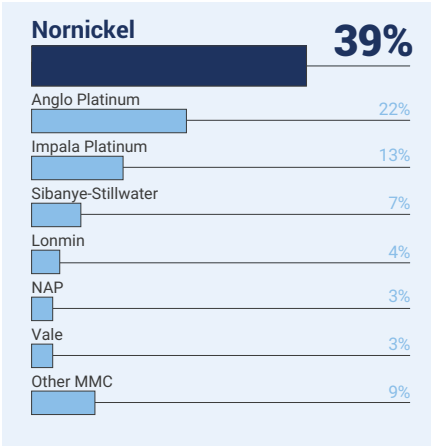
PALLADIUM

Pd

No. 1
in palladium production[1]



Source: *Company data*

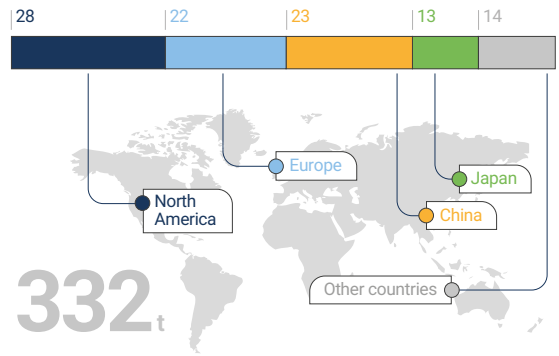
[1] *Refined metal including own feedstock under tolling agreements at third-party facilities.*

Key trends in the palladium market

2018

Palladium prices grew for a third consecutive year on the back of increased consumption in the car-making industry amid tightened environmental standards across the world and limited metal production. The deficit was offset by supplies of previously accumulated reserves.

Industrial consumption of palladium by regions *(%)*



Outlook: positive. The market deficit is expected to widen, as industrial consumption will grow faster than production, which is set to climb at a moderate pace.

Source: *Company data*

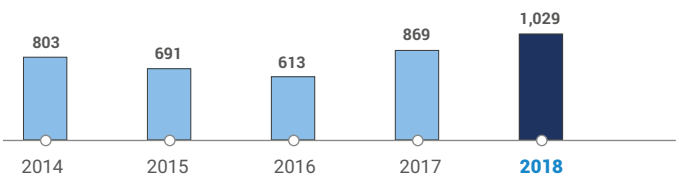
In January–August 2018, palladium prices experienced a moderate downward correction following two years of growth. Profit taking by speculative traders, who reduced their long speculative positions in the futures market, put pressure on prices. In the same period, a deficit in the spot market was partially offset by producers selling their reserves and ETFs scaling down their direct investments in the physical metal.

Driven by continued quantitative easing in the EU and Japan and the Federal Reserve's efforts to raise interest rates, a stronger US dollar negatively affected the price of the entire precious metal basket in the first half of 2018.

In the middle of the year, concerns about the effects of the escalating trade war between the US and China also put pressure on commodity prices as this conflict may have a negative impact on the growth of both industrial production and global GDP.

In the second half of August, palladium prices resumed their growth. The pressure put on prices by speculative investors, including macro funds and algorithmic traders, was mitigated by strong support from the deficit in the spot market. A stronger backwardation in the forward

Average annual palladium prices *(USD/oz)*



market and a spike in leasing rates prompted a shift in investor sentiment together with an increase in net long speculative positions in the futures market.

Another driver behind investors' growing interest in commodities was an overheated equity market in the US, which mainly ensued from industrial stocks and peaked out in early October.

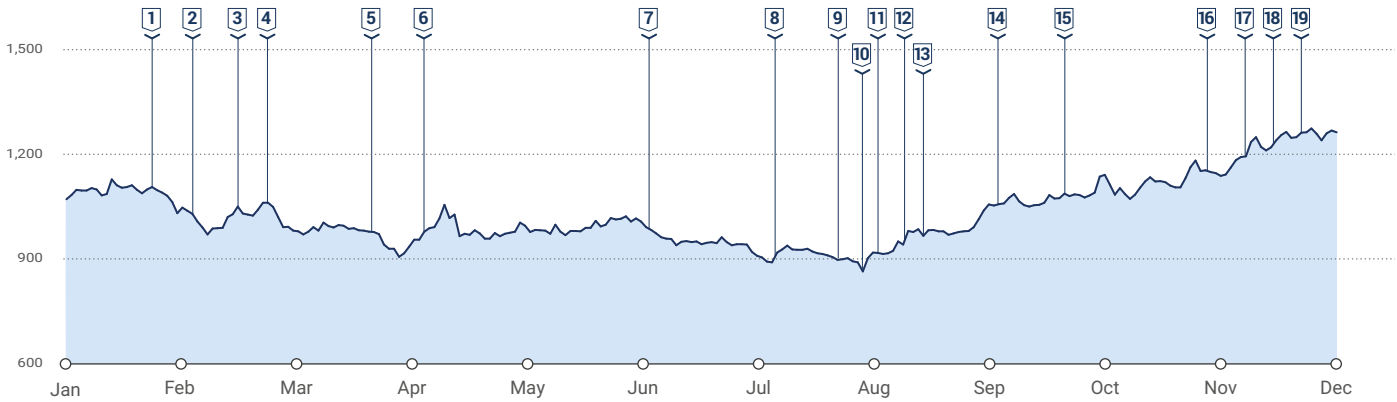
Throughout the year, prices were supported by long-term fundamental factors, such as many years of a sustained market deficit that saw palladium production lagging behind consumption; an increasing share of petrol cars; growing production of cars with hybrid propulsion systems; and expectations of a surge in palladium use within catalysts in automobile exhaust treatment systems – a trend triggered by tougher environmental requirements in key markets.

At the same time, PGM prices were constrained by slowing automobile production, especially in China, where falling car output and sales came as a result of lower consumer spending amid worries about the trade conflict with the US causing an economic slowdown. However, the negative effect from the car production decrease in absolute terms was fully offset by larger per unit use of palladium in exhaust treatment systems, which was facilitated by new standards for verifying environmental compliance of cars (WLTP and RDE tests) and environmental regulations (China 6, Euro 6d, the US's Tier 3, etc.).

During the year, palladium prices gained 20%, reaching an all-time high of USD 1,273 per oz (AM and PM Fix average, LBMA) on 20 December and averaging USD 1,029 per oz (up 18% vs the previous all-time high in 2017).

Together with other PGMs rhodium, iridium and ruthenium, palladium remained among the strongest performers in the commodity markets, with its premium to platinum reaching 60% by the year-end – the highest level since 2001.

Key industry developments and palladium price in 2018 *(USD/oz)*



1 Massive closing of long speculative positions

2 Dow Jones lost 11%

3 Dow Jones regained 8%

4 US released weak car sales data for February

5, 7, 14, 19 US Federal Reserve raised interest rates

6 Sanctions against RUSAL announced

8 US imposed first round of tariffs on Chinese goods

9 Impala Platinum announced a restructuring plan for the Lease Area (Rustenburg), providing for production cuts in the medium term

10 The US Dollar Index reached local highs of 97 p.

11 Spike in leasing rates

12 EU introduced the new WLTP emissions test cycle

13 US imposed financial sanctions against Russia

15 Dow Jones reached all-time high

16 South Africa's competition authorities approved Sibanye-Stillwater's takeover of Lonmin

17 US released strong car sales data for November

18 China released weak car sales data for November

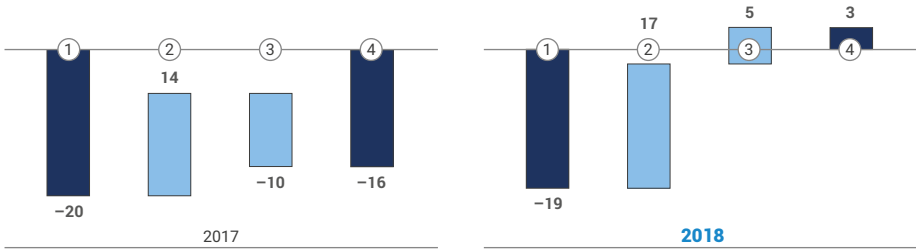
Sources: *LBMA, Company data*

Market balance

Since 2010, there has been a sustained undersupply in the palladium market covered by the consumption of accumulated reserves.

In the reporting period, the imbalance was largely offset by producers' reserves (including Nornickel's Global Palladium Fund) and the outflow from ETFs.

Palladium market balance[1] *(t)*



1. Production and consumption balance
2. Outflow from ETFs and retail investments
3. Reserve accumulation
4. Demand and supply balance

1. Production and consumption balance
2. Outflow from ETFs and retail investments
3. Destocking
4. Demand and supply balance

[1] *Excluding reallocated other reserves.*

Source: *Company data*

Consumption

In 2018, industrial consumption of palladium increased by 6 t (up 2%) compared to the previous year, hitting a new all-time high of 332 t.

Car-making industry. Exhaust treatment systems account for the bulk of total palladium consumption. In this sector, palladium is used in catalytic converters to detoxify exhaust fumes. In most countries, such converters are legally required to be installed on all cars.

Due to its unique catalytic properties ensuring effective chemical reactions throughout the entire vehicle life cycle, palladium has almost no alternatives except for platinum, which is used mostly in diesel cars, and rhodium. Given the significant share of already produced vehicles and small market size (global production stands at 24 t annually), rhodium suffers from high price volatility and the constant risk of physical metal deficit.

In 2018, palladium consumption by the car-making industry went up by 5 t and broke the record of 266 t. This was mostly driven by tougher regulations on pollutant emissions, including the Worldwide Harmonised Light Vehicle Test Procedure (WLTP) – a new procedure for establishing the CO2 emissions of new cars that will come into effect in the EU and Japan in September and October 2019, respectively. It is designed to make tests more rigorous by extending their distance and duration, increasing the car weight, requiring faster acceleration, and stipulating that testing should be performed at different altitudes and temperatures. Another upcoming regulation is Real Driving Emissions (RDE), to be applied starting September 2019. These developments forced car makers to implement more sophisticated exhaust treatment systems and expand the use of PGMs per catalyst.

The marked increase in palladium consumption by the car-making industry in China came on the back of toughened environmental requirements as part of the China 6 rollout across the country starting from 2019 and beyond. China 6 regulations are based on best practices in emission control as developed in the US and EU, and in some aspects set out additional requirements. In the US, 2018 saw the continued rollout of the Tier 3 standards to more than halve the fleet-average NOx emissions.

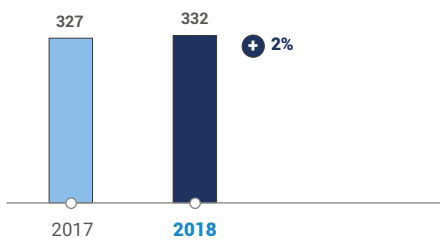
Changes in the transport also boosted palladium consumption among the car makers as more light diesel vehicles were replaced with petrol cars and hybrids,

Palladium consumption in 2018 by industry *(%)*

	%	t
Exhaust treatment systems	80	267
Chemical catalysts	8	26
Dental alloys	5	15
Jewellery	4	12
Electronics	2	7
Other	1	5

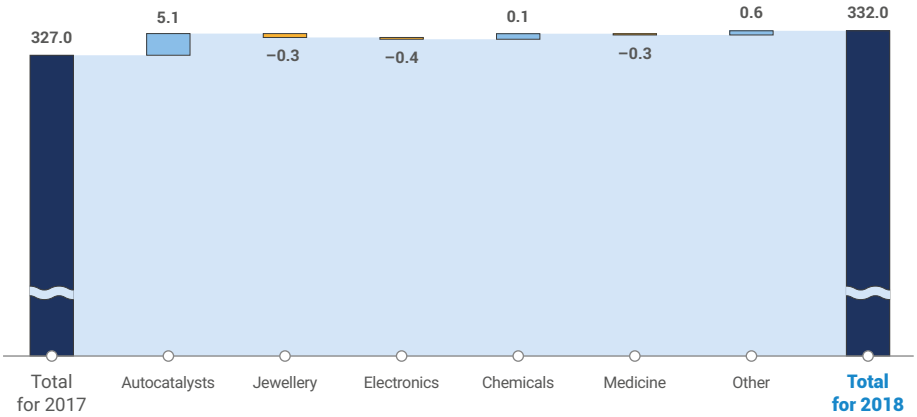
Source: *Company data*

Industrial consumption of palladium *(t)*



Source: *Company data*

Palladium consumption in 2017–2018 by application area *(t)*



Source: *Company data*

which make greater use of palladium-based catalytic converters for exhaust gases. The market share of diesel cars in Europe (27 countries) dropped from 44% to 36% y-o-y, the lowest since 2001.

Hybridisation is another positive trend in terms of palladium consumption, with production of mild, full and plug-in HEVs up by 22%, 46% and 46%, respectively. Petrol engine being a component of a hybrid necessitates wide use of palladium-based catalysts. Having the same displacement as the internal combustion engine, the hybrid uses more of the metal than a traditional petrol engine due to more frequent cold starts.

The growing use of PGMs in the car-making industry is also indirectly driven by consumers migrating from sedans to crossovers with larger engines.

Despite a significant expansion of 61% y-o-y, cars using batteries without PGM-based exhaust catalysts remained a niche market (2% of global car production).

Total car production around the world shrunk by 0.5% y-o-y, causing a drag on the industry's palladium consumption. The worst performer was China, the largest market globally. Its car makers showed a 4% decline as household spending fell amid worries about the trade war with the US prompting an economic slowdown. In North America, Europe and Japan, car production was almost flat, while automotive markets in Russia, India and Brazil grew markedly (up 14%, 8% and 7%, respectively). As mentioned above, the negative effect from decreasing overall car production was fully offset by more extensive use of palladium per vehicle.

By the end of 2018, an upward trend seen throughout the year pushed its premium vs platinum close to 60%. Nevertheless, there have been no signs of platinum replacing palladium within petrol cars catalysts. This would require additional research, reconfigured exhaust systems and changed engine settings, all of which is unlikely due to tougher emission requirements. Any new catalyst must be certified before production, and car makers would have to invest heavily in the above-mentioned, both time- and money-wise. Those costs would only be recoverable if the metal's premium to platinum became long-term. However, the palladium market has been experiencing backwardation (forward prices decrease as maturities extend further), while platinum has been in contango (forward prices increase with maturities). On the typical automotive planning horizon of two years, this resulted in the two metals trading around the same level in 2018.

Hybridisation

is a positive trend in terms of palladium consumption

Electronics. Palladium consumption in the electronics industry continued a moderate downward trend in 2018 (down 0.4 t). In recent years, the use of palladium in multi-layer ceramic capacitors has been in decline, reaching a point where it is limited to the most sophisticated products with a focus on reliability and performance under harsh conditions, such as those in the defence and aerospace industries. Given the metal price inelasticity of their demand, consumption in these sectors is expected to remain unchanged. However, the use of palladium as an electroplating material for connectors and lead frames continued to reduce, although the decrease in per unit consumption was partially offset by an output growth in absolute terms. The final months of the reporting period saw it attract a premium to gold, which, if sustained over a long time, might encourage manufacturers to favour the latter. In the long term, consumption of palladium in the electronics industry may be boosted by proliferation of the IoT and sensor-rich autonomous vehicles.

Chemical industry. The use of palladium in chemical catalysts went up for a second consecutive year to add 1 t in 2018 as a result of new capacities coming on stream, particularly under the Chinese programme to ensure self-sufficiency in basic chemicals. In the mid-term, growing consumption of palladium in the chemical industry will be driven by newly launched terephthalic acid capacities in China.

Healthcare. In the healthcare sector, palladium demand continued declining (down 0.4 t) due to transition to alternative composites. Japan, the largest consumer of the metal in dental prostheses (within the so-called Kinpala alloys), has been going down by an average of 8% annually in recent years, the country's Ministry of Health reports.

Jewellery. In this industry, palladium is used in white gold alloys or, in its pure form, to make wedding rings, as an example of the latter. Its jewellery-related consumption decreased by 0.3 t in 2018. A drop in the Chinese demand for these products amid a general slowdown in consumer spending and a shift to other luxury goods was the primary cause of this continued downward movement. Palladium jewellery sales were also affected by growing prices for the metal. Due to a lack of marketing support, it is often regarded as a cheaper alternative to platinum, especially when it comes to men's wedding rings. Its average premium vs platinum (17% in 2018) put pressure on the demand for palladium rings.

According to The Goldsmiths' Company Assay Office in London, 62,000 palladium articles (fineness of at least 500 ppt) were hallmarked in the UK during the year, which is 26% less than in 2017. However, buying palladium rings is still economically efficient as the metal's lower density allows producing twice as much jewellery per ounce compared to platinum.

Investment. Investment demand for palladium kept shrinking in 2018. The main reason was withdrawals from ETFs, which reduced their reserves by 17 t to 25 t – the lowest since 2009. The outflow amid growing palladium prices was driven by investors reallocating their capital to futures and other instruments to benefit from the backwardation. Retail investment demand grew slightly in the reporting period (up 0.4 t).

The use of palladium in chemical catalysts **went up for a second consecutive year to add 1 t**

Production

In 2018, primary refined palladium production contracted by 2% to 213 t.

Russia, the metal's major producer, saw a minor drop in output (down 2.1 t) due to MMC Norilsk Nickel terminating the third party feedstock processing.

South Africa, the world's No. 2 palladium producer, demonstrated a 3.7 t reduction in 2018. The main reason was a decline in refined palladium output experienced by Anglo American Platinum as repairs at two smelters prevented the company from processing the entire volume of ore mined. This was despite a considerable growth in production both by its own facilities and by joint ventures, as well as increased feedstock procurement from third parties. As part of its programme to restructure and close down unprofitable mines, Lonmin also slightly reduced output.

At the same time, Impala Platinum, despite some problems in smelting, boosted refined metal production in 2018, and Northam Platinum notably increased output thanks to processing the previously accumulated ore and concentrate inventories at the new smelter launched in the reporting period.

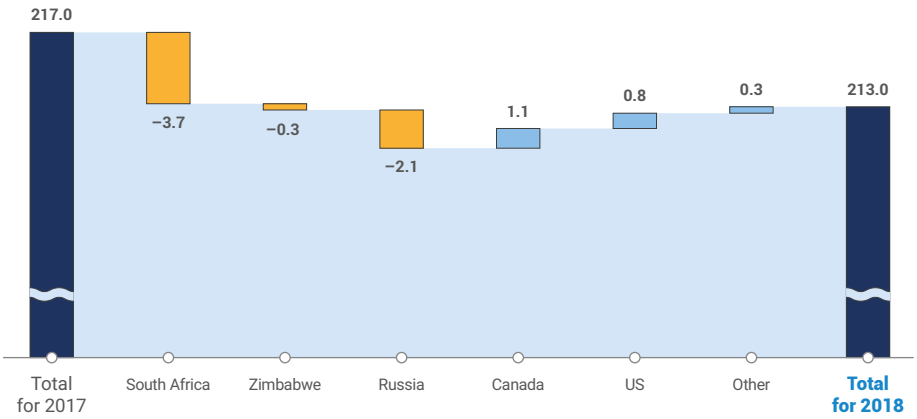
In Zimbabwe, output was close to the previous year's levels (down 0.3 t). Zimplats and Mimosa recorded a slight decline, with production returning to the 2016 rates. Unki reported a moderate growth in output.

Primary palladium production in Canada grew by 1.1 t, with North American Palladium as the largest contributor. Thanks to third-party feedstock, Glencore also posted an increase in production, while mining at its own projects shrank. Vale's output declined owing to the depleted resource base in Sudbury. The US saw a rise in production by 0.8 t. Sibanye-Stillwater, the only palladium producer in the country, increased output after launching the Blitz project.

The main sources of recycled palladium are used automotive exhaust gas catalysts, as well as jewellery and electronic scrap. In 2018, recycled output grew by 10 t to 100 t as collection of autocatalyst scrap increased on the back of higher prices for palladium and high prices for steel scrap. Jewellery and electronic scrap volumes remained flat.

The sources of previously accumulated palladium stockpiles include trading companies, financial institutions, government reserves, and surplus inventories of consumers. In 2017–2018, Nornickel's Global Palladium Fund (GPF) supplied the market with more than 1 moz of palladium on top of its own output – a reserve created through purchases from third parties.

Annual primary palladium output in 2017–2018 *(t)*



Source: *Company data*