105** |

**Table 7** Global industrial demand for ruthenium

| Demand '000 oz | 2022 | 2023 | 2024 |
|---|---|---|---|
| Chemical | 25 | 27 | 32 |
| Electrical | 35 | 33 | 38 |
| Electrochemical | 92 | 104 | 108 |
| Other | 60 | 60 | 59 |
| **Total demand** | **212** | **224** | **237** |

**Table 8** Global industrial demand for iridium

### Pollution control for non-road mobile machinery

Pollution control catalysts also represent a large and growing component of industrial demand: consumption of PGM in this application has nearly doubled over the past decade and is expected to reach 420,000 oz in 2024. Europe, North America and Japan have long required catalysts to be fitted to a range of non-road and stationary engines, to significantly reduce toxic emissions of CO, $NO_x$ and particulates, in the same way that autocatalysts control engine-out emissions from road vehicles. However, legislation in the large Chinese market was significantly less strict. It was only in December 2022 that China IV emissions standards came into effect, driving higher catalyst fitment on a range of agricultural and construction equipment with engines of over 560 kW from that date. As a result, PGM use in pollution control in China rose by 53% in 2023. It is now the turn of India to enforce stricter non-road emissions controls, starting in 2025. We expect to see PGM demand ramp up this year ahead of the new legislation.

Because most non-road engines are diesel, platinum and palladium are the main metals used in this application, typically in a ratio of approximately 2:1. While electrification is expected to erode diesel market share in non-road machinery in the longer term, the battery-electric share of this sector remains quite small. At present, it is estimated that less than 15% of non-road equipment is electrically powered, typically in smaller power bands for applications such as materials handling (for example, forklifts). Larger machines used in agriculture, construction and mining remain predominantly diesel-powered.

"One gigawatt of wind power may consume as much as 10,000 tonnes of glass fibre"

### PGM and the energy transition

Demand from new PGM uses related to the energy transition is also growing, albeit many of these applications are still at a very early stage of commercialisation. PGM use in the synthesis of biofuels and synthetic fuels is captured in our petroleum refining category. At present, demand is mainly for platinum, which is used in the hydro-treated vegetable oil/hydro-processed ester and fatty acid (HVO/HEFA) process. Since 2021, growth in demand for platinum catalysts used to manufacture alternative fuels has partly offset lower consumption in conventional petroleum refining catalysts.

A number of electrochemical applications for platinum, ruthenium and iridium have also been galvanised by environmental and energy transition considerations. For example, an iridium anode is used in the production (by electrodeposition) of ultrathin copper foils, required for lithium-ion batteries in BEVs, while ruthenium-iridium electrodes are used to purify ballast water on ocean-going

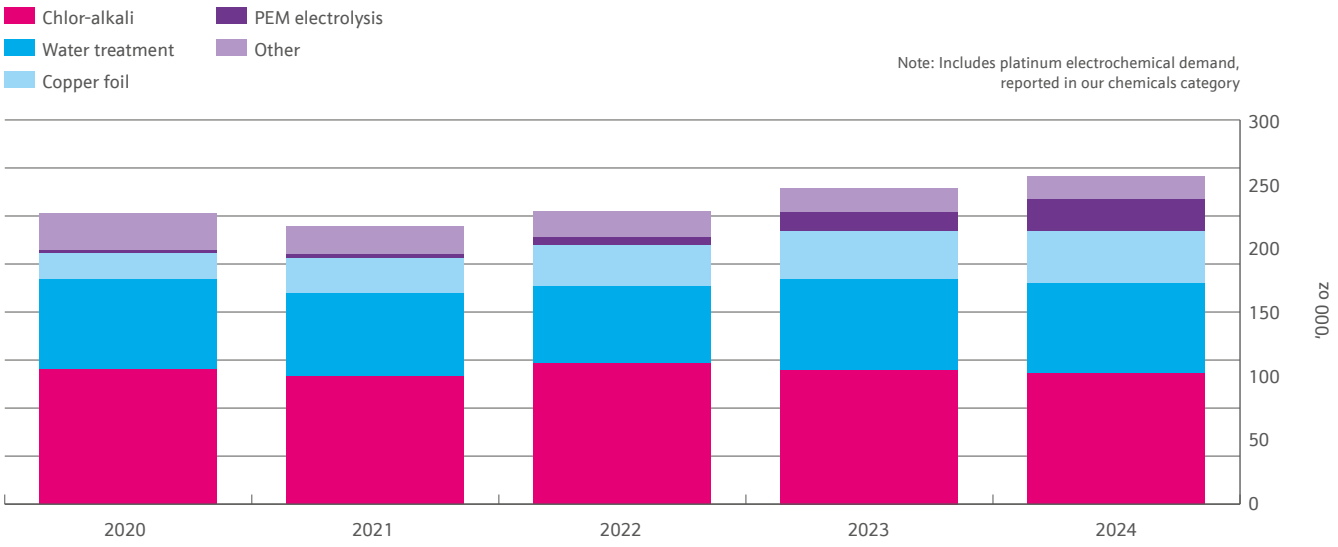


**Figure 24** Global PGM demand in electrochemical applications

| Demand '000 oz | 2022 | 2023 | 2024 |
|---|---|---|---|
| Chemical | 599 | 543 | 535 |
| Dental & biomedical | 190 | 193 | 185 |
| Electrical | 544 | 511 | 524 |
| Pollution control | 120 | 135 | 140 |
| Other | 83 | 97 | 88 |
| **Total demand** | **1,536** | **1,479** | **1,472** |

**Table 9** Global industrial demand for palladium

vessels, and platinum, iridium and ruthenium are used in PEM electrolysis for electrolytic or 'green' hydrogen production. All these applications saw gains in 2023, boosting total PGM use in electrochemical applications by 8%; we expect further steady growth this year. (Electrochemical demand for ruthenium and iridium is reported separately; for platinum, it is currently included in our chemical numbers.)

Use of platinum and iridium in electrochemical processes is currently growing faster than that of ruthenium, which is not used in copper foil production, and currently sees only very minor consumption in PEM electrolysis. Although it is an active catalyst for the electrochemical reaction in a PEM electrolysis cell, it is significantly less stable than iridium under the severe operating conditions involved. Recent technical development has focussed on improving ruthenium stability, opening the door to increased use (alongside iridium) in PEM electrolysis. Allied with conventional thrifting of iridium loadings, which is already well-advanced, the use of ruthenium could help boost the long-term sustainability of the PEM electrolysis sector. Iridium is the least abundant of the PGM, accounting for only around 3% of total South African PGM production, versus 11% for ruthenium.

Platinum use in industrial fuel cells (including non-road vehicles and stationary electricity generation) is currently mainly driven by uptake of fuel cells for power generation in Korea, under Korea's Hydrogen Strategy. Phosphoric acid fuel cell (PAFC) technology is currently the mainstay of these large stationary FC installations. This technology is a relatively intensive user of platinum, requiring an order of magnitude more platinum per kilowatt of fuel cell power than comparable proton exchange membrane fuel cells. While fuel cell grid power is being incentivised in Korea, and PAFC power plants offer high levels of reliability and durability, upfront costs for fuel cell power are still high and the sector was heavily impacted in 2023 by higher borrowing costs. We expect growth to resume in 2024, but from a much lower base.

## PGM in the electronics industry

A third major influence on PGM demand in the past five years has been the electronics industry, as the consumer electronics sector benefited from a surge in demand during the height of the Covid pandemic, followed by a downturn in 2022–2023 as economic and geopolitical headwinds buffeted the sector.

"Iridium anodes are used to produce ultrathin copper foils for lithium-ion batteries"

Palladium and ruthenium consumption in electronic components was particularly strong in 2020–2021, when Covid lockdowns spurred demand for computers, mobile phones and other connected devices, in line with a move towards home-based work and entertainment in most major economies. There was also an increase in platinum and ruthenium demand in hard disks, as cloud storage providers invested in data centre capacity. Although electrical demand has been in steady decline over the past two decades, in line with the miniaturisation of electronic components and a longstanding move away from palladium in multi-layer ceramic capacitors, total consumption of PGM in electronics made modest gains to record a four year high of 1.41 million oz in 2021.

However, since then, a downturn in consumer electronics markets has resulted in sharp decline in the manufacture of

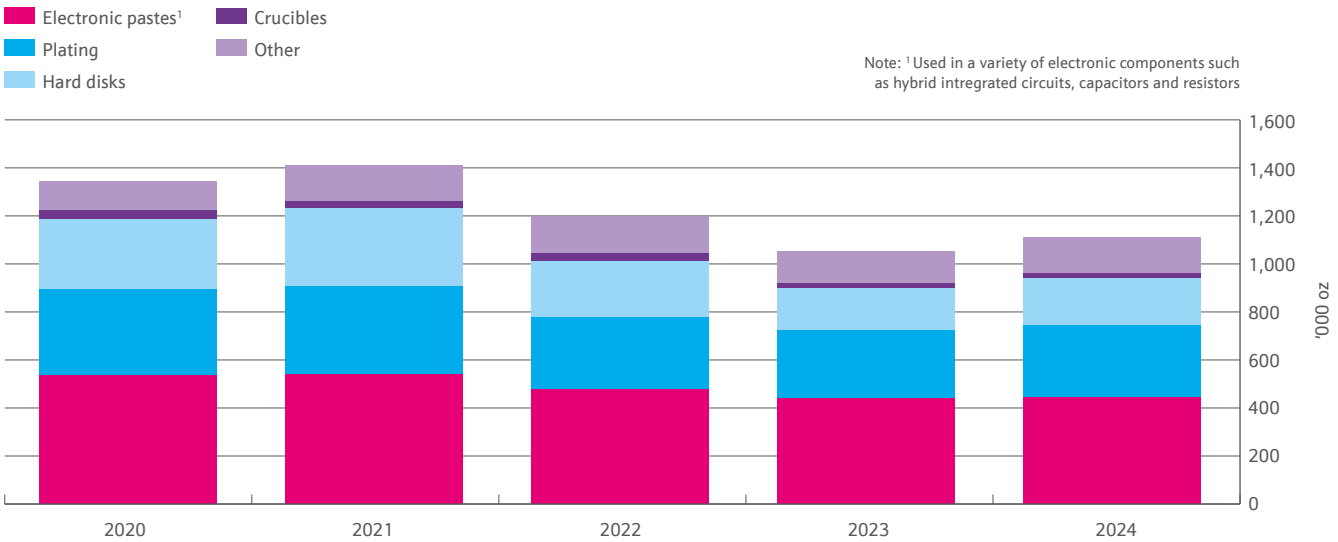


**Figure 25** Global PGM demand in electrical and electronics applications

PGM-containing components and disk drives, and this has been exacerbated by destocking of metal, components and finished products, especially in the hard disk industry. Total PGM use in electrical and electronics applications fell by a quarter between 2021 and 2023, to just over one million ounces.

Demand in hard disks is typically very responsive to peaks and troughs in the economic cycle. PGM are used in the form of solid metal alloy disks known as 'sputtering targets' for a physical vapour deposition process to coat the hard disk substrate with a thin film of metal. This process has an inherently low yield and generates significant volumes of recycling. As a result, large quantities of PGM circulate within a 'closed loop' in the hard disk industry (see page 32 of our 2023 report for an explanation of closed-loop recycling). This naturally large work-in-progress inventory amplifies the impact of any downturn in disk manufacturing, because manufacturers can temporarily meet their metal needs via recoveries from the refining of spent targets rather than new purchases. As hard disk production recovers, the opposite occurs. This contributed to a sharp downturn in platinum and ruthenium purchasing in 2023, which should be followed by an upswing this year.

Only relatively small quantities of iridium are used in the electronics industry, primarily in the form of solid iridium crucibles used to grow single crystals for applications such as surface wave filters (used in mobile telephony), and in iridium complexes for organic light emitting diodes (OLEDs). Demand was unusually depressed in 2022–2023, not only because of the general downturn in the electronics industry, but also because high iridium prices triggered some thrifting and substitution. This was particularly notable in the crystal-growing sector, with some Chinese single crystal producers replacing iridium with platinum in smaller crucible sizes. However, further substitution is not expected this year, and we expect iridium purchasing for crucibles to see a modest recovery.

"Demand in hard disks is very responsive to peaks and troughs in the economic cycle"

Trends in the electronics market also have the potential to affect PGM demand in other sectors, such as the flat panel display (FPD) industry. Despite general electronics market weakness, the last two years has seen a significant upturn in PGM purchasing by manufacturers of display glass, used in liquid crystal displays (and some other flat panel technologies) for a range of end-uses including phones, computer screens and televisions. This demand is counted in our glass numbers.

This upturn relates to an increase in flat panel display manufacturing capacity in China, stimulated by a drive for increased domestic self-sufficiency, amid expectations that an upturn in the FPD market is imminent. Much LCD glass goes into televisions and monitors, which although much less numerous than smaller devices such as mobile phones consume significantly greater quantities of glass. Panel sizes continue to grow (industry estimates suggest that the average television size is now over 50 inches), while the replacement cycle is generally becoming shorter. This year, consumer demand for televisions should be galvanised by major sporting events such as the Summer Olympic Games and the UEFA Euro 2024 football tournament, while increasing use of onboard displays in vehicles is also contributing to higher display glass requirements.

Domestic Chinese glassmakers have responded by setting up or expanding display glass capacity near downstream FPD plants, thereby increasing their market share significantly. These new LCD glass plants required large quantities of both platinum and rhodium over the 2022–2023 period; because of very stringent quality requirements for display glass, the rhodium content of alloys used in these factories has not changed significantly.

These Chinese expansions have triggered rationalisation at display glassmakers in other regions, resulting in the sale of some PGM, but to date the net impact on demand has nevertheless been highly positive. Glassmakers in other Asian countries have generally preferred to maintain their operations for geopolitical and supply-chain reasons, or have opted to repurpose their plants to produce glass for more advanced flat panel displays using OLED and QLED (quantum LED) technology.

## The future of industrial PGM demand

Beyond 2024, there are good prospects for further growth in industrial PGM demand. Platinum consumption in industrial applications has been stable at 2.8–2.9 million oz over the last four years, and there is little sign of demand waning: the outlook for the glass fibre industry is buoyant, while growth in energy transition applications (including sustainable fuels, PEM electrolysis and fuel cells) should more than offset declining use in conventional petroleum refining.

Ruthenium and iridium are also poised to benefit from greater demand in a range of electrochemical processes that are crucial to increased electrification and the hydrogen economy. In view of the supply profile of these metals, thrifting and more efficient recycling of end-of-life scrap will be required to ensure that supply can keep pace with demand. We also expect some older applications to gradually relinquish iridium and ruthenium, improving availability for newer uses. Examples are iridium use in spark plugs, set to decrease naturally as vehicle electrification progresses (and this decline could potentially be amplified by increases in spark plug recycling), and ruthenium consumption in hard disks, which could fall in the medium term if next-generation heat-assisted magnetic recording (HAMR) technology is adopted more widely. Unlike current technology, HAMR hard disks do not require ruthenium.

The outlook for palladium and rhodium is currently less positive: in recent years, high prices have deterred the development of new applications. However, waning autocatalyst demand and ample availability will create new opportunities to use these PGM in industrial processes, and PGM producers and fabricators have initiated research projects aimed at developing new uses for these metals.

# Platinum supply and demand

## Troy ounces

| Primary supply '000 oz | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| South Africa | 4,344 | 3,243 | 4,609 | 3,965 | 4,001 | 3,979 |
| Russia | 721 | 699 | 638 | 450 | 780 | 660 |
| North America | 367 | 334 | 279 | 280 | 288 | 303 |
| Zimbabwe | 451 | 482 | 465 | 488 | 515 | 530 |
| Others | 154 | 205 | 222 | 203 | 207 | 209 |
| **Total primary supply** | **6,037** | **4,963** | **6,213** | **5,386** | **5,791** | **5,681** |

| Secondary supply '000 oz[1] | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Automotive | 1,389 | 1,157 | 1,236 | 1,205 | 1,036 | 1,071 |
| Electrical & electronics | 40 | 37 | 43 | 39 | 37 | 41 |
| Jewellery | 663 | 506 | 367 | 273 | 227 | 223 |
| **Total secondary supply** | **2,092** | **1,700** | **1,646** | **1,517** | **1,300** | **1,335** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Combined primary and secondary supply** | **8,129** | **6,663** | **7,859** | **6,903** | **7,091** | **7,016** |

| Demand '000 oz[2] | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Automotive | 2,589 | 2,024 | 2,410 | 2,747 | 3,342 | 3,299 |
| Chemical | 662 | 614 | 670 | 695 | 647 | 643 |
| Dental & biomedical | 254 | 218 | 224 | 251 | 264 | 273 |
| Electrical & electronics | 216 | 227 | 263 | 247 | 195 | 221 |
| Glass | 490 | 560 | 836 | 708 | 776 | 721 |
| Investment | 1,131 | 1,022 | -28 | -565 | 46 | 120 |
| Jewellery | 2,073 | 1,657 | 1,468 | 1,391 | 1,361 | 1,343 |
| Petroleum | 262 | 285 | 223 | 240 | 174 | 180 |
| Pollution control | 190 | 181 | 214 | 234 | 275 | 279 |
| Other | 542 | 417 | 444 | 483 | 529 | 535 |
| **Total demand** | **8,409** | **7,205** | **6,724** | **6,431** | **7,609** | **7,614** |
| Movement in stocks | -280 | -542 | 1,135 | 472 | -518 | -598 |

[1]**Secondary supply** comprises 'open-loop' recycling from the automotive, jewellery and electronics sectors.

[2]**Industrial demand** is net of 'closed-loop' recycling and sales of surplus metal back to the market, for example due to plant closures. It represents new metal requirements by industrial consumers in each year.

# Platinum demand by region

## Troy ounces

| Demand '000 oz | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| Europe | Automotive | 1,193 | 858 | 739 | 794 | 1,007 | 910 |
| | Chemical | 121 | 116 | 126 | 135 | 145 | 139 |
| | Dental & biomedical | 63 | 54 | 56 | 65 | 67 | 69 |
| | Electrical & electronics | 11 | 11 | 13 | 13 | 12 | 13 |
| | Glass | 13 | 14 | 18 | 15 | 12 | 12 |
| | Investment | 566 | 308 | 126 | -284 | -93 | 60 |
| | Jewellery | 195 | 150 | 203 | 238 | 229 | 231 |
| | Petroleum | 15 | -28 | -11 | 4 | -4 | 35 |
| | Pollution control | 41 | 44 | 50 | 53 | 54 | 53 |
| | Other | 171 | 128 | 134 | 145 | 159 | 159 |
| | **Total** | **2,389** | **1,655** | **1,454** | **1,178** | **1,588** | **1,681** |

| Demand '000 oz | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| Japan | Automotive | 264 | 203 | 239 | 237 | 245 | 240 |
| | Chemical | 42 | 40 | 40 | 40 | 40 | 38 |
| | Dental & biomedical | 14 | 17 | 17 | 19 | 20 | 21 |
| | Electrical & electronics | 20 | 24 | 27 | 22 | 19 | 21 |
| | Glass | 27 | 17 | 14 | 11 | 8 | 10 |
| | Investment | 32 | 392 | -21 | -126 | 53 | 1 |
| | Jewellery | 296 | 238 | 246 | 234 | 230 | 234 |
| | Petroleum | 2 | 2 | 1 | 1 | 1 | 1 |
| | Pollution control | 62 | 55 | 62 | 64 | 65 | 63 |
| | Other | 68 | 56 | 58 | 57 | 60 | 58 |
| | **Total** | **827** | **1,044** | **683** | **559** | **741** | **687** |

| Demand '000 oz | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| North America | Automotive | 289 | 214 | 319 | 438 | 516 | 537 |
| | Chemical | 99 | 95 | 122 | 119 | 122 | 132 |
| | Dental & biomedical | 98 | 65 | 68 | 81 | 87 | 90 |

| Demand '000 oz | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| North America | Electrical & electronics | 24 | 24 | 30 | 30 | 27 | 30 |
| | Glass | 21 | 34 | 58 | 26 | 26 | 22 |
| | Investment | 156 | 602 | 115 | -69 | -12 | 46 |
| | Jewellery | 211 | 210 | 224 | 250 | 260 | 250 |
| | Petroleum | 17 | 4 | 28 | 26 | 36 | 44 |
| | Pollution control | 53 | 44 | 41 | 41 | 41 | 40 |
| | Other | 150 | 95 | 104 | 124 | 139 | 145 |
| | **Total** | **1,118** | **1,387** | **1,109** | **1,066** | **1,242** | **1,336** |

| Demand '000 oz | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| China | Automotive | 158 | 216 | 399 | 396 | 568 | 591 |
| | Chemical | 273 | 273 | 287 | 308 | 241 | 204 |
| | Dental & biomedical | 47 | 34 | 34 | 35 | 36 | 37 |
| | Electrical & electronics | 44 | 46 | 53 | 67 | 45 | 46 |
| | Glass | 343 | 435 | 677 | 562 | 660 | 590 |
| | Investment | 0 | 0 | 13 | 15 | 8 | 13 |
| | Jewellery | 1,119 | 945 | 665 | 518 | 477 | 453 |
| | Petroleum | 163 | 215 | 97 | 127 | 52 | 39 |
| | Pollution control | 17 | 20 | 31 | 44 | 81 | 83 |
| | Other | 66 | 61 | 62 | 64 | 69 | 68 |
| | **Total** | **2,230** | **2,245** | **2,318** | **2,136** | **2,237** | **2,124** |

| Demand '000 oz | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| Rest of World | Automotive | 685 | 533 | 714 | 882 | 1,006 | 1,021 |
| | Chemical | 127 | 90 | 95 | 93 | 99 | 130 |
| | Dental & biomedical | 32 | 48 | 49 | 51 | 54 | 56 |
| | Electrical & electronics | 117 | 122 | 140 | 115 | 92 | 111 |
| | Glass | 86 | 60 | 69 | 94 | 70 | 87 |
| | Investment | 377 | -280 | -261 | -101 | 90 | 0 |
| | Jewellery | 252 | 114 | 130 | 151 | 165 | 175 |
| | Petroleum | 65 | 92 | 108 | 82 | 89 | 61 |
| | Pollution control | 17 | 18 | 30 | 32 | 34 | 40 |
| | Other | 87 | 77 | 86 | 93 | 102 | 105 |
| | **Total** | **1,845** | **874** | **1,160** | **1,492** | **1,801** | **1,786** |
| | **Grand total** | **8,409** | **7,205** | **6,724** | **6,431** | **7,609** | **7,614** |

# Platinum supply and demand

## Tonnes

| Primary supply tonnes | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| South Africa | 135.1 | 100.9 | 143.4 | 123.3 | 124.4 | 123.8 |
| Russia | 22.4 | 21.7 | 19.8 | 14.0 | 24.3 | 20.5 |
| North America | 11.4 | 10.4 | 8.7 | 8.7 | 9.0 | 9.4 |
| Zimbabwe | 14.0 | 15.0 | 14.5 | 15.2 | 16.0 | 16.5 |
| Others | 4.8 | 6.4 | 6.9 | 6.3 | 6.4 | 6.5 |
| **Total primary supply** | **187.7** | **154.4** | **193.3** | **167.5** | **180.1** | **176.7** |

| Secondary supply tonnes[1] | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Automotive | 43.2 | 36.0 | 38.4 | 37.5 | 32.2 | 33.3 |
| Electrical & electronics | 1.3 | 1.1 | 1.4 | 1.2 | 1.1 | 1.3 |
| Jewellery | 20.6 | 15.7 | 11.4 | 8.5 | 7.1 | 6.9 |
| **Total secondary supply** | **65.1** | **52.8** | **51.2** | **47.2** | **40.4** | **41.5** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Combined primary and secondary supply** | **252.8** | **207.2** | **244.5** | **214.7** | **220.5** | **218.2** |

| Demand tonnes[2] | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Automotive | 80.5 | 63.0 | 74.9 | 85.4 | 104.0 | 102.7 |
| Chemical | 20.6 | 19.1 | 20.8 | 21.6 | 20.1 | 19.9 |
| Dental & biomedical | 7.9 | 6.8 | 6.9 | 7.8 | 8.2 | 8.5 |
| Electrical & electronics | 6.6 | 6.9 | 8.1 | 7.7 | 6.1 | 6.9 |
| Glass | 15.3 | 17.4 | 26.0 | 22.0 | 24.1 | 22.5 |
| Investment | 35.2 | 31.8 | -0.9 | -17.5 | 1.3 | 3.7 |
| Jewellery | 64.5 | 51.5 | 45.7 | 43.3 | 42.3 | 41.8 |
| Petroleum | 8.2 | 8.9 | 7.0 | 7.5 | 5.4 | 5.6 |
| Pollution control | 5.8 | 5.7 | 6.7 | 7.3 | 8.6 | 8.6 |
| Other | 16.9 | 13.0 | 13.8 | 15.0 | 16.5 | 16.6 |
| **Total demand** | **261.5** | **224.1** | **209.0** | **200.1** | **236.6** | **236.8** |
| Movement in stocks | -8.7 | -16.9 | 35.5 | 14.6 | -16.1 | -18.6 |

[1]**Secondary supply** comprises 'open-loop' recycling from the automotive, jewellery and electronics sectors.

[2]**Industrial demand** is net of 'closed-loop' recycling and sales of surplus metal back to the market, for example due to plant closures. It represents new metal requirements by industrial consumers in each year.

# Platinum demand by region

## Tonnes

| Demand tonnes | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| Europe | Automotive | 37.1 | 26.7 | 23.0 | 24.7 | 31.3 | 28.3 |
| | Chemical | 3.8 | 3.6 | 3.9 | 4.2 | 4.5 | 4.3 |
| | Dental & biomedical | 2.0 | 1.7 | 1.7 | 2.0 | 2.1 | 2.1 |
| | Electrical & electronics | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 0.4 |
| | Glass | 0.4 | 0.4 | 0.6 | 0.5 | 0.4 | 0.4 |
| | Investment | 17.6 | 9.6 | 3.9 | -8.8 | -2.9 | 1.9 |
| | Jewellery | 6.1 | 4.7 | 6.3 | 7.4 | 7.1 | 7.2 |
| | Petroleum | 0.5 | -0.9 | -0.3 | 0.1 | -0.1 | 1.1 |
| | Pollution control | 1.3 | 1.4 | 1.6 | 1.6 | 1.7 | 1.6 |
| | Other | 5.3 | 4.0 | 4.2 | 4.5 | 4.9 | 4.9 |
| | **Total** | **74.4** | **51.5** | **45.3** | **36.6** | **49.4** | **52.2** |

| Demand tonnes | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| Japan | Automotive | 8.2 | 6.3 | 7.4 | 7.4 | 7.6 | 7.5 |
| | Chemical | 1.3 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 |
| | Dental & biomedical | 0.4 | 0.5 | 0.5 | 0.6 | 0.6 | 0.7 |
| | Electrical & electronics | 0.6 | 0.7 | 0.8 | 0.7 | 0.6 | 0.7 |
| | Glass | 0.8 | 0.5 | 0.4 | 0.3 | 0.2 | 0.3 |
| | Investment | 1.0 | 12.2 | -0.7 | -3.9 | 1.6 | 0.0 |
| | Jewellery | 9.2 | 7.4 | 7.7 | 7.3 | 7.2 | 7.3 |
| | Petroleum | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Pollution control | 1.9 | 1.7 | 1.9 | 2.0 | 2.0 | 2.0 |
| | Other | 2.1 | 1.7 | 1.8 | 1.8 | 1.9 | 1.8 |
| | **Total** | **25.6** | **32.3** | **21.0** | **17.4** | **22.9** | **21.5** |

| Demand tonnes | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| North America | Automotive | 9.0 | 6.7 | 9.9 | 13.6 | 16.1 | 16.7 |
| | Chemical | 3.1 | 3.0 | 3.8 | 3.7 | 3.8 | 4.1 |
| | Dental & biomedical | 3.0 | 2.0 | 2.1 | 2.5 | 2.7 | 2.8 |

| Demand tonnes | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| North America | Electrical & electronics | 0.7 | 0.7 | 0.9 | 0.9 | 0.8 | 0.9 |
| | Glass | 0.7 | 1.1 | 1.8 | 0.8 | 0.8 | 0.7 |
| | Investment | 4.9 | 18.7 | 3.6 | -2.2 | -0.4 | 1.4 |
| | Jewellery | 6.6 | 6.5 | 7.0 | 7.8 | 8.1 | 7.8 |
| | Petroleum | 0.5 | 0.1 | 0.9 | 0.8 | 1.1 | 1.4 |
| | Pollution control | 1.6 | 1.4 | 1.3 | 1.3 | 1.3 | 1.2 |
| | Other | 4.7 | 3.0 | 3.2 | 3.8 | 4.3 | 4.5 |
| | **Total** | **34.8** | **43.2** | **34.5** | **33.0** | **38.6** | **41.5** |

| Demand tonnes | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| China | Automotive | 4.9 | 6.7 | 12.4 | 12.3 | 17.7 | 18.4 |
| | Chemical | 8.5 | 8.5 | 8.9 | 9.6 | 7.5 | 6.3 |
| | Dental & biomedical | 1.5 | 1.1 | 1.1 | 1.1 | 1.1 | 1.2 |
| | Electrical & electronics | 1.4 | 1.4 | 1.6 | 2.1 | 1.4 | 1.4 |
| | Glass | 10.7 | 13.5 | 21.1 | 17.5 | 20.5 | 18.4 |
| | Investment | 0.0 | 0.0 | 0.4 | 0.5 | 0.2 | 0.4 |
| | Jewellery | 34.8 | 29.4 | 20.7 | 16.1 | 14.8 | 14.1 |
| | Petroleum | 5.1 | 6.7 | 3.0 | 4.0 | 1.6 | 1.2 |
| | Pollution control | 0.5 | 0.6 | 1.0 | 1.4 | 2.5 | 2.6 |
| | Other | 2.1 | 1.9 | 1.9 | 2.0 | 2.2 | 2.1 |
| | **Total** | **69.5** | **69.8** | **72.1** | **66.6** | **69.5** | **66.1** |

| Demand tonnes | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| Rest of World | Automotive | 21.3 | 16.6 | 22.2 | 27.4 | 31.3 | 31.8 |
| | Chemical | 3.9 | 2.8 | 3.0 | 2.9 | 3.1 | 4.0 |
| | Dental & biomedical | 1.0 | 1.5 | 1.5 | 1.6 | 1.7 | 1.7 |
| | Electrical & electronics | 3.6 | 3.8 | 4.4 | 3.6 | 2.9 | 3.5 |
| | Glass | 2.7 | 1.9 | 2.1 | 2.9 | 2.2 | 2.7 |
| | Investment | 11.7 | -8.7 | -8.1 | -3.1 | 2.8 | 0.0 |
| | Jewellery | 7.8 | 3.5 | 4.0 | 4.7 | 5.1 | 5.4 |
| | Petroleum | 2.0 | 2.9 | 3.4 | 2.6 | 2.8 | 1.9 |
| | Pollution control | 0.5 | 0.6 | 0.9 | 1.0 | 1.1 | 1.2 |
| | Other | 2.7 | 2.4 | 2.7 | 2.9 | 3.2 | 3.3 |
| | **Total** | **57.2** | **27.3** | **36.1** | **46.5** | **56.2** | **55.5** |
| | **Grand total** | **261.5** | **224.1** | **209.0** | **200.1** | **236.6** | **236.8** |

# Palladium supply and demand

## Troy ounces

| Primary supply '000 oz | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| South Africa | 2,571 | 1,975 | 2,645 | 2,276 | 2,347 | 2,305 |
| Russia | 2,987 | 2,636 | 2,689 | 2,300 | 2,700 | 2,600 |
| North America | 1,042 | 990 | 908 | 832 | 863 | 901 |
| Zimbabwe | 379 | 410 | 392 | 409 | 427 | 432 |
| Others | 140 | 185 | 212 | 209 | 210 | 216 |
| **Total primary supply** | **7,119** | **6,196** | **6,846** | **6,026** | **6,547** | **6,454** |

| Secondary supply '000 oz[1] | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Automotive | 2,916 | 2,691 | 2,886 | 2,728 | 2,334 | 2,450 |
| Electrical & electronics | 477 | 428 | 443 | 455 | 463 | 460 |
| Jewellery | 12 | 8 | 9 | 10 | 10 | 9 |
| **Total secondary supply** | **3,405** | **3,127** | **3,338** | **3,193** | **2,807** | **2,919** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Combined primary and secondary supply** | **10,524** | **9,323** | **10,184** | **9,219** | **9,354** | **9,373** |

| Demand '000 oz[2] | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Automotive | 9,675 | 8,570 | 8,501 | 8,460 | 8,745 | 8,145 |
| Chemical | 530 | 498 | 593 | 599 | 543 | 535 |
| Dental & biomedical | 320 | 228 | 209 | 190 | 193 | 185 |
| Electrical & electronics | 711 | 634 | 647 | 544 | 511 | 524 |
| Investment | -87 | -190 | 17 | -109 | 61 | 29 |
| Jewellery | 128 | 85 | 88 | 88 | 86 | 85 |
| Pollution control | 88 | 87 | 117 | 120 | 135 | 140 |
| Other | 120 | 93 | 96 | 83 | 97 | 88 |
| **Total demand** | **11,485** | **10,005** | **10,268** | **9,975** | **10,371** | **9,731** |
| Movement in stocks | -961 | -682 | -84 | -756 | -1,017 | -358 |

[1]**Secondary supply** comprises 'open-loop' recycling from the automotive, jewellery and electronics sectors.

[2]**Industrial demand** is net of 'closed-loop' recycling and sales of surplus metal back to the market, for example due to plant closures. It represents new metal requirements by industrial consumers in each year.

# Palladium demand by region

## Troy ounces

| Demand '000 oz | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| Europe | Automotive | 2,095 | 1,792 | 1,869 | 1,927 | 1,997 | 1,806 |
| | Chemical | 71 | 53 | 73 | 108 | 74 | 80 |
| | Dental & biomedical | 43 | 29 | 32 | 31 | 28 | 26 |
| | Electrical & electronics | 85 | 73 | 74 | 63 | 57 | 57 |
| | Investment | -56 | -17 | -17 | -58 | 32 | 1 |
| | Jewellery | 42 | 28 | 29 | 29 | 29 | 30 |
| | Pollution control | 26 | 27 | 29 | 30 | 31 | 30 |
| | Other | 12 | 10 | 10 | 10 | 10 | 13 |
| | **Total** | **2,318** | **1,995** | **2,099** | **2,140** | **2,258** | **2,043** |

| Demand '000 oz | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| Japan | Automotive | 917 | 776 | 737 | 708 | 805 | 719 |
| | Chemical | 17 | 16 | 17 | 16 | 16 | 16 |
| | Dental & biomedical | 140 | 102 | 89 | 78 | 87 | 83 |
| | Electrical & electronics | 180 | 162 | 158 | 128 | 122 | 126 |
| | Investment | 1 | 3 | 2 | 1 | 7 | 3 |
| | Jewellery | 45 | 31 | 32 | 31 | 29 | 27 |
| | Pollution control | 14 | 13 | 14 | 14 | 14 | 14 |
| | Other | 6 | 4 | 6 | 6 | 6 | 6 |
| | **Total** | **1,320** | **1,107** | **1,055** | **982** | **1,086** | **994** |

| Demand '000 oz | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| North America | Automotive | 2,058 | 1,701 | 1,724 | 1,827 | 1,894 | 1,916 |
| | Chemical | 84 | 35 | 76 | 70 | 70 | 76 |
| | Dental & biomedical | 112 | 77 | 70 | 65 | 63 | 61 |
| | Electrical & electronics | 103 | 91 | 93 | 79 | 74 | 74 |
| | Investment | -5 | -35 | 34 | -25 | 23 | 21 |
| | Jewellery | 21 | 13 | 13 | 14 | 14 | 14 |
| | Pollution control | 13 | 10 | 14 | 14 | 14 | 14 |
| | Other | 37 | 27 | 30 | 29 | 29 | 29 |
| | **Total** | **2,423** | **1,919** | **2,054** | **2,073** | **2,181** | **2,205** |

| Demand '000 oz | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| China | Automotive | 2,700 | 2,631 | 2,246 | 1,853 | 1,777 | 1,450 |
| | Chemical | 252 | 289 | 320 | 295 | 271 | 248 |
| | Dental & biomedical | 6 | 6 | 5 | 5 | 5 | 5 |
| | Electrical & electronics | 131 | 118 | 123 | 103 | 96 | 99 |
| | Investment | 0 | 0 | 0 | 0 | 0 | 0 |
| | Jewellery | 1 | 0 | 0 | 0 | 0 | 0 |
| | Pollution control | 31 | 33 | 49 | 50 | 63 | 66 |
| | Other | 43 | 38 | 34 | 24 | 27 | 22 |
| | **Total** | **3,164** | **3,115** | **2,777** | **2,330** | **2,239** | **1,890** |

| Demand '000 oz | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| Rest of World | Automotive | 1,905 | 1,670 | 1,925 | 2,145 | 2,272 | 2,254 |
| | Chemical | 106 | 105 | 107 | 110 | 112 | 115 |
| | Dental & biomedical | 19 | 14 | 13 | 11 | 10 | 10 |
| | Electrical & electronics | 212 | 190 | 199 | 171 | 162 | 168 |
| | Investment | -27 | -141 | -2 | -27 | -1 | 4 |
| | Jewellery | 19 | 13 | 14 | 14 | 14 | 14 |
| | Pollution control | 4 | 4 | 11 | 12 | 13 | 16 |
| | Other | 22 | 14 | 16 | 14 | 25 | 18 |
| | **Total** | **2,260** | **1,869** | **2,283** | **2,450** | **2,607** | **2,599** |
| | **Grand total** | **11,485** | **10,005** | **10,268** | **9,975** | **10,371** | **9,731** |

# Palladium supply and demand

## Tonnes

| Primary supply tonnes | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| South Africa | 80.0 | 61.4 | 82.3 | 70.8 | 73.0 | 71.7 |
| Russia | 92.9 | 82.0 | 83.6 | 71.5 | 84.0 | 80.9 |
| North America | 32.4 | 30.8 | 28.2 | 25.9 | 26.8 | 28.0 |
| Zimbabwe | 11.8 | 12.8 | 12.2 | 12.7 | 13.3 | 13.4 |
| Others | 4.3 | 5.7 | 6.6 | 6.5 | 6.5 | 6.7 |
| **Total primary supply** | **221.4** | **192.7** | **212.9** | **187.4** | **203.6** | **200.7** |

| Secondary supply tonnes[1] | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Automotive | 90.7 | 83.7 | 89.7 | 84.9 | 72.6 | 76.2 |
| Electrical & electronics | 14.9 | 13.3 | 13.8 | 14.1 | 14.4 | 14.4 |
| Jewellery | 0.3 | 0.2 | 0.3 | 0.3 | 0.3 | 0.3 |
| **Total secondary supply** | **105.9** | **97.2** | **103.8** | **99.3** | **87.3** | **90.9** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Combined primary and secondary supply** | **327.3** | **289.9** | **316.7** | **286.7** | **290.9** | **291.6** |

| Demand tonnes[2] | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Automotive | 301.0 | 266.6 | 264.4 | 263.1 | 272.0 | 253.4 |
| Chemical | 16.4 | 15.5 | 18.5 | 18.7 | 16.9 | 16.7 |
| Dental & biomedical | 9.9 | 7.1 | 6.6 | 5.9 | 6.1 | 5.8 |
| Electrical & electronics | 22.1 | 19.7 | 20.1 | 17.0 | 15.9 | 16.3 |
| Investment | -2.7 | -5.9 | 0.6 | -3.4 | 1.9 | 0.9 |
| Jewellery | 4.0 | 2.7 | 2.7 | 2.7 | 2.6 | 2.5 |
| Pollution control | 2.7 | 2.6 | 3.5 | 3.7 | 4.2 | 4.3 |
| Other | 3.8 | 2.8 | 3.0 | 2.5 | 3.0 | 2.8 |
| **Total demand** | **357.2** | **311.1** | **319.4** | **310.2** | **322.6** | **302.7** |
| Movement in stocks | -29.9 | -21.2 | -2.7 | -23.5 | -31.7 | -11.1 |

[1]**Secondary supply** comprises 'open-loop' recycling from the automotive, jewellery and electronics sectors.

[2]**Industrial demand** is net of 'closed-loop' recycling and sales of surplus metal back to the market, for example due to plant closures. It represents new metal requirements by industrial consumers in each year.

# Palladium demand by region

## Tonnes

| Demand tonnes | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| Europe | Automotive | 65.2 | 55.8 | 58.1 | 60.0 | 62.1 | 56.2 |
| | Chemical | 2.2 | 1.6 | 2.3 | 3.4 | 2.3 | 2.5 |
| | Dental & biomedical | 1.3 | 0.9 | 1.0 | 1.0 | 0.9 | 0.8 |
| | Electrical & electronics | 2.6 | 2.3 | 2.3 | 2.0 | 1.8 | 1.8 |
| | Investment | -1.7 | -0.5 | -0.5 | -1.8 | 1.0 | 0.0 |
| | Jewellery | 1.3 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| | Pollution control | 0.8 | 0.8 | 0.9 | 0.9 | 1.0 | 0.9 |
| | Other | 0.4 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 |
| | **Total** | **72.1** | **62.1** | **65.3** | **66.7** | **70.3** | **63.5** |

| Demand tonnes | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| Japan | Automotive | 28.5 | 24.1 | 22.9 | 22.0 | 25.0 | 22.4 |
| | Chemical | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| | Dental & biomedical | 4.3 | 3.2 | 2.8 | 2.4 | 2.7 | 2.6 |
| | Electrical & electronics | 5.6 | 5.0 | 4.9 | 4.0 | 3.8 | 3.9 |
| | Investment | 0.0 | 0.1 | 0.1 | 0.0 | 0.2 | 0.1 |
| | Jewellery | 1.4 | 1.0 | 1.0 | 1.0 | 0.9 | 0.8 |
| | Pollution control | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| | Other | 0.2 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 |
| | **Total** | **40.9** | **34.4** | **32.8** | **30.5** | **33.7** | **30.9** |

| Demand tonnes | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| North America | Automotive | 64.0 | 52.9 | 53.6 | 56.8 | 58.9 | 59.6 |
| | Chemical | 2.6 | 1.1 | 2.4 | 2.2 | 2.2 | 2.4 |
| | Dental & biomedical | 3.5 | 2.4 | 2.2 | 2.0 | 2.0 | 1.9 |
| | Electrical & electronics | 3.2 | 2.8 | 2.9 | 2.5 | 2.3 | 2.3 |
| | Investment | -0.2 | -1.1 | 1.1 | -0.8 | 0.7 | 0.7 |
| | Jewellery | 0.7 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| | Pollution control | 0.4 | 0.3 | 0.4 | 0.4 | 0.4 | 0.4 |
| | Other | 1.2 | 0.8 | 0.9 | 0.9 | 0.9 | 0.9 |
| | **Total** | **75.4** | **59.6** | **63.9** | **64.4** | **67.8** | **68.6** |

| Demand tonnes | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| China | Automotive | 84.0 | 81.8 | 69.9 | 57.6 | 55.3 | 45.1 |
| | Chemical | 7.8 | 9.0 | 10.0 | 9.2 | 8.4 | 7.7 |
| | Dental & biomedical | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| | Electrical & electronics | 4.1 | 3.7 | 3.8 | 3.2 | 3.0 | 3.1 |
| | Investment | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Jewellery | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Pollution control | 1.0 | 1.0 | 1.5 | 1.6 | 2.0 | 2.1 |
| | Other | 1.3 | 1.2 | 1.1 | 0.7 | 0.8 | 0.7 |
| | **Total** | **98.4** | **96.9** | **86.5** | **72.5** | **69.7** | **58.9** |

| Demand tonnes | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| Rest of World | Automotive | 59.3 | 52.0 | 59.9 | 66.7 | 70.7 | 70.1 |
| | Chemical | 3.3 | 3.3 | 3.3 | 3.4 | 3.5 | 3.6 |
| | Dental & biomedical | 0.6 | 0.4 | 0.4 | 0.3 | 0.3 | 0.3 |
| | Electrical & electronics | 6.6 | 5.9 | 6.2 | 5.3 | 5.0 | 5.2 |
| | Investment | -0.8 | -4.4 | -0.1 | -0.8 | 0.0 | 0.1 |
| | Jewellery | 0.6 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| | Pollution control | 0.1 | 0.1 | 0.3 | 0.4 | 0.4 | 0.5 |
| | Other | 0.7 | 0.4 | 0.5 | 0.4 | 0.8 | 0.6 |
| | **Total** | **70.4** | **58.1** | **70.9** | **76.1** | **81.1** | **80.8** |
| | **Grand total** | **357.2** | **311.1** | **319.4** | **310.2** | **322.6** | **302.7** |

# Rhodium supply and demand

## Troy ounces

| Primary supply '000 oz | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| South Africa | 606 | 483 | 645 | 570 | 559 | 574 |
| Russia | 68 | 58 | 53 | 54 | 70 | 59 |
| North America | 24 | 22 | 17 | 20 | 20 | 21 |
| Zimbabwe | 40 | 43 | 42 | 43 | 46 | 44 |
| Others | 7 | 6 | 6 | 6 | 6 | 6 |
| **Total primary supply** | **745** | **612** | **763** | **693** | **701** | **704** |

| Secondary supply '000 oz[1] | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Automotive | 356 | 338 | 361 | 334 | 285 | 295 |
| **Total secondary supply** | **356** | **338** | **361** | **334** | **285** | **295** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Combined primary and secondary supply** | **1,101** | **950** | **1,124** | **1,027** | **986** | **999** |

| Demand '000 oz[2] | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Automotive | 1,031 | 961 | 956 | 946 | 989 | 931 |
| Chemical | 56 | 55 | 57 | 67 | 81 | 92 |
| Electrical & electronics | 6 | 7 | 7 | 5 | 6 | 6 |
| Glass | 52 | 10 | -7 | -24 | 18 | 18 |
| Other | 22 | 6 | 12 | 16 | 17 | 17 |
| **Total demand** | **1,167** | **1,039** | **1,025** | **1,010** | **1,111** | **1,064** |
| Movement in stocks | -66 | -89 | 99 | 17 | -125 | -65 |

[1]**Secondary supply** comprises 'open-loop' recycling from the automotive, jewellery and electronics sectors.

[2]**Industrial demand** is net of 'closed-loop' recycling and sales of surplus metal back to the market, for example due to plant closures. It represents new metal requirements by industrial consumers in each year.

# Rhodium supply and demand

## Tonnes

| Primary supply tonnes | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| South Africa | 18.9 | 15.0 | 20.1 | 17.7 | 17.4 | 17.9 |
| Russia | 2.1 | 1.8 | 1.7 | 1.7 | 2.2 | 1.8 |
| North America | 0.8 | 0.7 | 0.5 | 0.6 | 0.6 | 0.6 |
| Zimbabwe | 1.2 | 1.3 | 1.3 | 1.3 | 1.4 | 1.4 |
| Others | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| **Total primary supply** | **23.2** | **19.0** | **23.8** | **21.5** | **21.8** | **21.9** |

| Secondary supply tonnes[1] | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Automotive | 11.1 | 10.5 | 11.2 | 10.4 | 8.9 | 9.2 |
| **Total secondary supply** | **11.1** | **10.5** | **11.2** | **10.4** | **8.9** | **9.2** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Combined primary and secondary supply** | **34.3** | **29.5** | **35.0** | **31.9** | **30.7** | **31.1** |

| Demand tonnes[2] | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Automotive | 32.1 | 29.9 | 29.6 | 29.5 | 30.8 | 28.9 |
| Chemical | 1.7 | 1.7 | 1.8 | 2.0 | 2.5 | 2.8 |
| Electrical & electronics | 0.2 | 0.2 | 0.2 | 0.1 | 0.2 | 0.2 |
| Glass | 1.7 | 0.3 | -0.1 | -0.8 | 0.6 | 0.6 |
| Other | 0.6 | 0.2 | 0.5 | 0.6 | 0.6 | 0.6 |
| **Total demand** | **36.3** | **32.3** | **32.0** | **31.4** | **34.7** | **33.1** |
| Movement in stocks | -2.0 | -2.8 | 3.0 | 0.5 | -4.0 | -2.0 |

[1]**Secondary supply** comprises 'open-loop' recycling from the automotive, jewellery and electronics sectors.

[2]**Industrial demand** is net of 'closed-loop' recycling and sales of surplus metal back to the market, for example due to plant closures. It represents new metal requirements by industrial consumers in each year.

# Ruthenium supply and demand

## Troy ounces

| Primary supply '000 oz | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| **Total primary supply** | **885** | **930** | **1,421** | **968** | **921** | **1,028** |

| Demand '000 oz | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Chemical | 409 | 395 | 343 | 393 | 427 | 508 |
| Electrical & electronics | 416 | 419 | 441 | 369 | 309 | 323 |
| Electrochemical | 144 | 138 | 129 | 131 | 133 | 132 |
| Other | 137 | 103 | 114 | 134 | 139 | 142 |
| **Total demand** | **1,106** | **1,055** | **1,027** | **1,027** | **1,008** | **1,105** |
| Movement in stocks | -221 | -125 | 394 | -59 | -87 | -77 |

# Ruthenium supply and demand

## Tonnes

| Primary supply tonnes | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| **Total primary supply** | **27.5** | **28.9** | **44.2** | **30.1** | **28.7** | **32.0** |

| Demand tonnes[1] | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Chemical | 12.7 | 12.3 | 10.7 | 12.2 | 13.3 | 15.8 |
| Electrical & electronics | 12.9 | 13.0 | 13.7 | 11.5 | 9.6 | 10.0 |
| Electrochemical | 4.5 | 4.3 | 4.0 | 4.1 | 4.1 | 4.1 |
| Other | 4.3 | 3.2 | 3.5 | 4.2 | 4.3 | 4.4 |
| **Total demand** | **34.4** | **32.8** | **31.9** | **32.0** | **31.3** | **34.3** |
| Movement in stocks | -6.9 | -3.9 | 12.3 | -1.9 | -2.6 | -2.3 |

[1]**Industrial demand** is net of 'closed-loop' recycling and sales of surplus metal back to the market, for example due to plant closures. It represents new metal requirements by industrial consumers in each year.

# Iridium supply and demand

## Troy ounces

| Primary supply '000 oz | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| **Total primary supply** | **235** | **236** | **232** | **222** | **225** | **248** |

| Demand '000 oz | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Chemical | 18 | 24 | 30 | 25 | 27 | 32 |
| Electrical & electronics | 48 | 59 | 52 | 35 | 33 | 38 |
| Electrochemical | 81 | 83 | 83 | 92 | 104 | 108 |
| Other | 92 | 65 | 65 | 60 | 60 | 59 |
| **Total demand** | **239** | **231** | **230** | **212** | **224** | **237** |
| Movement in stocks | -4 | 5 | 2 | 10 | 1 | 11 |

[1]**Industrial demand** is net of 'closed-loop' recycling and sales of surplus metal back to the market, for example due to plant closures. It represents new metal requirements by industrial consumers in each year.

# Iridium supply and demand

## Tonnes

| Primary supply tonnes | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| **Total primary supply** | **7.3** | **7.3** | **7.2** | **6.9** | **7.0** | **7.7** |

| Demand tonnes[1] | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Chemical | 0.6 | 0.7 | 0.9 | 0.8 | 0.9 | 1.0 |
| Electrical & electronics | 1.5 | 1.8 | 1.6 | 1.1 | 1.0 | 1.2 |
| Electrochemical | 2.5 | 2.6 | 2.6 | 2.8 | 3.2 | 3.4 |
| Other | 2.8 | 2.0 | 2.0 | 1.9 | 1.9 | 1.8 |
| **Total demand** | **7.4** | **7.1** | **7.1** | **6.6** | **7.0** | **7.4** |
| Movement in stocks | -0.1 | 0.2 | 0.1 | 0.3 | 0.0 | 0.3 |

[1]**Industrial demand** is net of 'closed-loop' recycling and sales of surplus metal back to the market, for example due to plant closures. It represents new metal requirements by industrial consumers in each year.

# Glossary

| | |
|---|---|
| **BEV** | Battery electric vehicle |
| **CARB** | California Air Resources Board |
| **CCM** | Catalyst coated membrane |
| **CF** | Conformity factor |
| **CNG** | Compressed natural gas |
| **CO** | Carbon monoxide |
| **$CO_2$** | Carbon dioxide |
| **DOC** | Diesel oxidation catalyst |
| **DPF** | Diesel particulate filter |
| **EC** | European Commission |
| **ELV** | End-of-life vehicle |
| **EP** | European Parliament |
| **EPA** | Environmental Protection Agency |
| **EREV** | Extended range electric vehicle |
| **ETF** | Exchange traded fund |
| **EUCO** | European Council |
| **FCEV** | Fuel cell electric vehicle |
| **FPD** | Flat panel display |
| **GPF** | Gasoline particulate filter |
| **GVW** | Gross vehicle weight |
| **HAMR** | Heat assisted magnetic recording |
| **HDD** | Heavy duty diesel |
| **HVO/HEFA** | Hydro-treated vegetable oil/ hydro-processed ester and fatty acid |
| **ICE** | Internal combustion engine |
| **IRA** | Inflation Reduction Act |
| **LCD** | Liquid crystal display |
| **LDG** | Light duty gasoline |
| **LDD** | Light duty diesel |
| **LED** | Light emitting diode |
| **LEV** | Low emission vehicle |
| **LPPM** | London Platinum and Palladium Market |
| **LV** | Light vehicle |
| **NEV** | New energy vehicle (BEV, PHEV or FCEV) |
| **$NO_x$** | Oxides of nitrogen |
| **NYMEX** | New York Mercantile Exchange |
| **OLED** | Organic light emitting diode |
| **PAFC** | Phosphoric acid fuel |
| **PEM** | Proton exchange membrane |
| **PGM** | Platinum group metals |
| **PHEV** | Plug-in hybrid electric vehicle |
| **PM** | Particulate matter or soot |
| **PN** | Particle number |
| **PTA** | Purified terephthalic acid |
| **PV** | Photovoltaic |
| **PX** | Paraxylene |
| **QLED** | Quantum LED |
| **RDE** | Real driving emissions |
| **RoW** | Rest of World region |
| **SAW filter** | Surface acoustic wave filter |
| **SCR** | Selective catalytic reduction |
| **SGE** | Shanghai Gold Exchange |
| **UF** | Utility factor |
| **ZEV** | Zero emission vehicle |
| **4E grade** | Combined content of four elements: platinum, palladium, rhodium and gold |
| **6E grade** | Combined content of six elements: platinum, palladium, rhodium, gold, ruthenium and iridium |