10 December 2024

Quintessentially PGMs

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KEY TAKEAWAYS

Since our latest issue, palladium, platinum, and rhodium prices have kept on following a side-way trend. Seemingly, this is a stalemate situation as the PGM basket price found its fundamental support as half of the South African PGM mines are unprofitable at the current PGM basket price. There have been no mine closure announcements in the region so far: currently, everyone but Sibanye has sufficient financial reserves and can cross-subsidise. At the same time, the price increase will incentivise the recycling of hoarded spent autocatalyst scrap, which, in turn, will put pressure on quotes.

Lower automotive production and PGM thrifting programmes have recently hit the demand and are seen as a delayed reaction to the 2020-2022 palladium and rhodium price rises. Given the ongoing growth of the BEVs' market share, the downward demand trend is expected to persist in the near future. So far, only secondary production has reacted to the fall in PGM prices, as mine supply cuts from North American operations seem insufficient to have a meaningful impact on PGM quotes. However, risks of further primary supply cuts will persist in 2025 as South African producers focus on cost optimisation.

Due to the high by-product content, PGM mine supply in Russia is extremely price-inelastic and is expected to grow further despite the current downfall of the market and geopolitical tensions. Meanwhile, despite several years of PGM recycling underperformance, it is just a matter of time before spent autocatalysts reach the smelters. Hence, the South African mining sector seems to be the only balancing tool for the PGM market in crisis, and some industry experts are already talking about a possible 10% PGM output decline in South Africa in 2025.

Palladium. We expect the palladium market to be balanced in the short term, with some risks of a sizeable surplus appearing only by the end of the decade. Palladium demand is expected to fall by 6% YoY in 2024. ICE-equipped light vehicles market is expected to shrink slightly by 3% YoY to 77.5 million units. Even though the slowing BEV market penetration favours hybrids and benefits palladium demand, aggressive thrifting by the OEMs in China, Japan and the US, offset this effect. If the BEV penetration slowdown continues, an upward revision of global palladium demand should follow, which might reverse the investors' negative sentiment. Prerequisites for this are mainly observed in the US and European markets, as the new oil-lobby-backed Republican administration puts the US long-term transport electrification plans at risk while the newly introduced European import tariffs on Chinese EVs are going to deprive European customers of cheap EV options, making ICE-equipped models even more price attractive.

As for the palladium output, mine supply has only started to react to the recent destocking-driven palladium price fall with upcoming meaningful production cuts in North America. Having said that, these are more likely to come from South Africa, especially from financially troubled Sibanye-Stillwater. Moreover, recycling remains subdued amid high interest rates and depressed PGM prices.

Speculative pressure and destocking by OEMs and fabricators have not so far locked palladium price below $1,000/oz. Given that, upside risks currently prevail on the palladium market, as the metal's price might have found strong support at this level in the medium term. However, the lack of price reaction to the recent short covering shows that the palladium market remains well-supplied.

The recent monetary policy easing cycle in the developed Western economies is likely to have a net positive effect on palladium price, as the newly bought vehicles have higher PGM loadings than those that are to be sent to scrapyards.

Palladium, YoY change	2024E	2025E
Demand ex. investment	-0.5 Moz -6%	+0.01 Moz flat
Supply ex. stocks sales	-0.1 Moz -1%	+0.02 Moz flat

Platinum. Platinum demand is also on a downward trend. Metal use in the automotive industry suffers from the diesel market shrinkage and reverse substitution with palladium as some OEMs have already substituted platinum in favour of palladium completely, while platinum jewellery demand is also falling, especially so in China because of the long-stagnant price. However, this is partially offset by the 0.1 Moz increase in platinum demand in other industrial applications. Moreover, the hydrogen economy kick-off seems to be postponed yet again due to cost challenges, which was also reflected in FCEV sales 17% YoY fall in 9M 2024.

On the other hand, South African PGM mine production is also expected to follow a downward trend amid mines' shrinking margins, which will counterweight the falling demand.

In the longer run, stable palladium-platinum price parity is expected to be sustained as a mutual substitution in autocatalysts will narrow price differences between the two metals, however, the PGM basket price will depend on the scale of production optimisation efforts in South Africa.

Platinum, YoY change	2024E	2025E
Demand ex. investment	-0.2 Moz -3%	-0.05 Moz -0.5%
Supply ex. stocks sales	-0.0 Moz -0%	-0.1 Moz -2%

Rhodium will also benefit from the falling South African mine production and slowing BEV market penetration. Although it will be partially offset by PGM thrifting in the automotive industry as well as rhodium substitution with platinum in glass production. The market is expected to sustain a very modest deficit in the medium term, which will be covered by the excessive stocks accumulated by consumers and traders in 2023-2024.

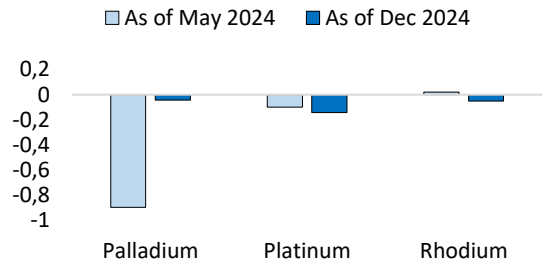
MARKET BALANCE

We have revised our earlier 2024 **palladium** market deficit estimate (excluding investments) from 0.9 Moz to a nearly balanced state due to a stronger output from the Russian operations and the major revision of automotive demand related to the PGM thrifting programmes in China, Japan and the US. Meanwhile, we maintain our view on the balanced state of the **platinum** market. As for **rhodium**, we still expect a marginal deficit of 50 koz to persist. It will be covered by the automakers' and glass makers' stocks.

In 2025, we expect the **palladium** market to remain balanced as lower PGM mine production in North America and South Africa will be offset by the rebouncing autocatalyst recycling. The total demand is expected to stagnate on a YoY basis if no acceleration happens in response to interest rate cuts in the Western world and economy support stimuli in China.

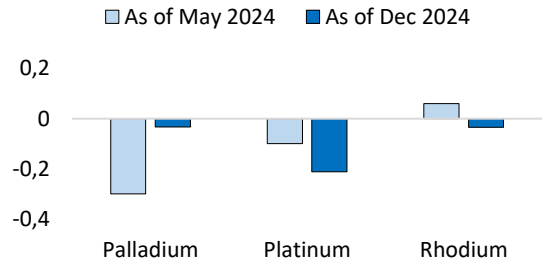
The **platinum** market is expected to remain nearly balanced with a small deficit appearing at 0.2 Moz, predominantly due to lower refined production in South Africa. The **rhodium** market is expected to be balanced.

2024 market balance forecast, Moz



Source: NN Analysis

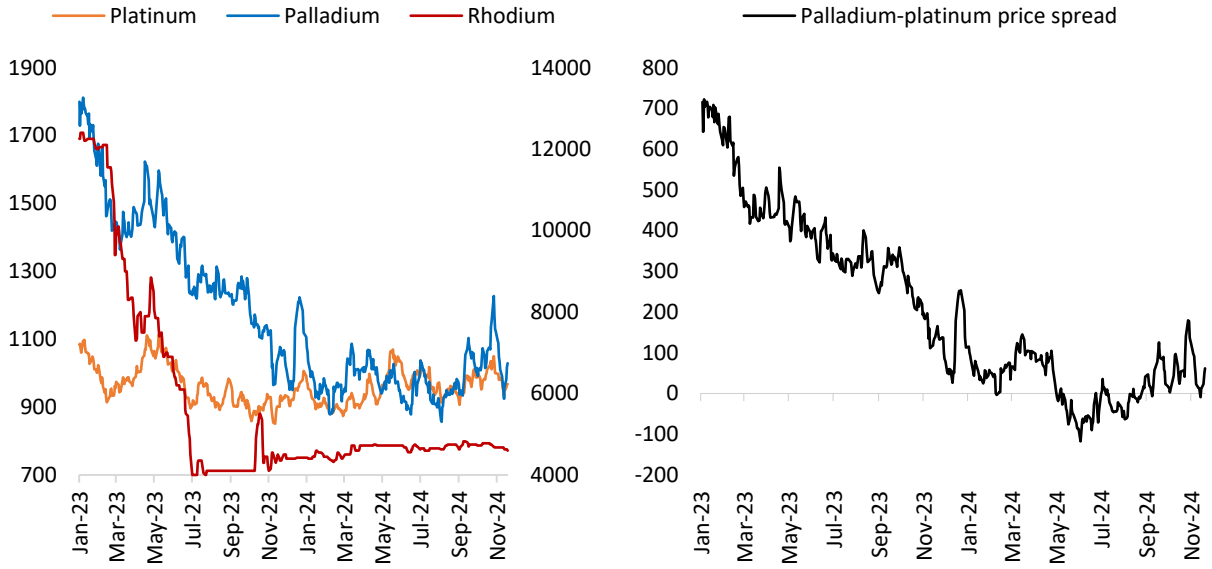
2025 market balance forecast, Moz



Source: NN Analysis

MARKET SENTIMENT

PGM prices in 2023-2024 YTD, USD/oz



Source: LPPM, Johnson Matthey

Palladium price has bottomed out at around $1,000/oz level having experienced unprecedented speculative pressure and mass destocking by automakers and fabricators. As we see the signs of a more balanced market and the end of the stock release, we expect palladium price to follow a side-way trend for the time being. Mine supply cuts and slower BEV market penetration may prop the palladium price but the immediate reaction of the recyclers who are likely to release autocatalyst scrap may push the price back.

At the end of May, palladium reached the $900/oz support level for the first time since mid-February. This was accompanied by extremely low trade volume, which signalled a risk-off sentiment among traders who paused metals buying in anticipation of the largest economies' May PMI data. As the price reached a long-term support level, RSI came closer to the oversold zone, which propped palladium quotes.

The price remained depressed and was fluctuating around $900/oz level in the following weeks. However, on 24 June, palladium gained 4%, closed above the $950/oz resistance level and continued rising until 8

July. The latter price rise was driven by the increase of palladium leasing rate by up to 4% caused by the lack of spot metal availability coupled with an upcoming NYMEX futures rolling, which made palladium leasing more expensive. This also caused palladium ETF outflow as the bullions were used to boost the liquidity with total holding falling by 60 koz from 20 June till 5 July and drove palladium price up to the $1,050/oz long-term resistance level.

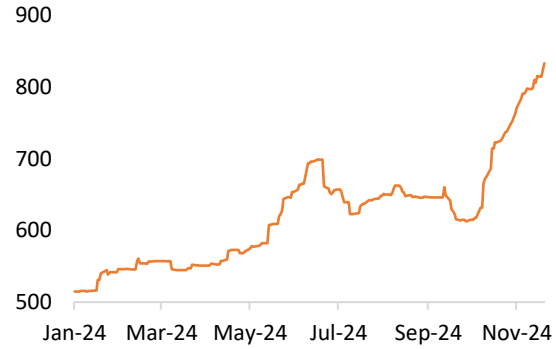
Later in July, palladium price retreated to $900/oz as the metal net import by China appeared to be particularly weak recording 101 koz only, the lowest monthly result since August 2023. By the end of the month, palladium broke the $900/oz support level, but the precious metals price rally on 31 July held palladium in the earlier established price range.

However, on 5 August, palladium fell by 5% and reached $820/oz, the long-term strong support level. The latter fall was commodity-wide and was caused by some negative macro data from the US. Falling PMI, rising unemployment and lowering non-farm payrolls sowed panic in the commodity and money markets, which was reflected in the VIX rising above 65 points. Once again, palladium price fell to the long-term support coinciding with the RSI moving closer to the oversold zone (33 points on 5 August), which reversed the price trend. This was the beginning of the palladium bullish trend.

As the US recession fear faded away and VIX cooled off, palladium price returned to the level above $900/oz. From 9 September onwards, palladium price gained 16% in 7 trading days. This was caused by several external supply shocks. Firstly, on 11 September, Russian President Vladimir Putin raised an issue of possible uranium, titanium and nickel export restrictions, which increased the fear of palladium being drawn into the discussion too. The next day, Sibanye announced the cost-driven PGM production halving at their Stillwater mine in 2025, which led palladium to close above EMA 200 for the first time since October 2022. This, in turn, provoked a US senator from Montana to introduce a bill to ban Russian palladium import. These events drove palladium price up to the $1,125/oz long-term resistance level on 17 September and set the Pd-Pt premium at the local maximum of $125/oz, the highest since March, while speculative net short positions also shrunk by 0.4 Moz to 0.7 Moz, the lowest since June 2023 and RSI moved into the overbought zone.

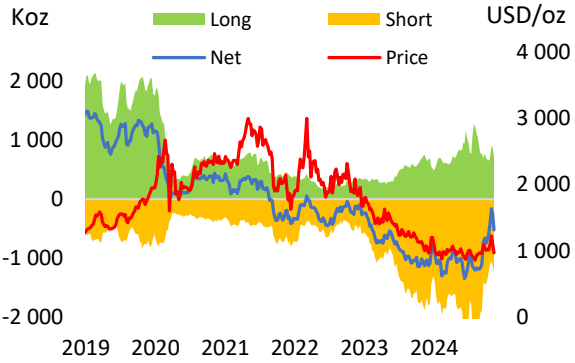
During the next 4 weeks, palladium price stabilised in the $1,000-1,100/oz price range. However, on 24 October palladium price gained 6% as the US officials asked G7 members to consider an import ban on Russian palladium and titanium. This led to a sharp palladium price growth accompanied by short coverings. By the end of October, palladium speculative net short positions shrunk down to 164 koz, the lowest since December 2022. However, as palladium price reached the $1,225/oz long-term resistance level and RSI once again entered the oversold zone, palladium price experienced a correction to below the $1,000/oz level.

Palladium ETF holdings, koz



Source: NN analysis

Palladium: net speculative positions



Source: CFTC

Platinum keeps following the 3-year sideway trend. Market outlook remains neutral: decreasing mine supply and stronger industrial & glass use were offset by falling automotive and jewellery sectors' demand. Meanwhile, shrinking margins of South African PGM mines and the possibility of price substitution for palladium put a cap on both upside and downside price movements. Central Banks' buying-driven gold rally dragged along silver but had no effect on platinum quotes. What was more than 0.9 Au-Pt 2-year correlation in early 2016 became only 0.1 in November 2024 as the long-term side-way trend of platinum failed to catch up with the rising gold price. For some investors, it is a sign of platinum's undervaluation. However, this might also signal a structural shift in precious metals pricing.

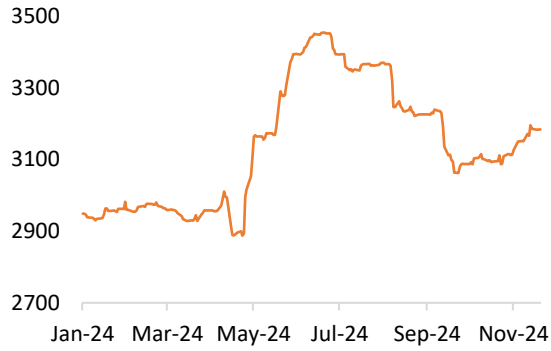
The early May platinum price rally, caused by the anticipation of mine supply cuts in the South African PGM mining industry, drove the metal's price to a nearly 12-month high. However, as the price got closer to the $1,100/oz resistance level and RSI reached the overbought zone by mid-May, it experienced a correction down to the $950/oz, which started the 4-month-long downward trend.

As the South African pro-business coalition was formed in the middle of June, the South African rand began to strengthen. It supported the platinum price temporarily, leading it to the $1,050/oz resistance level. However, the price soon resumed its downward trend, retreating to $950/oz by the end of July, which was accompanied by the net long speculative positions' shrinkage.

Similarly to palladium, macro-driven US recession fears dipped platinum to the $950/oz long-term support level at the beginning of August. Even though the September 50bp rate cut by the Fed did not have a meaningful impact on platinum price, some further South African rand strengthening to below USD/ZAR 18 dragged platinum out of a downward trend as the price gained a firm foothold above EMA 200. After reaching a long-term resistance level of $1,050/oz in late October, platinum fell below $950/oz by the end of November, following the precious metals-wide correction amid DXY strengthening.

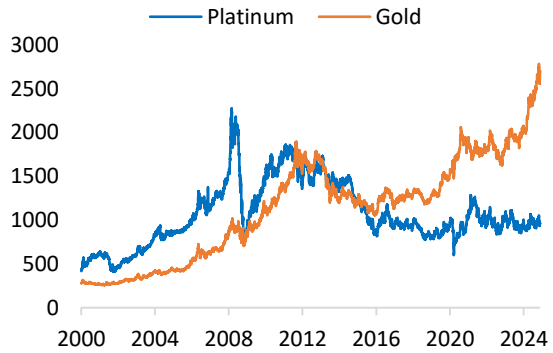
On 21 October, the Moscow Exchange launched palladium and platinum spot trading. Market participants can buy up from 1g of platinum or palladium for roubles on the terms of settlement tomorrow and today, and these metals will be delivered to the unallocated accounts. This initiative may increase investment demand for palladium and platinum in Russia.

Platinum ETF holdings, Moz



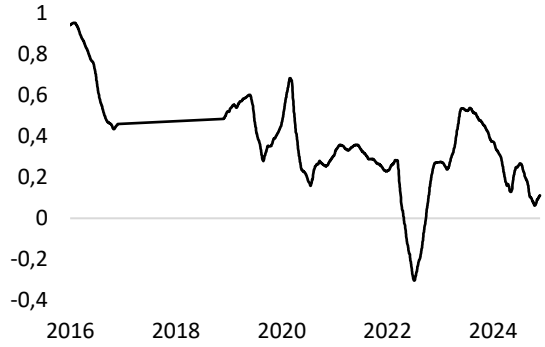
Source: NN analysis

Gold and platinum price, USD/oz



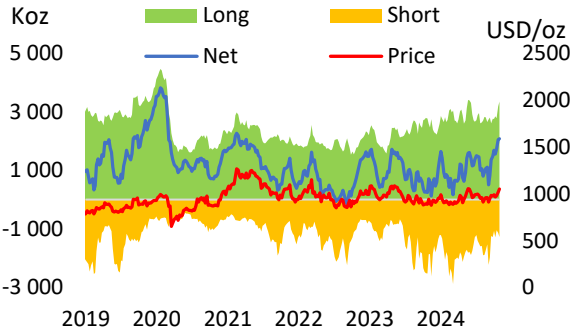
Source: LBMA, LPPM

Au-Pt 2Y correlation



Source: NN analysis

Platinum: net speculative positions



Source: CFTC

GLOBAL PGM DEMAND

AUTOMOTIVE

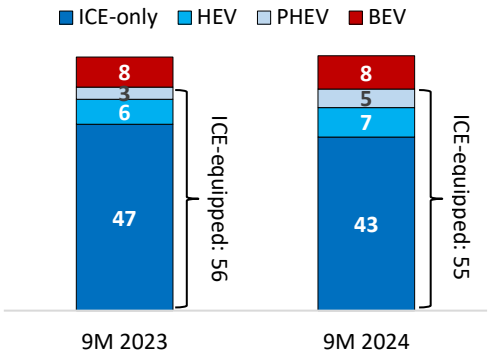
Global light vehicle production is expected to shrink by 3% to 77.5 million units this year as the high interest rates environment puts pressure on demand. BEV market penetration is also slowing down significantly (especially in Europe, where BEV sales fell 2% YoY in 9M 2024) with only 10% YoY growth in 9M 2024. Moreover, the major contribution to BEV sales growth comes from China, where the trade-in programme subsidises the purchase of NEVs. As this program ends in December and taking into account the new Trump administration's plan to eliminate EV subsidies, global vehicle electrification might further shift towards the PGM-containing hybrids (in 9M 2024 PHEVs and HEVs sales growth recorded 50% and 19% YoY growth respectively, compared with just a 10% YoY sales growth of BEVs). As the global transition towards BEVs decelerates, there are risks of further BEV market penetration slowdown across all the major regions in favour of gasoline hybrids.

In 2024-2025, no meaningful emission legislation tightening is expected outside the US, where it is revised annually. However, its impact on the PGM demand is limited due to the loadings' optimisation programmes.

ICE-powered light vehicle sales in **the US** recorded a marginal 0.4% growth YoY in 9M 2024. ***This year, we expect the North American ICE-equipped light vehicle production to stagnate at 14.6 million units.***

BEV sales growth slowed to only 6% YoY, while a 34% increase in HEV sales offset a 3% fall in pure ICE-powered cars resulting in stagnation of the catalysed LDV sales.

Global auto sales in 9M 2024, million units



Source: NN analysis

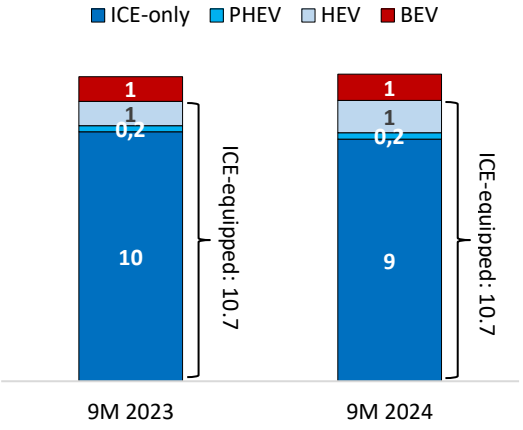
Tight monetary policy and not recovering auto inventories (which also might be an effect of the post-COVID digitalisation of auto purchases) keep new vehicle prices and loan rates elevated, which puts a pressure on auto sales. However, as the Fed follows the interest rate cut cycle, car loan rates are expected to cool off, which should support the overall automotive market in the US.

Meanwhile, the incoming Trump administration is reportedly working on scrapping the $7,500 consumer tax credit for EV purchases, which might undermine the medium-term BEV market penetration. Even though, at first sight, it might seem that this will hit Trump's ally Elon Musk and his Tesla, the long-term effect on the American BEV maker is still likely to be positive as Tesla's local and European rivals are more sensitive to the tax credit cuts.

Moreover, Trump might also roll back some of Biden's emissions regulations, which aim to cut fleet-wide CO_2 emissions from 2026 onwards. This will no longer force the OEMs to expand the share of BEVs produced.

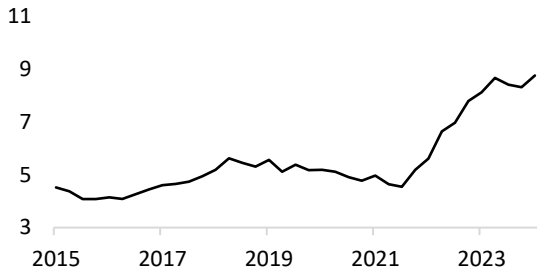
Taking all this into account, there are significant short- and long-term upside risks for ICE-equipped vehicle production in the highest palladium-loaded automotive market.

US auto sales in 9M 2024, million units



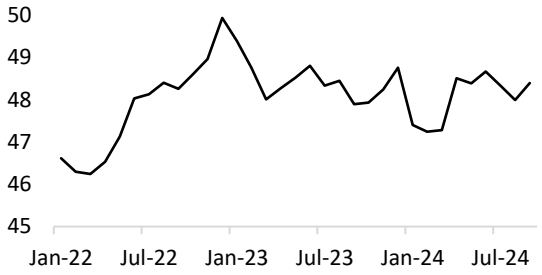
Source: NN analysis

Finance Rate on Consumer Instalment Loans at Commercial Banks, New Autos 72 Month Loan, %



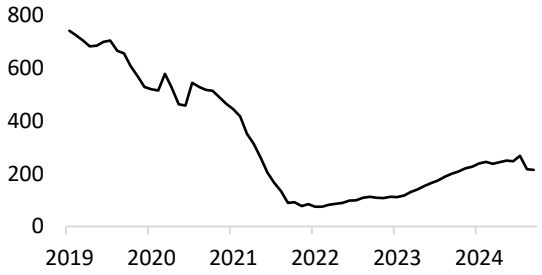
Source: Federal Reserve Bank of St. Louis

Average transaction price, thousand USD



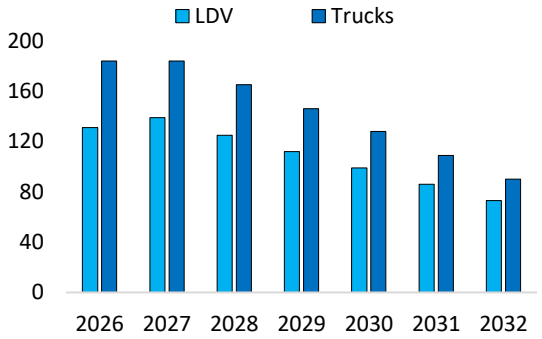
Source: Kelley Blue Book

US domestic auto inventories, thousands of units



Source: Federal Reserve Bank of St. Louis

LDV and trucks CO2 target, g/mile



Source: US Environmental Protection Agency

European auto sales recorded a nominal 1% YoY growth in 9M 2024. ***Notably, their BEV sales fell by 2% YoY.*** This was mainly caused by France's and Germany's EV purchase and leasing subsidy programmes' end while ICE-equipped LV sales grew by

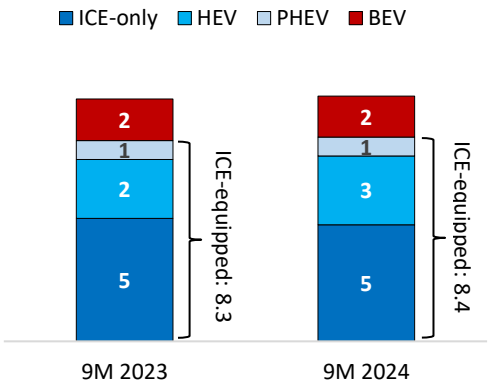
2% YoY and HEV sales increased by 17% YoY during the same period. ***We expect this year's ICE-equipped light vehicle production in Western Europe to fall by 2% YoY to 13 million units.***

Weak demand and cost inflation caused lower capacity utilisation among the major automakers in Western Europe, which, in turn, provoked the wave of layoffs that may affect the total global auto production next year.

Just like in the US, there are several significant downside risks for BEVs' demand in Europe. Firstly, the newly imposed import tariffs on Chinese BEVs will deprive European customers of cheap EV options, making ICE-equipped models even more price-attractive. Secondly, European automakers continue to skew their electrification plans towards gasoline cars (e.g. Volvo scaled back its 2030 target of 100% BEV sales to 90% of electrified vehicles (incl. hybrids), and Daimler also switched from a full electric target towards hybridisation). This trend raises a question about Europe's ability to comply with its own 2035 ICE-powered vehicle sales ban. Italy is pushing EU officials for a pre-emptive revision of this law, which is a significant upside risk for the long-term palladium demand.

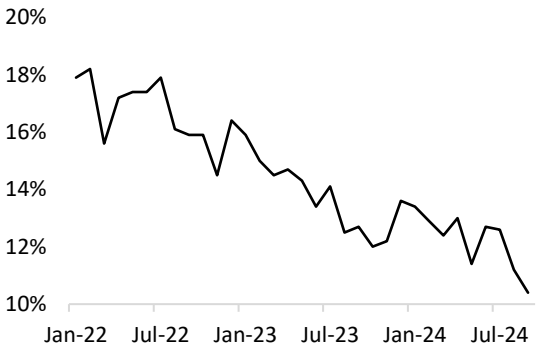
As for the platinum prospects, the diesel market share of Europe's new vehicles sold in September 2024 reached 10.4%, down from 12.7% the same month a year earlier and the downward trend persists.

Europe auto sales in 9M 2024, million units



Source: NN analysis

Diesel-powered cars Europe market share



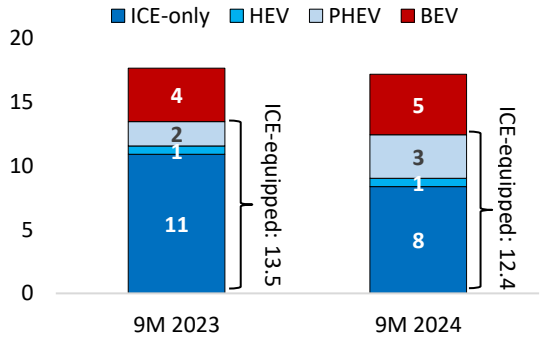
Source: ACEA

In 2024, ICE-powered light vehicle production in China is expected to contract by 7% YoY to 20.7 million units due to a higher BEV penetration rate. Chinese automotive market shrank by 3% YoY in 9M 2024 amid the economic downturn: as the Chinese real estate market collapsed, people had less appetite for large expenses and increased their savings.

ICE-equipped light vehicle sales fell by 8% YoY, while BEV and PHEV sales grew by 13% and 79% YoY respectively. These multidirectional dynamics were caused by the government's trade-in programme. The incentive program targets gasoline PV registered before 30/06/2011, other fuel PV registered before 30/06/2013 and NEV registered before 30/04/2018 and implies either buying a new car or just scrapping the old one only. Trading in older cars for ICE-only and HEV will result in a CNY 15,000 subsidy while trading in older cars for NEVs (incl BEV, PHEV and EREV) will result in a CNY 20,000 subsidy. This is why customers prefer buying BEVs and PHEVs. The programme will last until the end of 2024, which is expected to lead to another BEV/PHEV sales spike in December. So far, no announcement has been made about a potential prolongation of this programme. If it is not extended, we are likely to observe a slowdown in BEV sales growth in 2025 with a positive effect on the catalysed LVs market.

As we discussed in our earlier issues, local Chinese automakers have significantly lower PGM loadings in autocatalysts due to their know-how in catalyst coating. Moreover, it appears that they have also substituted almost all the platinum in favour of palladium in gasoline vehicles because of the price parity between these metals. Based on our communication with Chinese automakers, a 30% palladium price premium is needed for the return to platinum, as the local market palladium-to-platinum mass substitution is not 1:1, and more platinum is needed to replace palladium.

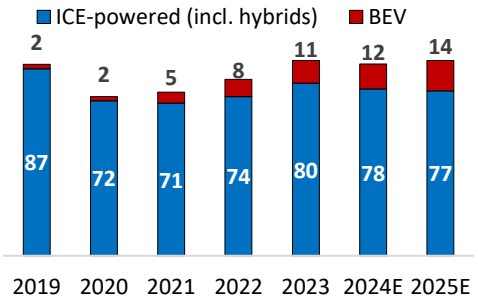
China auto sales in 9M 2024, million units



Source: NN analysis

As to the global 2025 projections, we expect global ICE-powered light vehicle production to decline marginally by 1% YoY to 76.7 million units. The 8% YoY decline of ICE-only light vehicle production will be partially offset by 13% and 21% growth of PHEV and HEV output respectively.

Global light vehicle production



Source: NN analysis

JEWELLERY AND OTHER INDUSTRIAL DEMAND

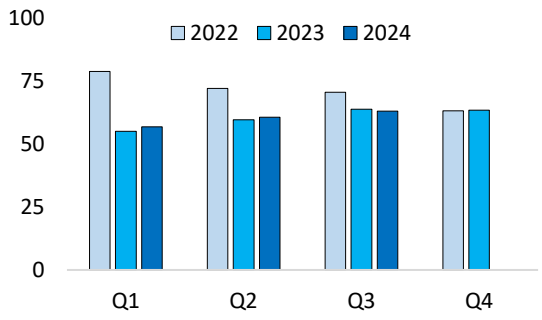
This year, we expect the palladium and platinum use in jewellery to fall by 3% and 4% YoY to 0.2 Moz and 1.7 Moz respectively amid a general downturn in the luxury market and unfavourable price dynamics, which suppress investment interest in the PGM jewellery.

Platinum jewellery demand in China – the largest platinum jewellery market – continues to fall this year following a long-term downward trend as consumer interest shifts towards gold jewellery due to a higher design variability and an upward gold price trend. As for 2025, the expected launch of palladium and platinum futures on the Guangzhou Futures Exchange in Q1 2025 might support jewellery PGM demand in China, as local manufacturers will gain easier access to price hedging. Moreover, slowing inflation and consequent rate cuts in Europe and the US will support jewellery demand in the developed economies in 2025. On top of that, a cut of the platinum import duty from 15.4% to 6.4% in India is also expected to support the local demand for platinum jewellery in the long term.

Palladium industrial demand is expected to fall by 2% this year to 1.6 Moz, while platinum industrial demand is expected to grow by 5% to 2.7 Moz.

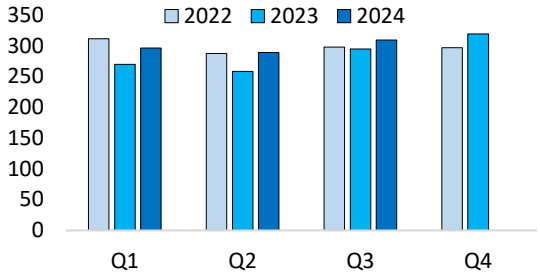
The use in **electronics** is expected to increase in 2024 by 3% and 2% YoY for palladium and platinum respectively. Personal computer shipments are virtually stagnating this year, marking a marginal 1% YoY growth in 9M 2024 to 180.5 million units. Moreover, smartphone shipments rose 9% YoY as easing inflationary pressure impacted sales in the mass-market price segment.

Global PC shipments, million units



Source: Canalys

Global smartphone shipments, million units



Source: Canalys

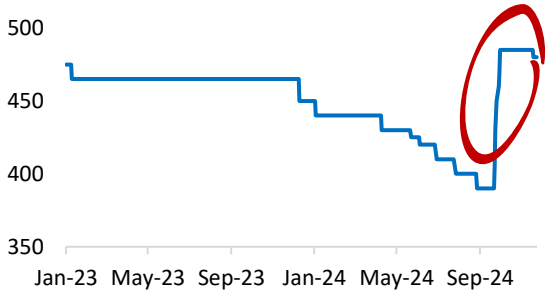
The recent gold price spike as well as the fall in the palladium price to the 2018 level is expected to incentivise R&D in gold substitution in the electronics sector as more than 8 Moz of gold is used in these applications.

Meanwhile, platinum-containing hard disk drive shipments stagnated in 9M 2024 as the rising AI-driven demand for cloud storage currently offsets the HDD demand decline in consumer electronics, caused by the wider use of SSD.

Interestingly, ruthenium's price rise in late September was attributed to strong buying in Japan caused by the sharp increase in hard disk production destined for import to China.

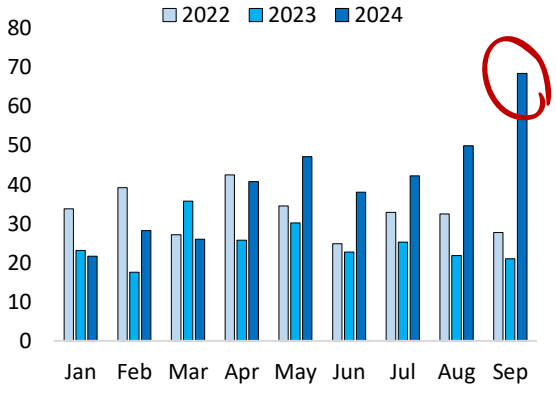
Palladium and platinum demand by the **chemical sector** is expected to increase by 2% and 1% YoY respectively, following the trend of pyroxene (platinum-based catalysts) and purified terephthalic acid (palladium-based catalysts) production capacities' growth in China.

Ruthenium price, USD/oz



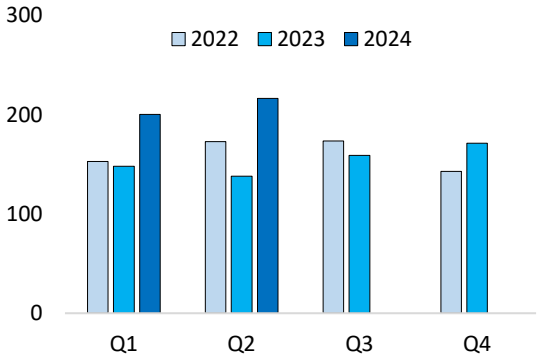
Source: Johnson Matthey

Minor PGMs import to Japan, koz



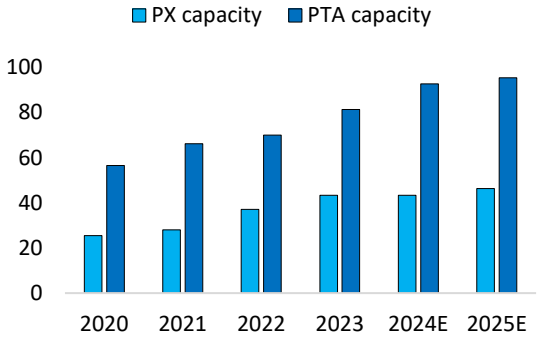
Source: Trade statistics

Global HDD shipments, million units



Source: NN analysis

PTA and PX capacities in China, million tonnes

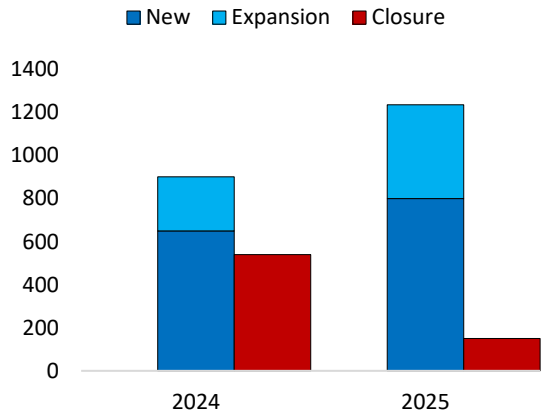


Source: NN analysis

Meanwhile, the demand for platinum by the **petrochemical** sector is also expected to increase by 5% this year. Global oil refining capacity is expected to increase marginally this year by 0.3%. The Africa's largest new oil refinery installation in Nigeria as well as capacity expansion in China, India and the Middle East will contribute to 900,000 bpd of capacity increase. However, this will be counterweighted by oil refinery closures in Europe (Scotland's only oil refinery in Grangemouth – 150,000 bpd and ExxonMobil's ethylene cracker (this process uses palladium-based catalysts) in Port Jerome in France – 270,000 bpd) as well as in Japan (Idemitsu's Yamaguchi plant – 120,000 bpd).

In 2025, new plant installations in China, Iran and Mexico will account for 800,000 bpd, while capacity expansion projects will also add up to 435,000 bpd. On the other hand, Shell announced the closure of its plant in Wesseling with a 150,000 bpd capacity in early 2025. However, inflated energy prices and a shift to greener energy might prop the trend of petroleum refining capacity shrinkage in Europe, which will lead to the inflow of platinum-based catalysts into open-loop recycling.

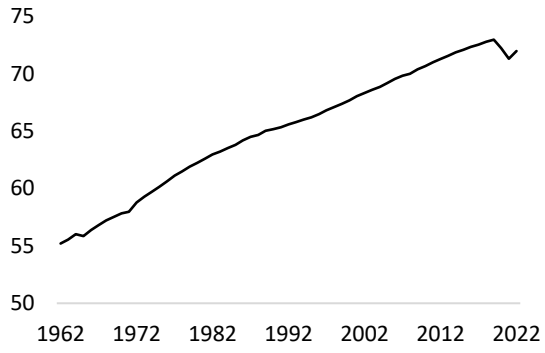
Change in global oil refining capacity, thousand barrels per day



Source: NN analysis

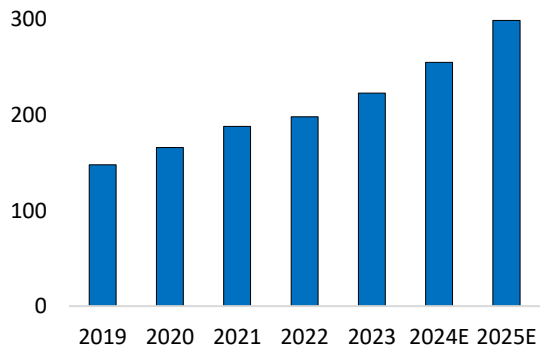
Palladium use in the **medical** sector is expected to contract by 10% YoY as it follows a long-term downward trend due to the substitution with ceramic crowns and fewer cases of dental prosthetics in Japan. Meanwhile, platinum use in this sector is expected to rise by 5% YoY in 2024. The average life expectancy is expected to bounce back after the pandemic-related fall in 2020-2021, which will increase the absolute number of cancer incidents as well as platinum-based medical devices. Moreover, global spending on cancer research and treatment is also expected to rise by around 15% YoY in 2024 and 2025.

Global life expectancy, years



Source: World Health Organization

Cancer medicine spending, billion USD



Source: IQVIA Institute for Human Data Science

In the **glassmaking** industry, we see a sustained continuous trend of substituting rhodium in favour of platinum. As a result of this trend, Chinese glass producers have accumulated significant rhodium stocks, and they keep selling the metal regularly when the rhodium price goes up. This caps the rhodium price upside and partially covers the metal's fundamental deficit. As a result of capacity expansion in China and substituting rhodium with platinum, we expect platinum use in this sector to increase by 21% YoY this year.

We expect the 2025 industrial demand for palladium and platinum to increase by 2% and 3% YoY to 1.6 Moz and 2.8 Moz respectively on the back of the rising use of both metals in electronics (+2% and +5% YoY for palladium and platinum respectively) and chemical sectors (+5% and +2% for palladium and platinum respectively), as well as rising platinum demand from petrochemical (+17% YoY), medical (+4% YoY) and glassmaking sectors (+3% YoY).

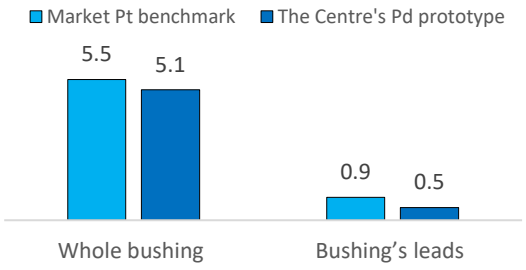
NORNICKEL'S PALLADIUM CENTRE R&D UPDATE

Against the backdrop of a downward trajectory in palladium demand in traditional applications, Nornickel, as the largest palladium producer, has established a commercial R&D unit – the Palladium Centre, aimed at bringing new effective palladium-based product technologies to the market.

Traditional PGM applications. Palladium could increase efficiency and reduce total costs for some technological processes in heavy industries, electrochemistry and several other applications when it replaces platinum, ruthenium or iridium.

In the case of fibreglass production, replacing platinum with palladium in bushings can significantly reduce end-user costs. While palladium is half the weight of platinum, the smelting temperature and recycling technology remain the same. Successful industrial testing of bushings with palladium leads (–7.3% of the weight) has already been completed, demonstrating their operational stability and ease of cutting and recycling. In 2025, a bushing featuring 30% palladium along with an applicable recycling technology is to be presented.

Pd leads for fibreglass production bushings, kg



Source: The Palladium Centre

In electrochemistry processes such as the extraction of nickel and copper, as well as the production of chlorine-alkali and water treatment, the Centre aims to incorporate palladium into existing ruthenium- and iridium-based electrodes. This year, the industrial testing of palladium-iridium-ruthenium tri-metallic anodes for water disinfection was completed. By replacing more than 4 times more expensive iridium with palladium, CAPEX has been reduced while the lifetime of these anodes has increased, and energy consumption has decreased by 5–20%. The first commercial series of Pd-Ru-Ir anodes is to be installed in water treatment facilities in Russia by the end of 2024. In 2025, the Centre plans to scale this palladium coating technology for other electrochemical applications and bring them to the mass market.

As for traditional industrial hydrogen production technologies, such as steam reforming and autothermal reforming, tests are being conducted with the addition of 0.2–0.5% (by weight) palladium to nickel catalysts. The catalyst's efficiency and service life are anticipated to increase by 15% and 20% respectively, which will reduce the end users' overall costs. Industrial tests are expected to be completed in 2025.

According to the Centre's estimates, switching to palladium from other PGMs in traditional applications could generate up to 0.5-0.6 Moz of annual palladium demand in the long-term.

Greentech. Given the fact that palladium has become 4.5 times cheaper than iridium, as well as the growing shortage in the iridium market from 2024 onwards, the substitution of iridium in favour of palladium is seemingly a necessary step for the sustainable development of the hydrogen economy. Palladium has properties of high catalytic activity and excellent hydrogen permeability; therefore, it is applicable in the entire hydrogen chain — production, use and storage.

Up to 30% of iridium has already been successfully replaced with palladium in the Centre's proton exchange membrane (PEM) electrolysis catalysts prototype, resulting in a reduction in both the cost (-11%) and energy consumption (-6%) of the electrode composition compared to pure iridium. The Centre delivered the product to four Membrane Electrode Assembly and PEM electrolyser producers in China to get feedback on the Pd-Ir catalyst performance in their processes. Next year, the Centre is planning to go further with technology localisation and scale-up having up to 6 other clients willing to test the prototypes.

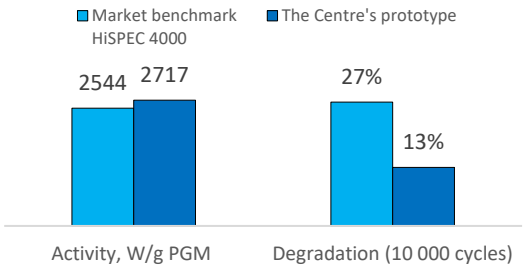
As to the alkaline electrolysis catalysts, an up to 10% decrease in energy consumption is expected after the test of the Centre's palladium-containing prototype.

In the case of fuel-cell catalysts, 25% of platinum has been replaced with palladium. The Centre's prototype outperforms the commercial ones in both activity (7%) and stability (53%), offering competitive advantages such as higher current output and enhanced lifetime due to reduced degradation. In 2025, an upgraded catalyst formula will be introduced based on the feedback from the existing clients and some further testing will be done, involving up to 10 clients, to find a local partner for this technology's adoption and scaling up.

In addition, the fuel cell cathode with increased palladium content (75%) has already successfully

passed laboratory tests for activity higher than a market benchmark. The PEM Anode with increased palladium content (40%) submitted for industrial testing in China.

The Centre's hydrogen fuel cell prototype



Source: The Palladium Centre

In solar energy, Pd-Se compounds enhance the efficiency both in traditional silicon solar cells by raising electrical conductivity in the cell's layers, and in new technology – perovskite solar cells – by expanding the range of the solar radiation sensitivity spectrum. Palladium-containing components should be able to increase the efficiency of these photovoltaic cells by 1-2 percentage points from the current level of 25% and 18% for silicon and perovskite, respectively.

In the production of biofuels, including environmentally friendly sustainable aviation fuels, the Centre has developed a promising project that adds palladium to existing nickel catalysts significantly increasing production efficiency.

According to the Centre's estimates, the use of palladium in greentech will bring up to 0.5-0.6 Moz of long-term annual demand, including 0.2-0.3 Moz annually for hydrogen in the long term.

High-tech industries. AI boom and vehicle electrification drive the demand for chips and capacitors, where palladium is used in lead frames (in chips) and bonding wires (in capacitors).

The Palladium Centre actively supports the development of palladium as a resistant coating for base metals (Cu, Ni) to replace more expensive gold in bonding wires and lead frames. The Centre also conducts fundamental research for new segments of microelectronics, like spintronics, which will also require palladium because of its conductivity, magnetic susceptibility and corrosion resistance qualities.

GLOBAL PGM SUPPLY

In 2024, the global refined palladium, platinum and rhodium production is expected to fall by 5%, 5% and 3% YoY to 9.1 Moz, 7.4 Moz and 1.0 Moz respectively.

Primary production is expected to stagnate as the Russian mine production will recover due to the much faster-than-expected smelter rebuilding, while South African refined output will be higher than the falling mine supply as a result of incentivised efforts to reduce WIP stocks. This will be offset by the lower autocatalyst recycling in the US and Europe, caused by lower PGM prices, subdued scrappage rates due to elevated car prices and the high cost of new car loans.

RUSSIA

PGM primary production in Russia is expected to be at the upper end of Nornickel's production guidance of 2.7 Moz and 0.7 Moz.

In 3Q 2024, Nornickel completed the largest capital repairs of the last decades. The flash smelting furnace #2 at Nadezhda Metallurgical Plant was completely rebuilt. Effectively, the furnace was built anew raising its smelting capacities by 25%. The furnace was launched in record time well ahead of schedule: the construction took only 60 days instead of the planned 90. Even though nickel production was already restored in the same quarter, PGMs have a longer production cycle compared to base metals, hence the output of finished products will be impacted from Q4 2024 onwards.

In the medium term, Nornickel will revert to the annual PGM output of the 2022 level as work-in-progress materials will be released and the 2025 production guidance is scheduled to be published in January.

As for the Company's long-term plans, the Talnakh Concentrator expansion is scheduled to be completed in 2028 while Russian Platinum's Chernogorskoye project is expected to launch its PGM production in 2H 2026. Our field research shows that the development of their open pit is nearly completed while the concentrator's construction is still underway.

SOUTH AFRICA

We expect South African primary PGM refined production to be flat this year at 2.4 Moz of palladium, 4.2 Moz of platinum and 0.6 Moz of rhodium as the declining mine supply is being offset by Amplats' WIP stocks processing.

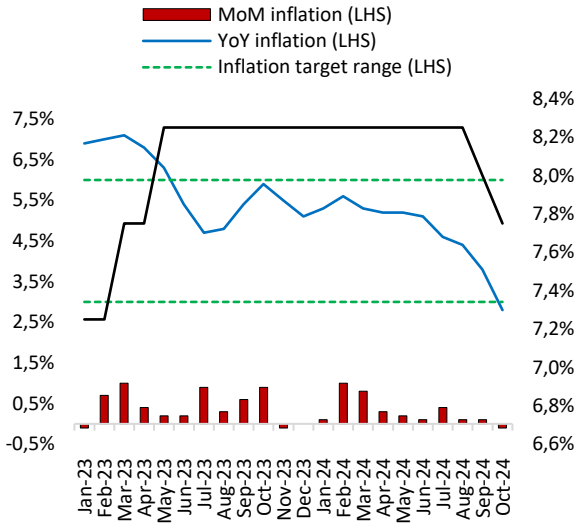
The falling PGM basket price was countered by cost-saving measures, implemented by the South African PGM mining companies, and excess PGM stock sales. So far, these restructuring efforts have resulted in several shaft closures and thousands of layoffs. Moreover, Amplats might be squeezing out margins before the London listing next year as ongoing cost inflation might push more mines above the 6E PGM basket price level.

The depressed South African rand has also affected the USD-denominated costs. Throughout 1H 2024, USD/ZAR traded above 18.5 following the horizontal trend until May, when ZAR began to appreciate and kept strengthening until late September when it reached 17.1. This rand appreciation was caused by the South African election results. Even though the long-ruling ANC remained the largest political party (40.2% of the votes), it lost its majority, which led to the formation of a coalition to re-elect the incumbent President Cyril Ramaphosa. DA (Democratic Alliance,

21.8% of the votes), MKP (UMkhonto weSizwe, 14.6% of the votes) and EFF (The Economic Freedom Fighters, 9.5% of the votes) were the options for the ANC to forge a coalition. MKP and EFF are far-left parties that advocate for export restrictions and nationalisation of mines, mining companies and the banking sector. Meanwhile, DA is a pro-business right-wing party, advocating for the fostering of foreign investment and liberalisation of the energy sector. On 14 June, the ANC struck a deal with the DA, which was warmly approved by the markets, and the long-term effect of this election on the rand is expected to be positive, which will impact local exporters including the PGM producers.

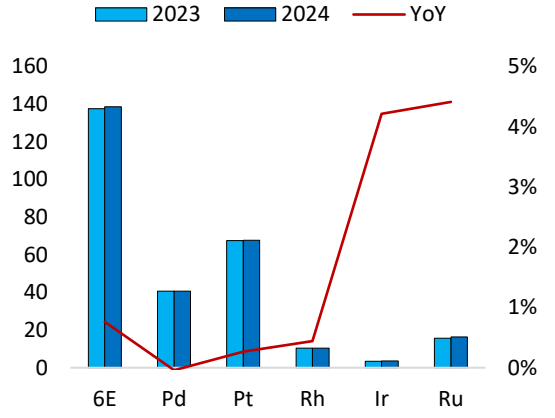
Inflation in South Africa has started to slow down noticeably in the second half of 2024 with YoY inflation reaching 2.8%, which is below the lower bound target of 3%. The CPI fell on a MoM basis in October for the first time since August 2023. This led to a cumulative 50bp repo rate cut in August-October this year. Slowing inflation is also expected to have a positive effect on South African rand exchange rate in the medium term.

South African inflation and repo rate



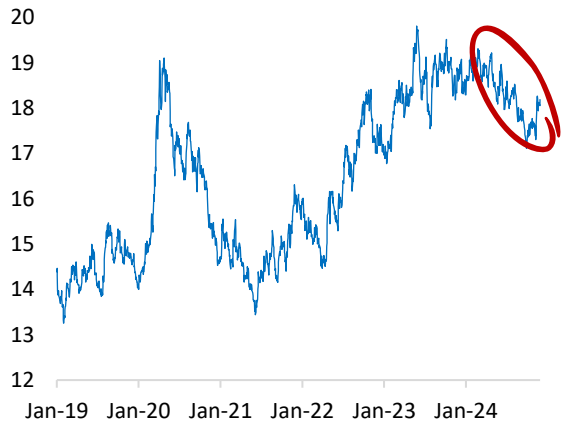
Source: South African Reserve Bank

South African 7M 2024 PGM mined production, koz



Source: Department of Mineral Resources and Energy of South Africa

USD/ZAR exchange rate

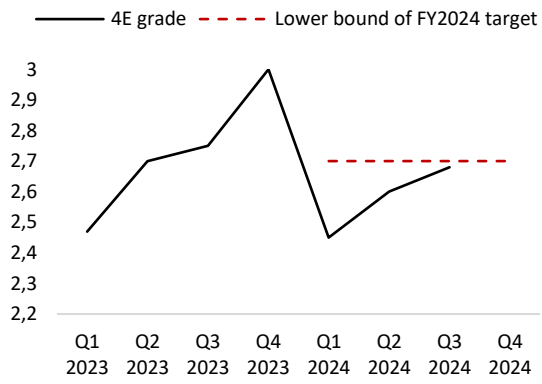


Source: trade statistics

In 9M 2024, **Amplats'** PGM mine production from South African operations fell by 12%, 15% and 21% YoY to 0.5 Moz, 0.6 Moz and 0.1Moz of palladium, platinum and rhodium respectively. The decline was observed across all the company's mines. Their largest mine – Mogalakwena – delivered 670 koz of 6E PGMs in 9M 2024 (-5% YoY) as the output suffered from July North Concentrator's primary mill downtime with some subsequent repair works. This caused the loss of around 45 koz of 6E PGMs. Moreover, the mine continues to suffer from lower grades, failing to reach the lower end of 2.7 g/t FY2024 guidance in every quarter so far. This is expected to lead the mine to fall short of 0.1 Moz 6E PGMs compared to the initial guidance for FY2024. Amandelbult and Mototolo mines also recorded a 9% fall in 6E PGM production in 9M 2024. Operations at Amandelbult were affected by safety stoppages in Q3 2024, while Mototolo suffered from lower grades caused by the Lebowa shaft reaching the end of life.

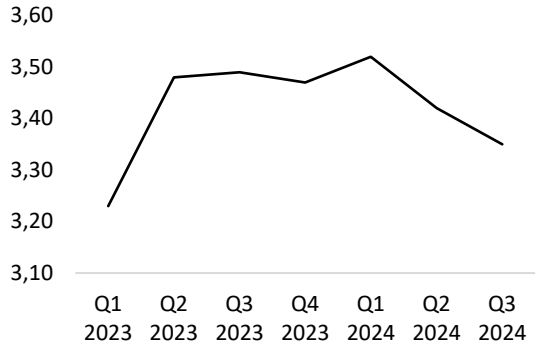
Despite a noticeable mine production contraction, in 9M 2024, Amplats increased its PGM refined output by 6%, 15% and 10% to 0.3 Moz, 0.5 Moz and 0.1 Moz of palladium, platinum and rhodium respectively as the company reduced work-in-progress materials stocks significantly (by 0.4 Moz 6E). This might have been a forced revenue-boosting action before the imminent London listing in 2025. After that, PGM refined production is likely to follow the downtrend of the mine production.

Mogalakwena 4E grade, g/t



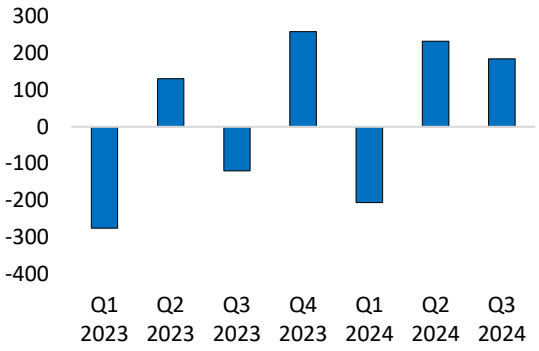
Source: Amplats

Mototolo 4E grade, g/t



Source: Amplats

Amplats 6E PGM stocks movement, koz



Source: NN analysis

Sibanye's 6E PGM refined production from the South African operations increased by 4% YoY to 1.6 Moz in 9M 2024 as it benefited from the Kroondal acquisition. Excluding Kroondal, the dynamics reverse with 6E PGM production falling by 2% (palladium, platinum and rhodium refined production decreased by 2%, 3% and 2% YoY to 0.3 Moz, 0.7 Moz and 0.1 Moz respectively). The PGM production's fall in the region was caused by the lower output at the company's second-largest mine in Rustenburg (palladium, platinum and rhodium refined production decreased by 6%, 8% and 5% YoY to 0.1 Moz, 0.3 Moz and 0.04 Moz respectively). Their mine's underground production was impacted by the Siphumelele shaft headgear bin failure that led to two months of output loss and a subsequent gradual ramp-up during Q3 2024.

PGM refined production at Sibanye's largest PGM mine Marikana stagnated YoY in 9M 2024 as the K4 shaft ramp-up offset restructuring of the Rowland shaft and the closure of the 4B shaft in 2023. Notably, the mine is on the verge of unprofitability, which might lead to further shaft restructuring (K3 shaft and E3 shafts have an estimated LoM of 7 and 10 years respectively).

Sibanye managed to lower the net debt-to-EBITDA ratio down to 1.43x by the end of 1H 2024 (with 3.5x covenants) as a result of the gold streaming deal. An additional $600-700 million is expected to be attracted via chromium, PGMs and gold streaming. This will ease the company's debt burden in the medium term but will deprive it of the PGM price upside.

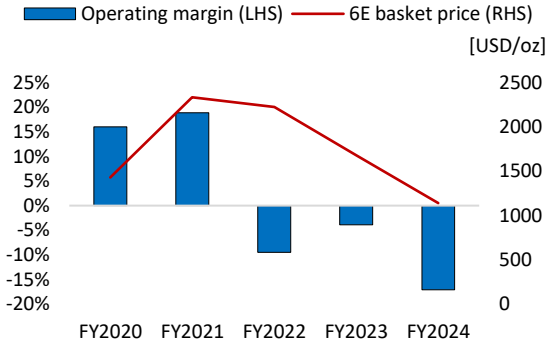
Implats' PGM refined production from South African operations in 9M 2024 fell 5% and 3% YoY to 0.3 Moz and 0.1 Moz of palladium and rhodium respectively, while their platinum output stagnated YoY at 0.6 Moz.

6E PGM refined production at the company's flagship Lease Area in Rustenburg marginally fell by 1% YoY (palladium and rhodium refined production decreased by 4% and 1% YoY to 0.2 Moz and 0.1 Moz respectively, while platinum output rose insignificantly by 1% YoY) as Number 5 furnace underwent a rebuild earlier this year. Despite some higher smelting capacity availability next year, we don't expect PGM mine output to increase at this asset, as the mine is positioned in the 4th quartile of the industry's cost curve and might be subject to output cuts via high-cost shaft restructuring.

6E PGM output at Marula also fell by 7% YoY in 9M 2024 due to Section 54 (Stop and fix) safety stoppages following a fatality in August 2023.

Northam plans to fulfil a 1.0 Moz 4E PGM production target from its own operations by 2028, which will require a 10% production growth at Zondereinde and doubling the current PGM concentrate output at Eland. However, due to the PGM basket price fall, Eland mine is currently unprofitable with an operating margin of −17%, which might force the company to abandon its PGM production growth plans, unless the PGM basket price recovers noticeably, and focus on the M&A activity in South Africa instead.

Eland performance



Source: Northam Platinum

As for the probable projects in South Africa, the most promising PGM mine in the region — Bakubung — is at an advanced stage of readiness. Earlier this year, Wesizwe Platinum said the production would start in Q1 2025. However, the project's funding uncertainty is likely to postpone the launch.

The need for a concentrate treatment partnership remains Waterberg's main obstacle. Moreover, the proximity to populated areas raises questions about the feasibility of tailings' treatment.

In 2025, we expect South African primary PGM production to fall by 3% YoY to 2.3 Moz, 4.1 Moz and 0.6 Moz of palladium, platinum and rhodium respectively. Amplats is expected to finish the refining of raw materials, while Implats is likely to increase refined PGM output due to the processing of accumulated work-in-progress materials. At the same time, we are hearing voices from the South African mining industry that the contraction could be up to 10% as a result of the cost-cutting efforts by the miners.

ZIMBABWE

We expect Zimbabwean primary 6E PGM production to increase by 6% YoY this year to 0.5 Moz, 0.6 Moz and 0.1 Moz of palladium, platinum and rhodium respectively.

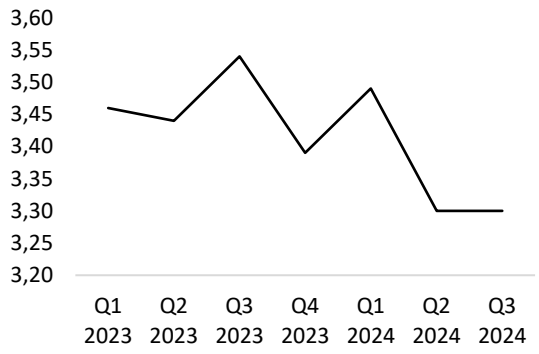
The country's largest PGM mine Zimplats increased matte production in 9M 2024 by 30 koz 6E PGMs (palladium and platinum matte production increased by 8% and 7% YoY to 0.2 Moz and 0.2 Moz respectively) on the back of Mupani and Bimha mines expansion as Rukodzi and Ngwarati mines had been depleted. Newer shafts might help Zimplats to improve its position on a cost curve, which became vulnerable on the back of a falling palladium price due to the higher relative content of this metal in their ore (39% of total 6E PGMs). As for Mimosa, the mine also recorded a rise in the PGM concentrate production by 5% YoY to 190 koz 6E in 9M 2024.

At the same time, the PGM concentrate production at Amplats' Unki fell by 1% YoY (palladium production was stagnating at 69 koz, while their platinum and rhodium production decreased by 2% and 1% to 81 koz and 8 koz respectively). Unki's production suffers from mining through a low-grade section.

As for the probable projects in Zimbabwe, the launch of Karo will depend on the palladium price recovery (the orebody heavily relies on palladium: the metal split is 42:39:4:4:2:8 for platinum, palladium, rhodium, ruthenium, iridium and gold respectively), as the currently depressed PGM basket price puts mine's economic viability at risk.

No operational updates on the Darwendale project have become available since our latest issue.

Unki 4E grade, g/t



Source: Amplats

In 2025, we expect Zimbabwean PGM production to remain at the 2024 level. Moreover, the Zimbabwean government has moved ahead with the implementation of a 5% export tax on unrefined PGMs. This will affect local mines' margins and might lead to further cost-saving measures.

NORTH AMERICA

We expect the 2024 North American primary refined production to stagnate at 0.8 Moz and 0.3 Moz of palladium and platinum respectively.

The palladium price fall resulted in the unprofitability of the PGM mines in North America due to palladium-rich ore and the high cost of production. In September, **Sibanye-Stillwater** announced the restructuring of its PGM operations in Montana, which increased its PGM production in 9M 2024 by 13% YoY to 271 koz of palladium and 80 koz of platinum. ***This implies a reduction of PGM production by 200 koz 2E PGM (approximately 150 koz of palladium and 50 koz of platinum) starting from 2025. It translates into a 45% reduction compared with the current annual output.*** The company will place the older mine Stillwater West on care & maintenance and reduce production and defer CAPEX at East Boulder while increasing production at higher grade Stillwater East. By doing this, Sibanye aims to lower the all-in sustaining cost of Stillwater underground operations to $1,000/oz (vs $1,274/oz in Q3 2024).

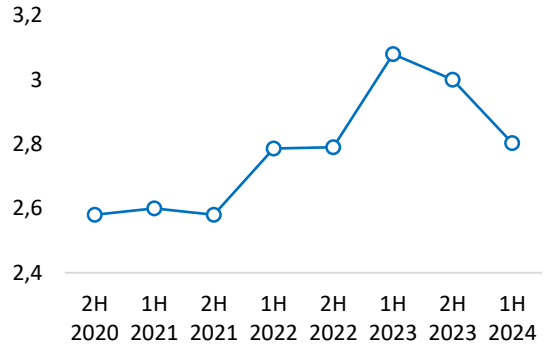
PGM concentrate production by Impala Canada in 9M 2024 fell by 3% to 185 koz and 15 koz of palladium and platinum respectively due to the falling grades. Because of the falling palladium price, the mine started to target higher-grade areas in 1H 2023 to lower unit costs. In 1H 2024, the mine's grade fell back to the 2H 2022 level of 2.80 g/t, which might indicate that the mine is running out of cost-optimisation opportunities and might be placed on care and maintenance shortly.

As for the PGM output of the base metals' producers in the region, Vale's PGM production in 9M 2024 fell by 25% YoY to 82 koz of palladium and 71 koz of platinum. However, this was partially offset by a higher output of Glencore, which increased PGM production by 14% and 25% YoY to 163 koz and 45 koz of palladium and platinum respectively.

In 2025, we expect North American primary PGM production to fall dramatically by 20% and 14% YoY to 0.7 Moz and 0.2 Moz of palladium and platinum respectively on the back of the Stillwater mine restructuring.

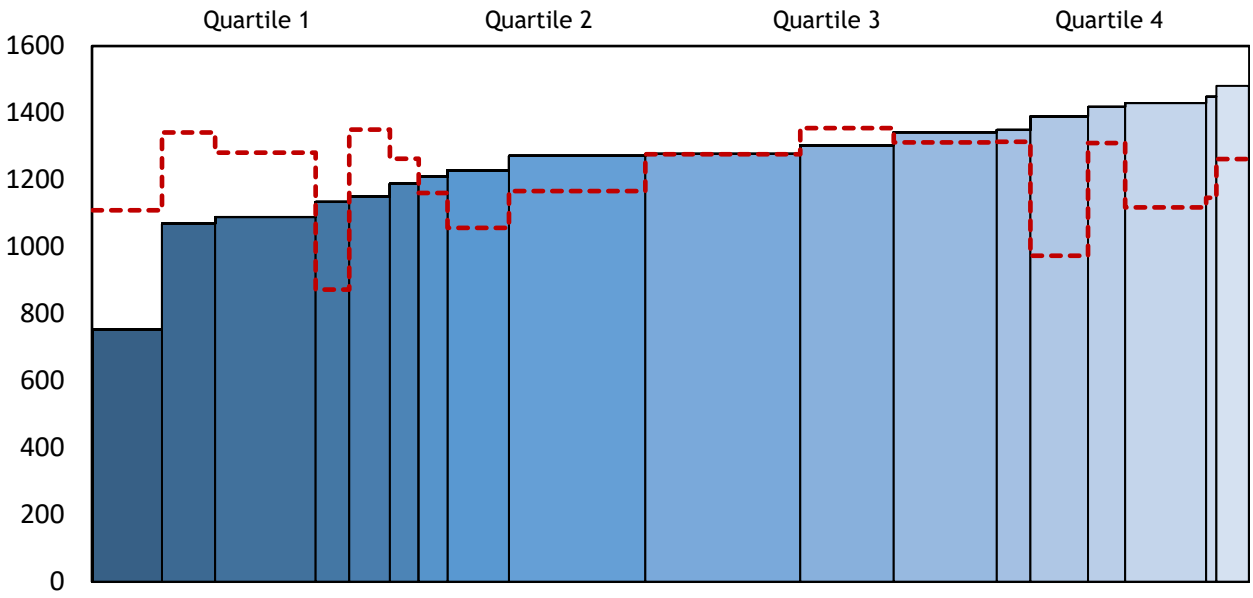
Overall, we expect the global primary supply of palladium, platinum and rhodium to fall in 2025 by 1%, 4% and 2% YoY to 6.2 Moz, 5.6 Moz and 0.7 Moz. Cost-driven output contraction in South Africa and mine restructuring in North America will be partially offset by the recovery of the Russian PGM output.

Impala Canada's grade (6E g/t)



Source: Implats, NN analysis

Major African and North American PGM mines All-in Sustaining Cost and Current PGM Basket Price, USD/6E oz



Source: NN analysis

Currently more than 60% of PGM primary production outside of Russia is loss-making at spot PGM prices despite cost-saving measures implemented across African and North American PGM mines.

RECYCLING

The **North American** PGM recycling market currently showcases mixed dynamics. Since May 2023, the used car prices in the US have been gradually falling, which indicates the cooling demand for used cars. Having said that, prices are still way above the pre-pandemic level. The interest rate cuts cycle, which started in September, will positively impact new car loan affordability with some delay, which, in turn, will increase the used vehicles flow into the scrapyards. However, in 9M 2024, spent autocatalysts imports in the US fell dramatically by 45% YoY, with imports from Canada falling by 62% YoY, which indicates lesser scrap availability for recycling. Such mixed market dynamics were also reflected in Sibanye's US recycling operation results as their secondary PGM production stagnated in 9M 2024.

There also are noticeable downside risks to the recovery of PGM recycling in the US as the market perceived Trump's re-election as a pro-inflationary signal, lowering the expectations of the pace of rate cuts (the probability of cumulative rate cuts to 4.0-4.5% by the January FOMC meeting fell from 44% to 28% after the elections while back on October, this scenario was considered the most probable).

Moreover, The US Senate is considering amendments to the proposed bipartisan Preventing Auto Recycling Theft Act, which could affect autocatalyst recycling in the medium term. This bill implies that new vehicles are to have unique and traceable identifying numbers stamped on catalytic converters at the time of assembly, which should be traceable back to the car's vehicle identification number. In addition to that, the bill also stipulates that catalytic converter transactions are recorded and made readily accessible to law enforcement officials. If the law is passed, it might create severe bottlenecks across the whole autocatalyst recycling value chain in the US.

European used car prices fell in Q1 2024 but have stagnated ever since despite the beginning of June's 110bp rate cut. They remain elevated compared with historical levels. Industry representatives report a significant recycling capacity underload in the region.

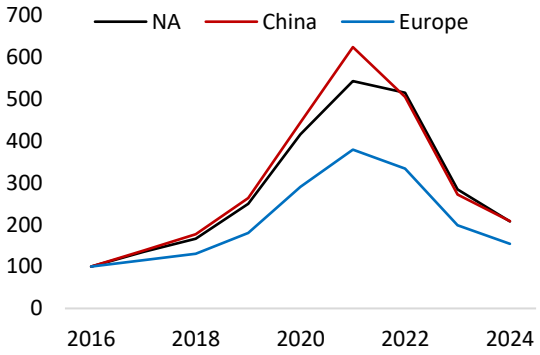
At the same time, PGM recycling in **China** benefited from the passenger vehicle trade-in programme introduced in Q2 2024. This program targets cars with catalysts under China 3/China III legislation ***(palladium loadings in such catalysts are even higher than current loading by the local OEMs under China 6/VI legislation)***: - i.e. gasoline vehicles registered before 2H 2011 and other fuel vehicles registered before 2H 2013. The programme offers not only a new NEV purchase subsidy but also a scrapping subsidy if one opts not to buy a new vehicle. Even though current PGM loadings are low, the programme provides increased subsidies for the early scrapped vehicles equipped with higher PGM-containing catalysts. Currently, the programme is expected to last until the end of 2024 only, but it might be extended.

Nevertheless, PGM recycling capacities in China remain underloaded and the autocatalyst scrap deficit, coupled with falling PGM prices, makes this market highly competitive.

Taking all these factors into account, we revise our earlier expectations of a PGM secondary supply stagnation in 2024. Now, we expect it to fall by 5% YoY — to 2.7 Moz of palladium, 1.4 Moz of platinum, and 0.2 Moz of rhodium.

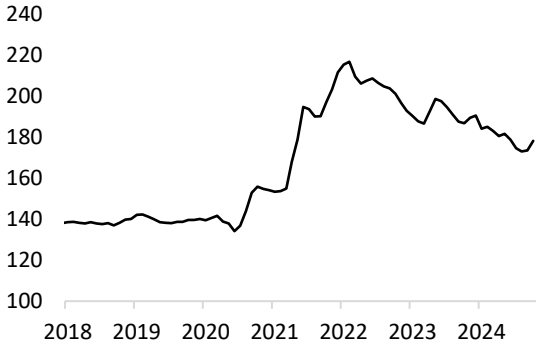
As for 2025, we expect the PGM secondary supply to rise by 9% YoY to 2.9 Moz, 1.5 Moz and 0.3 Moz of palladium, platinum and rhodium respectively but remain lower than the pre-pandemic level.

Falling autocat price incentivises scrap hoarding: 3E PGM value of a new autocat installed index



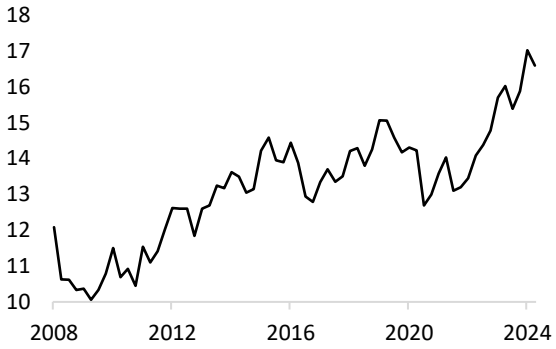
Source: NN analysis

US: Consumer Price Index for All Urban Consumers: Used Cars and Trucks



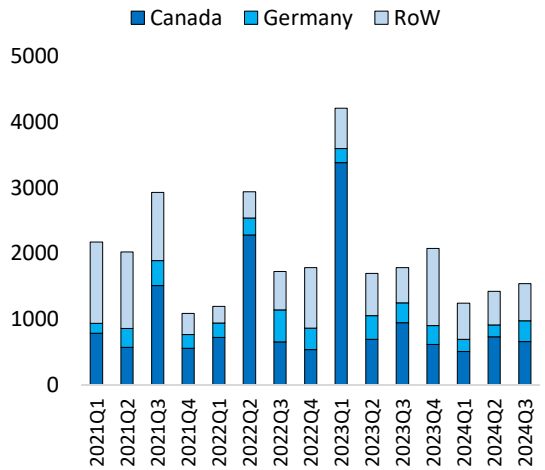
Source: Federal Reserve Bank of St. Louis

US: Average Finance Rate of Used Car Loans at Finance Companies, %



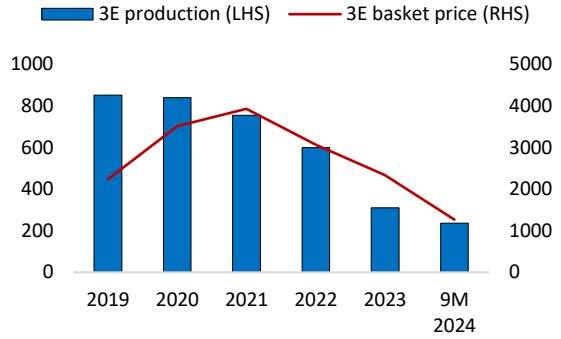
Source: Federal Reserve Bank of St. Louis

US: import of spent autocatalyst (ceramic), tonnes



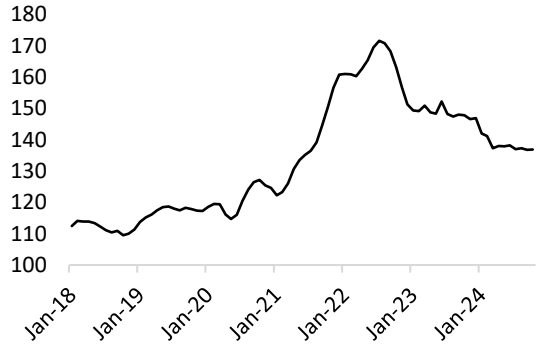
Source: Trade statistics

Sibanye-Stillwater's recycled production, koz



Source: Sibanye-Stillwater

The European Used Car Price Index



Source: AUTO1 Group

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GLOSSARY OF TERMS

Abbreviation	Term
(t)oz	Troy ounce
(P)HEV	(Plug-in) hybrid electric vehicle
2E	Platinum, palladium
3E	Platinum, palladium, rhodium
4E	Platinum, palladium, rhodium and gold
6E	Platinum, palladium, rhodium, iridium, ruthenium, and gold
BEV	Battery electric vehicle
CFTC	Commodity Futures Trading Commission
CO2	Carbon dioxide
COVID-19 (COVID)	Coronavirus Disease 2019
CPI	Consumer price index
DXY	US Dollar index
EMA 200	200-day Exponential Moving Average
EPA	U.S. Environmental Protection Agency
EREV	Extended Range Electric Vehicle
ETF	Exchange-traded fund
EU	European Union
EV	Electric vehicle
FCEV	Fuel cell electric vehicle
FED	Federal Reserve System
FOMC	The Federal Open Market Committee
ICE	Internal combustion engine
HDD	Hard disk drive
HDV	Heavy-duty vehicle
koz	Thousand troy ounces
LHS	Left-hand side
LBMA	London Bullion Market Association
LDV	Light-duty vehicle
LoM	Life of mine
LPPM	London Platinum and Palladium Market
M&A	Mergers and acquisitions
MMC	Mining metallurgical company
MoM	Month-on-month
Moz	Million troy ounces
NEV	New energy vehicle
NOX	Nitrogen oxides
NYMEX	New York Mercantile Exchange
OEM(s)	Original equipment manufacturers
PC	Personal computer

PGM(s)	Platinum group metals
PTA	Purified terephthalic acid
PX	Paraxylene
R&D	Research and development
RHS	Right-hand side
RSI	Relative strength index
VIX	Chicago Board Options Exchange Volatility Index
WIP	Work-in-progress
YoY	Year-on-year
YTD	Year to date