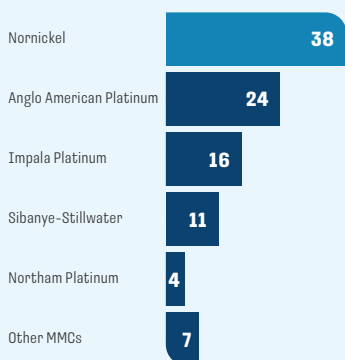


PALLADIUM (Pd)

Nº1

in palladium production (%)



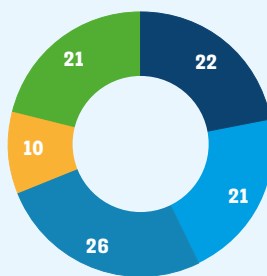
Refined metal output including production from third-party feedstock and production from own feedstock by third parties under tolling agreements.

Sources: producer reports, Company analysis as of 5 March 2022

Key trends in the palladium market

Industrial consumption of palladium by region (%)

309 t



- North America
- Europe
- China
- Japan
- Other countries

Source: Company data

Early in 2021, palladium was trading in the USD 2,300–2,500/oz range, followed by growth which started in mid-March and continued until early May when price hit a new all-time high of USD 2,994/oz. This trend was primarily driven by the recovery in global vehicle production after the strictest phase of the lockdown and expectations of a significant increase in demand for the metal during the year.

The Company's production cuts due to industrial incidents in the first half of the year also supported the price rally, as the market participants were concerned about a potential physical supply shortage.

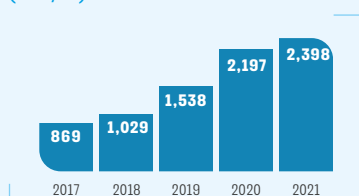
In mid-2021, palladium price stabilised in the USD 2,500–2,900/oz range; however, a downward trend began in August driven by revised estimates of the automotive industry's recovery pace. Semiconductor shortages forced automakers to cut vehicle production. Chip shortages prevented automakers from producing a total of about 8–9 million vehicles in 2021, equivalent to a



consumption of ~25–27 tonnes of palladium. The semiconductor crunch has affected both physical metal buying by consumers and the sentiment of speculative market participants. A low of USD 1,592/oz was hit in mid-September, followed by a rebound to about USD 2,000/oz.

On average, the palladium price increased by 9% y-o-y to USD 2,398/oz in 2021.

Average annual palladium prices (USD/oz)



Source: LBMA

LBMA palladium price in 2021 (USD/oz)



1. Industrial incidents in Norilsk.
2. Nornickel lowers its mining production guidance by 15%–20% due to deferred resumption of operations at its mines.
3. Reports of potential metal shortages coupled with expectations of the automotive industry recovery led to a five-month high in net long speculative positions and the price hitting an all-time high.
4. US vehicle sales in June fall short of expectations. Car dealer inventory shortages and low production trigger a negative trend.
5. Vehicle sales in the European Union plummet by more than 20% amid a shortage of vehicles available for purchase.
6. Automotive industry recovery forecasts by leading analytical publications revised, pushing the recovery further out.
7. Net long speculative positions hit a 12-month low.
8. Growth of palladium imports to China and Hong Kong.
9. Rebound amid inflationary concerns.

Market Balance

Since 2010, there has been a sustained undersupply in the physical palladium market covered by inventories accumulated in previous years. The sources of previously accumulated palladium stockpiles include trading companies, financial institutions, government reserves, and consumers' surplus inventories.

In 2021, despite lower consumption compared to pre-pandemic levels, the market was in a small deficit due to a slow recovery in metal supply to 2019 levels.

Consumption decline was driven primarily by a shortage of chips used in the automotive industry and a resulting decrease in metal consumption in the catalytic systems of new vehicles. The automotive industry accounts for over 80% of palladium consumption. Meanwhile, metal consumption in other industries showed a marked recovery growth. 2021 also saw a positive trend in investment demand for palladium from ETF and retail investors.

Palladium production recovery to pre-pandemic levels in 2021 was hampered by temporary production suspension at Nornickel due to industrial incidents, as well as lower secondary palladium production due to a shortage of new vehicles available for purchase and reduced recycling of old vehicles. At the same time, palladium production in South Africa grew significantly, preventing an acute shortage of the metal on the market.

Palladium market balance in 2021

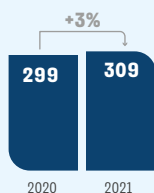
(t)

Production and consumption balance	-2
ETF inflow	1
Change in other inventories	2
Supply and demand balance	-1

Consumption

IN 2021, INDUSTRIAL CONSUMPTION OF PALLADIUM INCREASED BY 10 TONNES (+3%) Y-O-Y TO 309 TONNES.

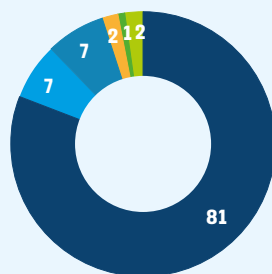
Industrial consumption of palladium in 2020–2021 (t)



Source: Company data

Palladium consumption in 2021 by industry (%)

309 t



- Exhaust aftertreatment systems
- Electronics
- Chemical catalysts
- Dental alloys
- Jewellery
- Other

Source: Company data

Automotive industry. Exhaust treatment systems account for the bulk of total palladium consumption. In this sector, palladium is used in catalytic converters which are mandatory for road transport and legally regulated in most countries.

Due to its unique catalytic properties ensuring effective chemical reactions throughout the entire vehicle life cycle, palladium has virtually no alternatives in this sector, except platinum, which is currently used mostly in diesel vehicles and rhodium, which is subject to high price volatility and risk of physical metal shortage due to an already significant share of the automotive industry in rhodium consumption and small market size (annual global production stands at 23 tonnes).

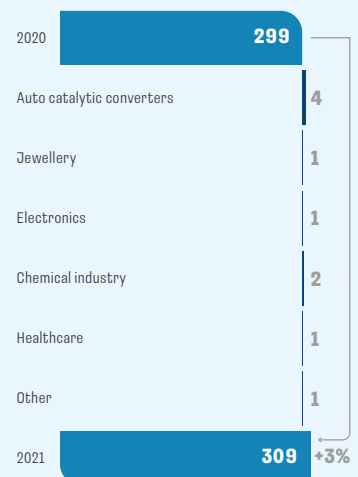
In 2021, palladium consumption in the automotive industry increased by 4 tonnes. The increase was driven by the automotive industry's partial recovery from the pandemic-induced manufacturing constraints. In 2021, a total of 76 million cars were made, up 2% y-o-y. Car production could have recovered much faster had it not been affected by semiconductor shortages, particularly in 2H 2021. Global car production lost a total of 8 to 9 million units because of the shortage of electronic components.

Moreover, demand is further boosted by higher PGM (platinum group metals) loading in autocatalysts. Higher PGM loadings per vehicle were primarily driven by stricter regulations on pollutant emissions. The US continues tightening emission requirements under Tier 3 standard. In China, higher palladium loadings per autocatalyst were driven by tougher environmental requirements of China 6b standard. The Euro-7 standard, which will be announced in 2022 and implemented in 2025, is expected to increase the usage of palladium in cars sold on the European market.

Changes in the fleet mix also boosted palladium consumption among automakers as light diesel vehicles were further replaced with petrol cars and hybrids, which make greater use of palladium-based catalytic converters for exhaust fumes. The market share of diesel cars in Europe (27 EU countries + UK + European Free Trade Association (EFTA) countries) dropped from 35.1% to 21.4% over the year.

Vehicle hybridisation is another trend driving palladium consumption. Production of hybrid-electric vehicles, so called mild, full and plug-in hybrids (PHEVs), increased by 56%, 29% and 79%, respectively. Since hybrids have petrol engines, they mostly use palladium-based catalytic converters. With the same engine displacement as the conventional petrol vehicle, the hybrid has a higher loading of the metal due to more frequent cold starts.

Change in palladium consumption in 2020–2021 by application (t)



Source: Company data

Electronics. In 2021, palladium consumption in the electronics industry increased by 1 tonne to 20 tonnes. In recent years, the use of palladium in multi-layer ceramic capacitors has been in decline, becoming limited to the most sophisticated products with a focus on reliability and performance in harsh environments, such as those in the defence and aerospace industries. Given the metal price inelasticity of demand in these sectors, its consumption is expected to remain flat. Transition to 5G networks and autonomous vehicles should also somewhat offset lower demand elsewhere. Moreover, despite disruptions at electronics assembly facilities due to lockdowns, the work-from-home trend driven by the pandemic bolstered demand for laptops and TV sets.

Chemical industry. In 2021, the use of palladium in chemical catalysts increased by 2 tonnes y-o-y. In the medium term, growing consumption of palladium in the chemical industry will be driven by production capacity additions in China (particularly for caprolactam and monoethylene glycol from coal).

Healthcare. Although demand for palladium from the healthcare sector increased by 1 tonne in 2021 as dental clinics returned to normal operations after the strictest phase of the lockdown, the long-term trend for palladium demand in this industry is negative due to its replacement by alternative composites and products made of gold, which is currently cheaper.

Jewellery. Palladium is used in white gold alloys or in its pure form to make jewellery such as wedding rings. In 2021, palladium consumption in the jewellery industry increased by 1 tonne, edging closer to pre-pandemic levels amid an overall recovery in economic activity. However, it is worth noting that in recent years, demand for palladium in jewellery production has been falling due to palladium overtaking the price of gold.

Investments. Investor demand for palladium increased by 2 tonnes in 2021 on the back of higher demand from exchange-traded funds (ETFs), whose inventories grew by 1 tonne to 19 tonnes. Retail investments into bullion grew by 1 tonne again in the reporting year.

Production

In 2021, primary refined palladium production increased by 12% y-o-y to 217 tonnes.

Production in the Russian Federation, the key producer of palladium, slipped by 7% to 81 tonnes due to a temporary shutdown of the Oktyabrsky and Taimyrsky Mines flooded by groundwater and suspension of operations at the Norilsk Concentrator.

Production in South Africa surged (+33 tonnes) to 90 tonnes in 2021 amid recovery from the nationwide COVID-19 lockdown and the processing of previously accumulated work in progress, primarily by Anglo American Platinum.

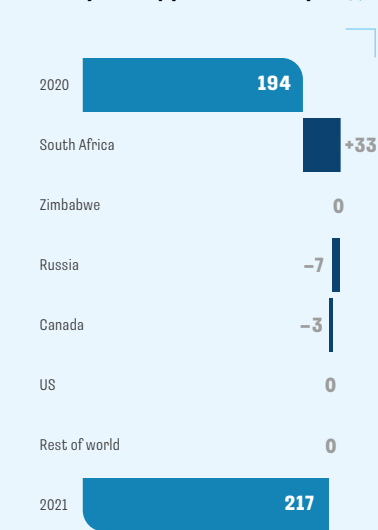
Primary palladium output in the United States and Zimbabwe did not change

significantly as operations in these regions were less affected by pandemic-related restrictions in 2020.

Primary palladium output in Canada dropped by 3 tonnes, mostly due to a decrease in Vale's output caused by a two-month strike of its employees.

The main sources of recycled palladium supply are scrapped auto catalytic converters, as well as jewellery and electronic scrap. In 2021, recycled output declined by 7 tonnes to 90 tonnes due to COVID-19 restrictions and a drop in new vehicle sales which, in turn, impacted the supply of vehicles for recycling.

Annual primary palladium output (t)



Source: Company data