3

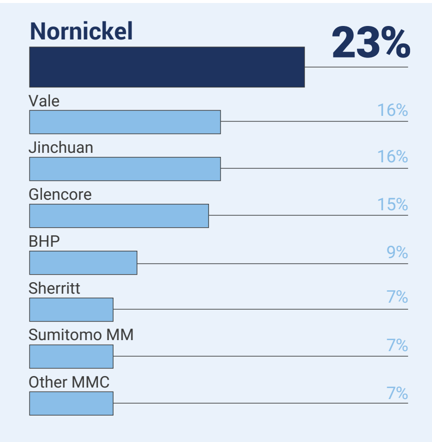
Markets commodity


НОРИЛЬСКИЙ НИКЕЛЬ

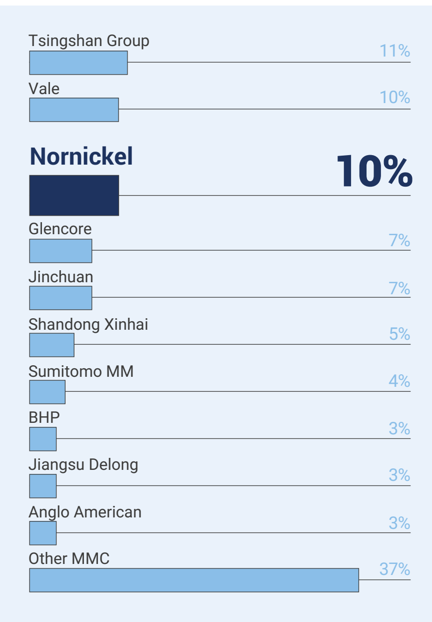
NICKEL

Ni

No. 1
in high grade nickel production



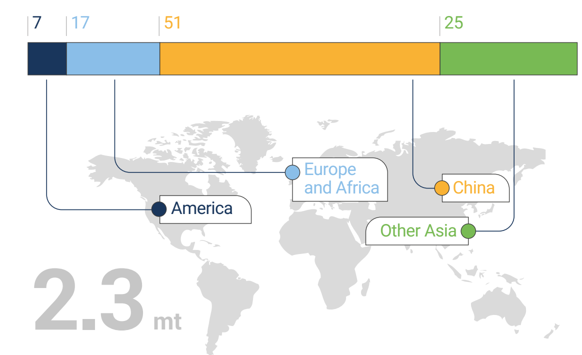
No. 3
in primary nickel production



Key trends in the nickel market

In 2018, the nickel deficit grew on the back of higher demand (primarily for stainless steel production in Indonesia and cathode materials for lithium-ion batteries) and slower production growth. Increased output of NPI, ferronickel, nickel sulphate, and other salts could not offset the deficit stemming from the decline in nickel metal and powder production.

Primary nickel consumption by region *(%)*

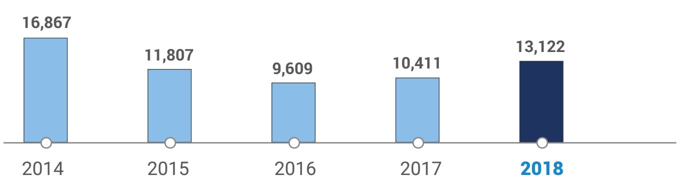


Outlook: cautiously optimistic. In 2019, the market deficit may go down to 50 kt as a result of significant increase in NPI production in Indonesia and China.

Source: *Company data*

An expected boom in the electric cars' sector and major outflows from the London Metal Exchange (LME)'s stocks triggered by the increased demand contributed to higher nickel prices in late 2017 through June 2018. In the second half of 2018, the escalating US-China trade war reversed the trend, and in October 2018, market concerns over a potential construction of large-scale lateritic nickel ore leaching facilities in Indonesia pushed the prices further down.

Average annual nickel price *(USD/t)*



In 2018, the average nickel price grew by

26%

Source: *LME (settlement)*

Nickel price and keyindustry developments in 2018 *(USD/t)*

1 › Rise in the US Federal Reserve interest rate

2 › The Company's announcement of planned delisting of Polar Division's cathodes on LME starting 18 April erroneously interpreted as new sanctions against Russian products introduced together with RUSAL sanctions

3 › The US considering import duties on Chinese imports worth USD 50 bn

4 › Consistent decline in the LME stocks, higher stainless steel production and expected electric car boom

5 › Rise in the US Federal Reserve interest rate

6 › The US announcing import duties on Chinese goods worth USD 50 bn

7 › The US announcing import duties on Chinese goods worth USD 200 bn

8 › Rise in the US Federal Reserve interest rate

9 › Announcement of planned construction of large-scale lateritic nickel ore leaching facilities in Indonesia for battery components

10 › Rise in the US Federal Reserve interest rate

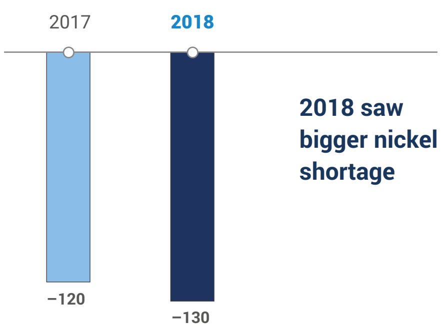
Source: *LME, Company data*

Market balance

In 2018, nickel shortage went up to 130 kt mainly driven by a 7%, or 159 kt y-o-y increase in metal consumption largely attributable to the Asian producers of stainless steel and batteries. At the same time, primary nickel production grew by 7%, or 148 kt. Only nickel production from lateritic ore was on the rise: in 2018, low grade nickel production increased by 16%, or around 170 kt y-o-y, mainly due to the Chinese and Indonesian NPI output growth. High grade nickel production decreased by 2%, or 22 kt, largely on the back of production cutbacks in Canada.

During the year, total LME and SHFE stocks decreased by 191 kt (47%) to 219 kt, which is about 4.5 weeks of global consumption.

Primary nickel production – consumption balance *(kt)*



2018 saw bigger nickel shortage

Source: *Company data*

Consumption

Nickel consumption is predominantly driven by the stainless steel industry (over 70% in 2018). Stainless steel comes to the market in various grades from all over the world, whereas its smelting structure ultimately determines the primary nickel consumption patterns. **Austenitic stainless steel** comprising the 200 series and 300 series steel is the most widespread type of that product (over three quarters of the global production). The 300 series steel has a higher nickel content (normally 8–12%, or up to 20% in a number of select grades). Nickel added in this proportion improves the steel's corrosion resistance and robustness in a wide range of temperature conditions, boosts its ductility and durability in aggressive environments, and enhances its non-magnetic properties. This series enjoys the highest demand, as it is applied in various industries, including construction, food and chemicals manufacturing, transportation, energy, etc. The 200 series steel cannot serve as a full substitute for the high nickel content grades, as it has a lower nickel content due to the addition of manganese. The 200 series steels are susceptible to surface (pitting) corrosion and non-resistant to heat and aggressive environments. Due to the lower price, this steel grade is often used in the production of consumer goods, such as home appliances. China and India account for over 90% of the total 200 series steel output.

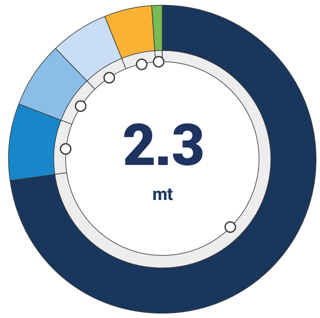
Austenitic-ferritic (duplex) stainless steels also use nickel and are characterised by a higher content of chromium (18–25%) and molybdenum (1–4%), but they account only for 1–2% of the global smelting output.

Ferritic and martensite stainless steels (400 series) usually do not contain nickel, while their properties are similar to those of low-carbon and highly corrosion-resistant steels. However, their mechanical properties are inferior to those of austenitic stainless steels. These steels are mainly used to manufacture automotive exhaust systems, cargo container frames, water heaters, washing machines, utensils and cutlery, kitchenware, home decor items and razor blades.

In 2018, the total stainless steel output increased by 5% and hit a record high of 50.3 mt. The growth was driven by a rise in 300 series steel production to over 2 mt at the Indonesian facility launched in mid-2017, one of the largest stainless steel facilities globally. Indonesia is a new steel market player with a robust growth outlook. The country has sufficient reserves of high grade lateritic ore, growing NPI capacities and, hence, low cash cost of austenitic stainless steel.

Over 50% of Indonesian stainless steel exports from January to October 2018 headed to China, primarily in form of slabs and hot-rolled steel. Growing imports had a negative impact on China's 300 series

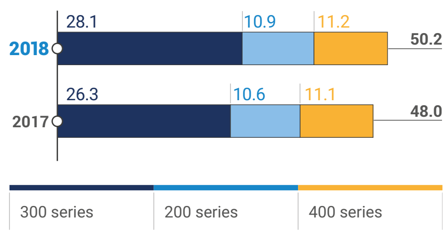
Primary nickel consumption in 2018 by industry *(%)*



	%	mt
Stainless steel	73	1,681
Alloys	8	194
Special steels	7	153
Electroplating	6	147
Batteries	5	124
Other industries	1	14

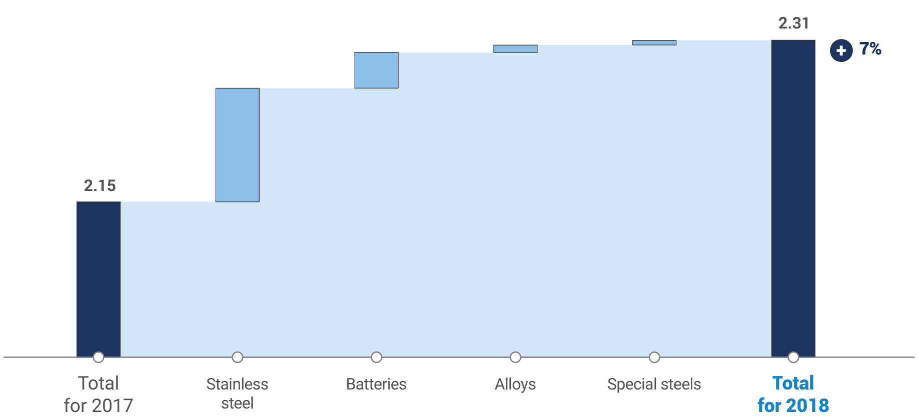
Source: *Company data*

Stainless steel production by grade series in 2017–2018 *(mt)*



Source: *Company data*

Primary nickel consumption in 2018 *(mt)*



stainless steel output, where it stayed flat according to our estimates.

Taiwan, the second largest importer of Indonesian stainless steel, also reported a 15% drop in domestic production. With that, the primary nickel consumption went down by only 8 kt because of the historically high use of scrap in the country. Other regions saw consistent 2–4% growth of austenitic stainless steel production.

Consumption of primary nickel by the global stainless steel producers rose by 7% to 1.68 mt as a result of an increase in the global 300 series and 200 series output by 7% and 4%, respectively, and a slight decrease in the average share of scrap. However, the use of high grade nickel in stainless steel smelting went down by 60 kt mostly due to the growing availability of low grade nickel.

Nearly all types of nickel feedstock are used in stainless steel production (except for a number of specific products, including nickel powder and compounds). Since the quality of nickel barely affects the quality of conventional stainless steel grades, the manufacturers opt for the cheapest nickel feedstock, turning to high grade nickel as their last resort. This is the reason why high grade nickel share has been declining in the structure of nickel units consumed in stainless steel production in recent years.

The battery industry uses nickel as a major component of the active cathodes for battery cells. The extent of nickel utilisation depends on the battery type.

Lithium-ion batteries (Li-Ion). Li-Ion batteries were first commercially released in 1991 and became fairly widespread in most areas due to their high energy capacity retained after multiple recharge cycles.

Nickel-metal hydride batteries (Ni-MH). Ni-MH batteries were developed in 1989 as a substitute for Ni-Cd batteries to avoid using cadmium. Currently, though, the nickel-metal hydride battery market is growing at a slow pace (with hybrid vehicles being its only growth driver) and faces considerable competition from the lithium-ion batteries.

Nickel-cadmium batteries (Ni-Cd). The first nickel-cadmium batteries were developed in 1899. Currently, their use is restricted, since cadmium is prohibited as a toxic substance under the EU ban.

The key driver behind Li-Ion battery growth is electric vehicles gaining ground.

In 2014–2018, CAGR of electric cars (plug-in HEVs and battery electric cars) has been around 46%. The key factors driving electrification of the transport system are incentives offered by the state, more stringent environmental controls, and improved technical specifications of batteries.

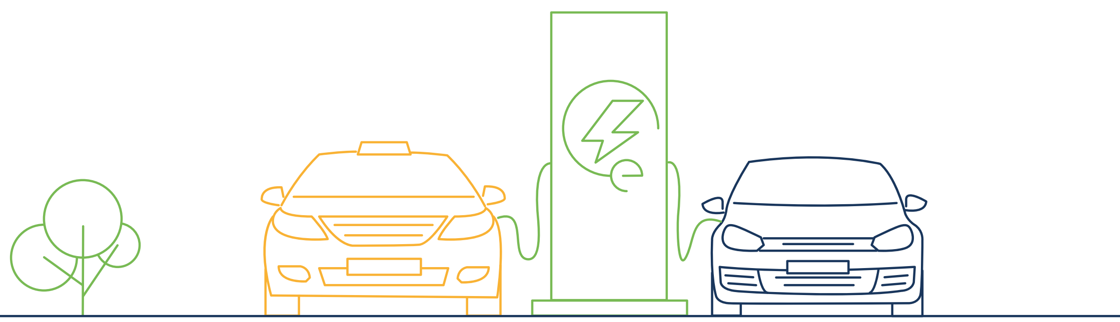
The electric car market growth is led by China. By 2020, it plans to increase the NEV (electric cars and plug-in HEVs) sales to 2 mln, and by 2025 – up to 7 mln vehicles. The Chinese government has implemented a number of initiatives to stimulate transport electrification, including subsidies for buying electric cars and mandatory requirements for large automakers regarding the production of electric cars and plug-in HEVs. In large cities and regions, the trend is supported by local initiatives.

Buyers of electric cars in a number of other countries, including Belgium, Germany, the UK and France, enjoy considerable subsidies and fiscal incentives. For instance, Norway (where electric cars account for 30% of all sales) grants tax exemptions (one-off registration tax and VAT) to buyers. Also, annual electric car tax is six times lower than that for a car powered by an internal combustion engine.

The key driver behind Li-Ion battery growth is **electric vehicles gaining ground**

~46%

CAGR of electric cars (plug-in HEVs and battery electric cars) in 2014–2018



USD 100 bn

of investments in electric cars earmarked by automakers

5%

growth of primary nickel consumption for alloys

The investments in electric cars earmarked by automakers already amount up to USD 100 bn.

There are several types of lithium-ion batteries depending on the cathode materials: LCO (lithium, cobalt oxide), LFP (lithium, iron, phosphate), LMO (lithium, manganese oxide), NCM (nickel, cobalt, manganese), NCA (nickel, cobalt, aluminium).

LCO is primarily used in portable electronic devices, but given high cobalt price coupled with unstable chemical compounds and low energy capacity, LCO is not applied in electric vehicles. However, other types of cathodes are widely used in the industry. LFP and LMO tend to be replaced with other cathode materials containing nickel as a result of a higher gravimetric and volumetric capacity of NCM and NCA, which helps to increase mileage.

The share of NCM and NCA in the total cathode material output used in Li-Ion batteries (excluding LCO) went up from 32% in 2012 to 78% in 2018.

Growing nickel consumption in Li-Ion batteries comes not only on the back of increasing share of nickel-containing types, but also higher average nickel content in the cathode material triggered by the need to substitute expensive cobalt units. While in 2016 NCM 1:1:1 (with nickel mass fraction of 20%) accounted for the lion share of nickel-magnesium compounds of the cathode material, in 2018 nickel-intensive compounds – NCM 6:2:2 (with nickel mass fraction of 36%) and NCM 5:3:2 (30%) took the lead. Going forward, batteries are expected to switch to NCM 8:1:1 (with the nickel mass fraction of 48%), and some producers announce plans to launch commercial production of LNO, a cathode material with nickel content of over 50%.

Further development of the automotive industry, the growing popularity of electric and hybrid cars, along with the evolution of the cathode technology towards nickel-intensive types lay the groundwork for major expansion of primary nickel consumption in this industry in the long run.

In 2018, the growth of primary nickel consumption for alloys stood at 5%, primarily driven by high demand from the aerospace industry. Heat-resistant alloys with high nickel content are among the key materials for aircraft engines. The order backlog of the major passenger aircraft producers is estimated at 7–10 years, and will support the nickel demand from the industry.

Importantly, the demand for nickel alloys from the oil and gas industry has recovered on the back of the oil price growth in the first half of 2018. Nickel is widely used in decorative and protective platings with their thickness ranging from 1 to 100 microns. Nickel electroplating is highly corrosion-resistant, hard and pleasing aesthetically. It is used for corrosion protection, and as an alternative to chromium plating. In recent years, China has been the leading manufacturer of nickel electroplating products. Since 2012, though, the electroplating industry has started to develop in other Asian countries, and the Chinese businesses are now transferring their production to achieve cost savings.

Production

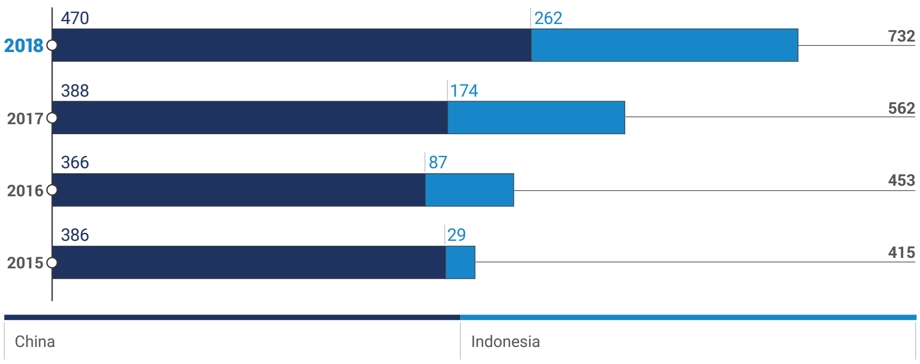
Primary nickel can be split into two major groups:

High grade nickel (cathodes, briquettes, carbonyl nickel and compounds) is produced from both sulphide and lateritic nickel ore. In 2018, the major high grade nickel producers included Nornickel, Jinchuan, Vale, Glencore, Sumitomo Metal Mining and BHP Billiton.

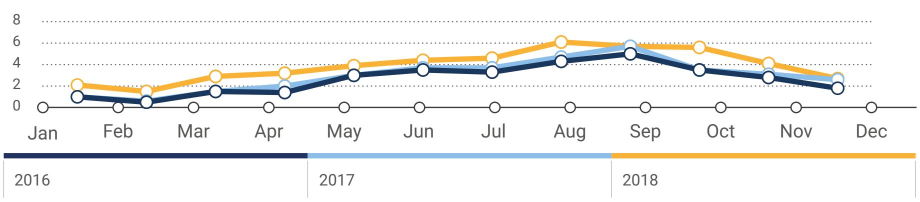
Low grade nickel (ferronickel, NPI and nickel oxide) is only produced from lateritic ore. In 2018, the major low grade nickel producers included Chinese and Indonesian NPI companies and also ferronickel producers: Eramet, Anglo American, South 32, Pamco and Posco (SNNC).

In 2018, primary nickel production grew by 7%, or 148 kt y-o-y, driven only by an increase in low grade nickel output (ferronickel and NPI). Compared to 2017, the low grade nickel production grew by 16%, or 170 kt.

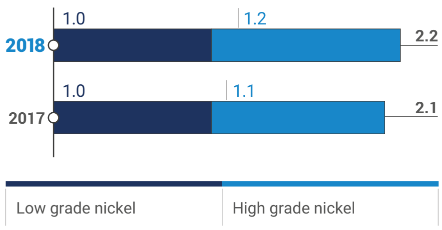
NPI production in 2015–2018 *(kt)*



Nickel ore and concentrate imports to China in 2016–2018 *(mt)*



Primary nickel production in 2017–2018 *(mt)*



Source: *Company data*

In 2018, high grade nickel output dropped by 2%, primarily driven by the following factors:

- discontinued nickel cathode production in Canada;
- reconfiguration of key players' production assets, including the upgrade of the Company's refining facilities;
- lower nickel briquette output on Madagascar due to hurricanes and in Canada on the back of shortages in Cuban feedstock supplies caused by heavy rains.

148 kt

of primary nickel production growth in 2018

This was coupled with greater output of nickel sulphate that serves as a key feedstock for the precursors of the cathode material in Li-Ion batteries. Apart from the integrated production of nickel sulphate through matte, the key sources of feedstock for nickel sulphate are the hydrometallurgy semi-products and crude nickel sulphate, a by-product of copper and PMG production. The shortage of primary feedstock for nickel sulphate production entailed higher demand for nickel briquettes and powders as well as scrap batteries in 2018.

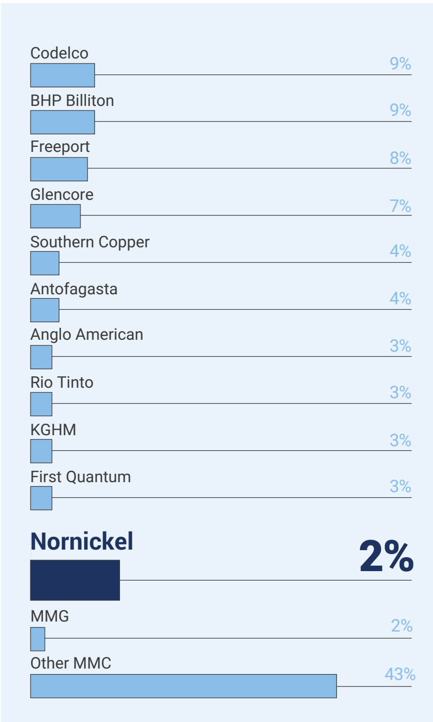
The growth in low grade nickel production was significantly above the decline in high grade nickel production. The global low grade nickel output growth in 2018 amounted to 16% as a result of increased NPI production in China and Indonesia and ferronickel production in all key regions except Europe, where a number of manufacturers had to cut output.

The key driver behind NPI production growth was the lifting of the ban on exports of unprocessed nickel ore from Indonesia in March 2017 contributing to the availability of rich nickel ore. China's total ore imports in 2018 grew by 34% and amounted to 47 mln wet tonnes, boosting the national NPI output growth by 21%, to 470 kt.

COPPER

Cu

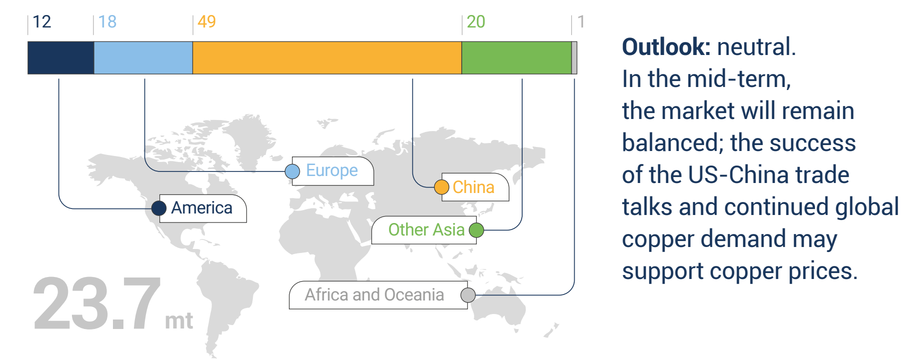
No. 11 by copper mining in 2018



Key trends in the copper market

2018
The prices surged in the first half of the year amid expectations of strikes at copper mines in Chile and Peru with a strong copper demand from EV manufacturers and then plunged in the second half of the year on the back of failed strikes and an escalation of the US-China trade tensions causing concerns over weaker demand.

Refined copper consumption by region *(%)*



Outlook: neutral. In the mid-term, the market will remain balanced; the success of the US-China trade talks and continued global copper demand may support copper prices.

Source: *Company data*

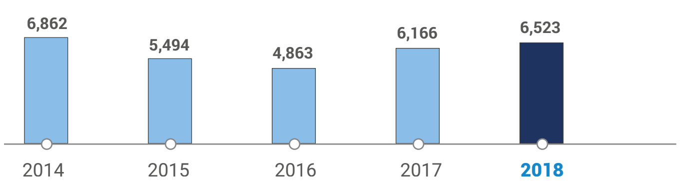
A slight decline in copper prices in the first quarter of 2018 as a result of lower imports in China and higher metal exchange inventories reversed in the second quarter, peaking at USD 7,300 per tonne, the highest over the last 4.5 years. The price growth was triggered by expectations of a deficit in the copper market in 2018 due to looming strikes at mines in Chile and Peru due to negotiations with trade unions on new labour agreements, amid lower copper exchange inventories.

In the second half of June, investor concerns over a possible slowdown in the global economic growth resulting from a risk of a trade war between the USA and the European Union and China led to a drop in copper prices, sinking to the year's minimum of USD 5,823 per tonne by early September.

In the fourth quarter of 2018, prices stabilised in the range of USD 6,070 and USD 6,330 per tonne due to the demand and supply balance. However, in December, the pessimism of market players about the US-China trade tensions surged again. In addition, Chile and Peru saw a successful signing of labour agreements. These were the reasons behind a decline in copper prices to USD 5,965 per tonne at the end of the year.

In 2018, the average LME copper price increased by 6% y-o-y to USD 6,523 per tonne vs USD 6,166 per tonne in 2017.

Average annual copper prices *(USD/t)*



Source: *LME (settlement)*

LME copper prices in 2018 *(USD/t)*

1 › BHP Billiton report posting production growth

2 › Copper import growth in China following scrap import restrictions

3 › Success in negotiations on the Grasberg mine sale to the government of Indonesia

4 › Signing of labour agreements at several mines in Chile and Peru

5 › Substantial growth in exchange inventories

6 › Threat of strikes at the Escondida and Chuquicamata mines

7 › Report posting production growth in Chile

8 › Increase in Chinese copper concentrate and cathode imports

9 › Successful signing of labour agreements at the Escondida mine

10 › Rise in the US Federal Reserve interest rate

11 › Introduction of US import duties on Chinese imports worth USD 50 bn

12 › Signing of a new permit for the concentrates export from Indonesia

13 › BHP Billiton and Rio Tinto reports posting production growth

14 › Short strike at the Chuquicamata mine

15 › Introduction of US import duties on Chinese imports worth USD 200 bn

16 › Strike at Andina mine (Chile)

17 › Research group reports on tightening market deficit

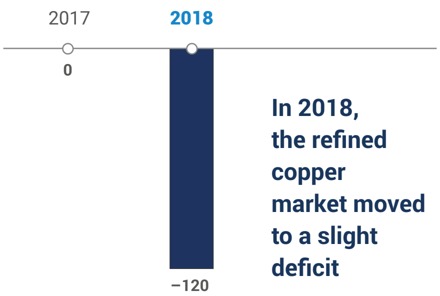
18 › Growing concerns about the consequences of the US-China trade tensions

Sources: *LME, Company data*

Market balance

In 2018, the refined copper market that had been balanced by the end of 2017 moved to a slight deficit. It stood at as little as 0.5% of the total market volume, or 120 kt. Total exchange inventories dropped by 35% to 351 kt (544 kt as at the end of 2017), or a little more than nine days of global consumption, with off-exchange inventories going slightly up.

Refined copper balance *(kt)*



In 2018, the refined copper market moved to a slight deficit

Source: *Company data*

Consumption

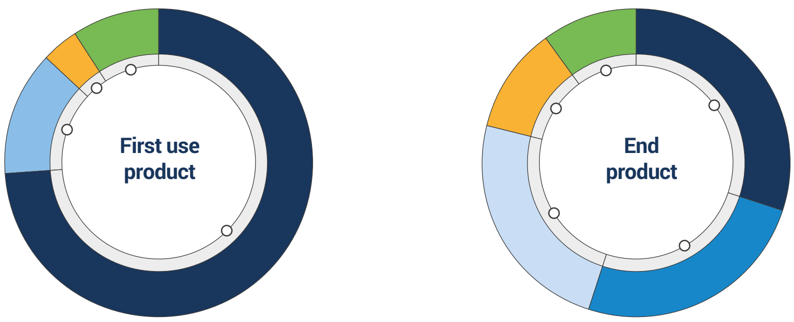
Given its high electrical and thermal conductivity, ductility and corrosion resistance, copper is widely used in various industries. Up to 75% of refined copper produced globally is used for manufacturing electrical conductors, including various types of cable and wire. Key copper-consuming industries include construction, electrical and electronic equipment manufacturing, power supply, transport, engineering, machine building and consumer goods production.

In 2018, global consumption of refined copper totalled 23.7 mt (up 3%, or 0.7 mt y-o-y), primarily owing to stronger demand from cable and wire manufacturers. Consumption in pipe, flat rolled products and billet production segments saw moderate growth.

China remains the key copper consumer globally, with its market share reaching 49% in 2018 due to the demand growth of 5%. Market concerns about China's economic slowdown (also due to the US-China trade tensions) did not materialise. The country kept ramping up copper imports and copper feedstock in particular. In 2018, Chinese refined copper imports added 13% to reach 5.3 mt offsetting a one-third drop in copper scrap imports due to the environmental constraints imposed by the state. Copper concentrate imports went up by 14% to 19.7 mt, which helped to meet China's growing consumption needs through the ramp-up of local production.

The demand for copper in developed economies saw only a moderate increase in 2018, with Europe (the Company's key market for copper cathodes) and North America up by 1.7% and 3.2%, respectively, and Asia (excluding China) remaining flat. Russian domestic copper cathode consumption in 2018 was moderately down.

Refined copper consumption by industry *(%)*



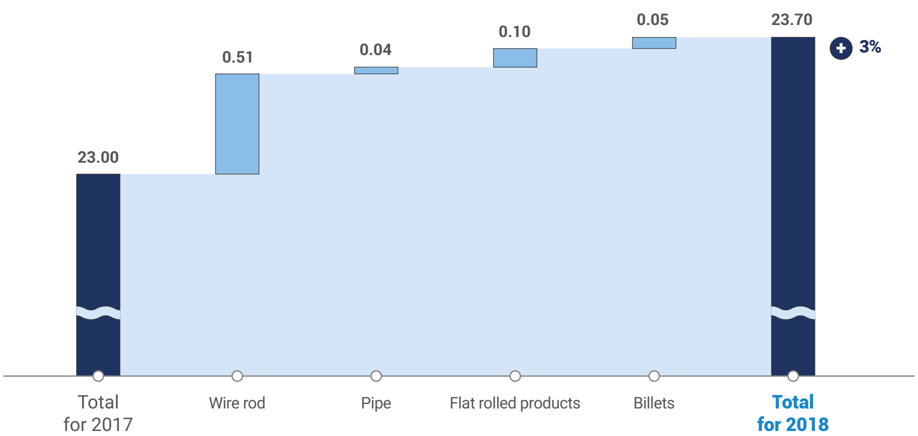
Wire rod	74
Flat rolled products	13
Billets	4
Pipe	9

Construction	30
Consumer goods and equipment	25
Power grids	24
Transport	11
Heavy engineering	10

Total **23.7** mt

Sources: *Company data, Wood Mackenzie*

Changes in refined copper consumption in 2018 by industry *(mt)*

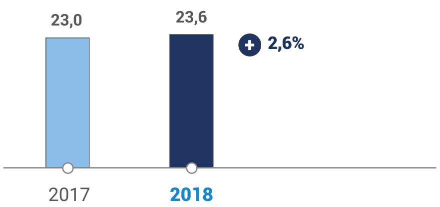


Sources: *Company data, Wood Mackenzie*

The demand for copper in developed economies saw **a moderate increase** in 2018

Production

Refined copper production in 2017–2018 *(mt)*



Sources: *Company data, Wood Mackenzie*

In 2018, global production of refined copper increased by 2.4%, or 0.56 mt, compared to 2017, totalling 23.6 mt. China remains the production leader, firmly committed to the expansion of domestic smelting and refining capacities. In 2018, refined copper production in China grew by 5% to 8.7 mt, while its share in global output was 37%. Only 20% of Chinese production is local extraction, with another 80% coming from imported copper concentrates and scrap.

In the rest of Asia (excluding China), production dropped by 2.7% (going down in India and Philippines, and up in Japan). In North America, it grew by 3.5% (up in the USA and Canada) and in South America, output remained unchanged. In Europe, copper production slipped by 1.4% triggered by Germany and Poland. According to preliminary estimates, Russia's production of refined copper saw modest growth.

In 2018, global copper production grew by 2.8% to 20.7 mt. Some 2.9 mt of refined copper was produced from accumulated concentrate stockpiles and scrap on the back of higher scarp collection in the first half of the year driven by higher copper prices. The growth in copper production came mainly on the back of the recovered production in Chile (facing a significant drop due to strikes a year earlier), a significant increase in production in Africa (Democratic Republic of the Congo and Zambia), in Indonesia (following the lifted state ban on concentrate exports) and the development of Chinese domestic mining industry.

Chile, the top global supplier of copper, saw a 5% production increase y-o-y (to 5.8 mt) in 2018 due to a 1.5-month strike at BHP's Escondida, the largest copper mine, where the workers did not agree with the conditions of their new labour agreements. The country also kept facing a lower output by the state-owned Codelco (1.8 mt, down 2% y-o-y) owing to a lack of investments in the old fields with declining copper grade.

A 12% growth in African production to USD 2.4 mt was mainly backed by KOV and Kamoto mines in the Democratic Republic of the Congo and Sentinel mine in Zambia.

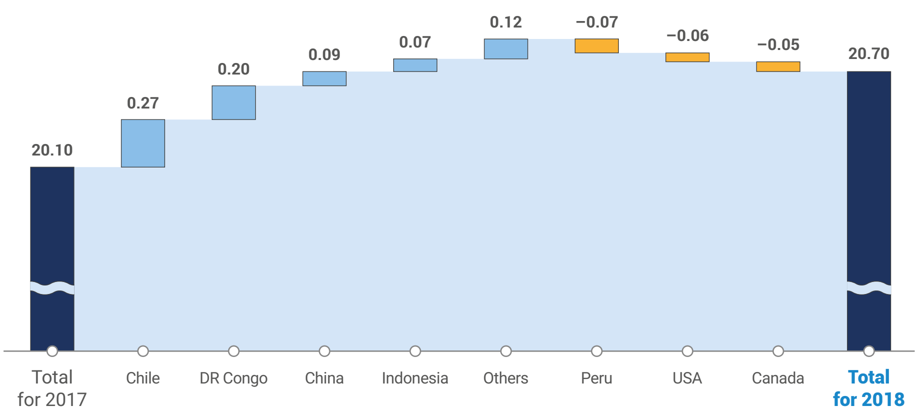
China, which is currently developing smaller mines, saw its production grow by 6% to 1.6 mt. Indonesia saw its copper output go up by 10% to 0.7 mt after the government lifted the ban on copper concentrate exports following the decision of Freeport-McMoRan and Rio Tinto to sell a majority stake (51%) in the Grasberg mine to Indonesia. In Kazakhstan, development of the new Bozshakol mine by KAZ Minerals drove the output up by 7%.

In Peru, production was below the expectations (2.3 mt, down 3% y-o-y) caused by some technical issues of lower copper output at the new Las Bambas mine purchased by China's MMG from Glencore several years ago. In North America, production dropped by 4% to 2.6 mt due to declining copper contents along with technical issues at some small mines in the USA and Canada.

According to preliminary estimates, Russia saw its production grow by about 6%.

The actual refined copper production for 2018 was above the analyst forecasts issued early in 2018 thanks to the production surge above expectations. The actual refined copper consumption was also above the analyst forecasts thanks to China maintaining its demand and the USA even increasing it despite the ongoing trade tensions between these two countries. This brought the global deficit close to the initial estimates.

Copper production in 2017–2018 *(mt)*

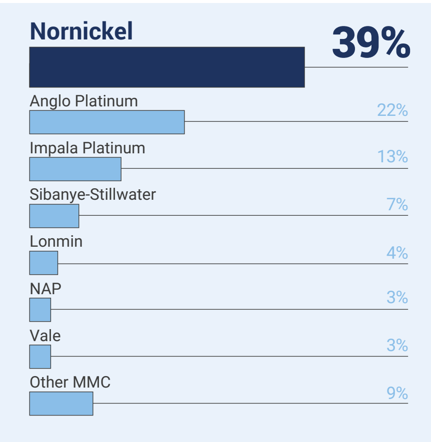


Sources: *Company data, Wood Mackenzie*

PALLADIUM

Pd

No. 1 in palladium production[1]



Source: *Company data*

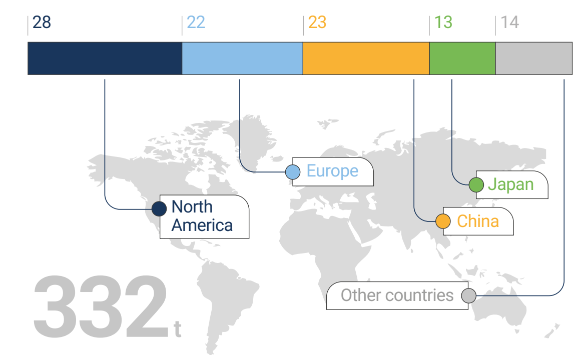
[1] *Refined metal including own feedstock under tolling agreements at third-party facilities.*

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*

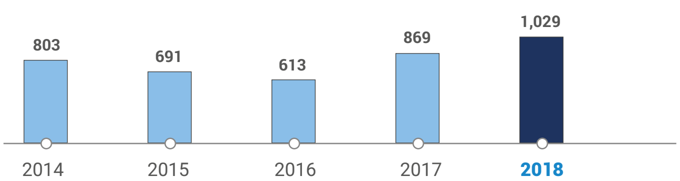
In January–August 2018, palladium prices experienced a moderate downward correction following two years of growth. Profit taking by speculative traders, who reduced their long speculative positions in the futures market, put pressure on prices. In the same period, a deficit in the spot market was partially 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.

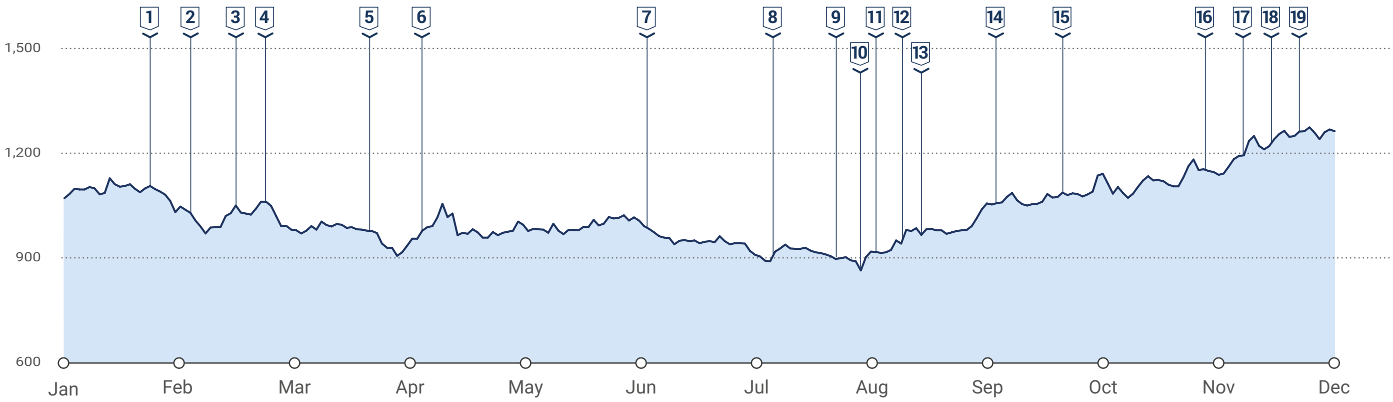
Throughout the year, prices were supported by long-term fundamental factors, such as many years of a sustained market deficit that saw palladium production lagging behind consumption; an increasing share of petrol cars; growing production of cars with hybrid propulsion systems; and expectations of a 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

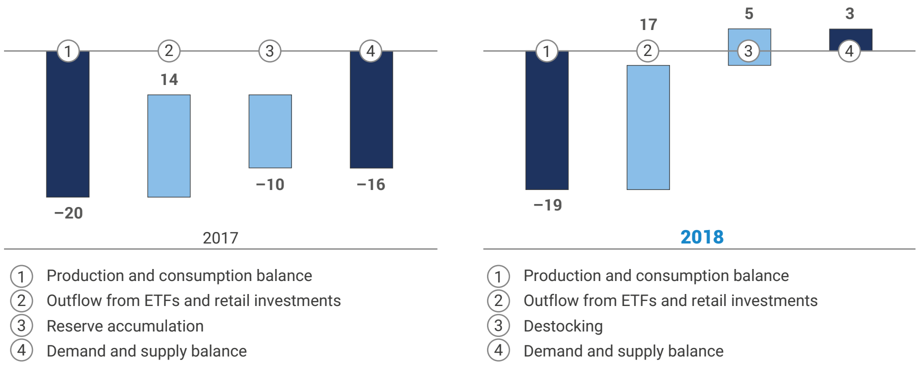
Sources: *LBMA, Company data*

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] *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.

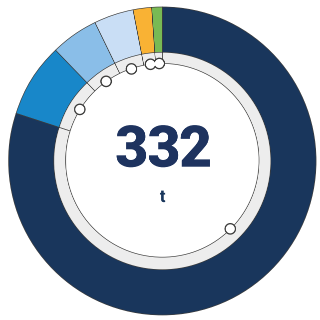
Due to its unique catalytic properties ensuring effective chemical reactions throughout the entire vehicle life cycle, palladium has almost no alternatives except for platinum, which is used mostly in diesel cars, and rhodium. Given the significant share of already produced vehicles and small market 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,

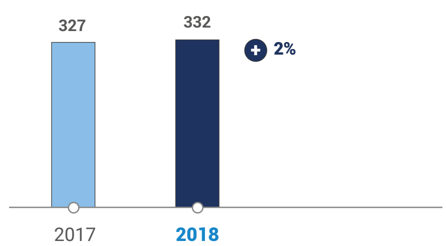
Palladium consumption in 2018 by industry *(%)*



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

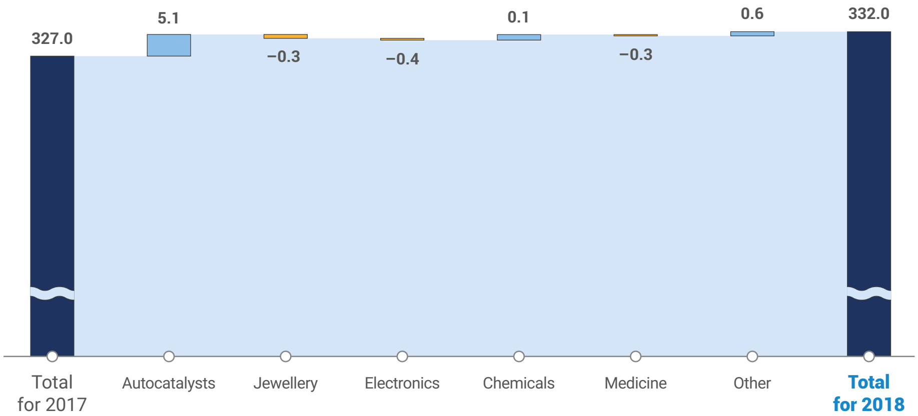
Source: *Company data*

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.

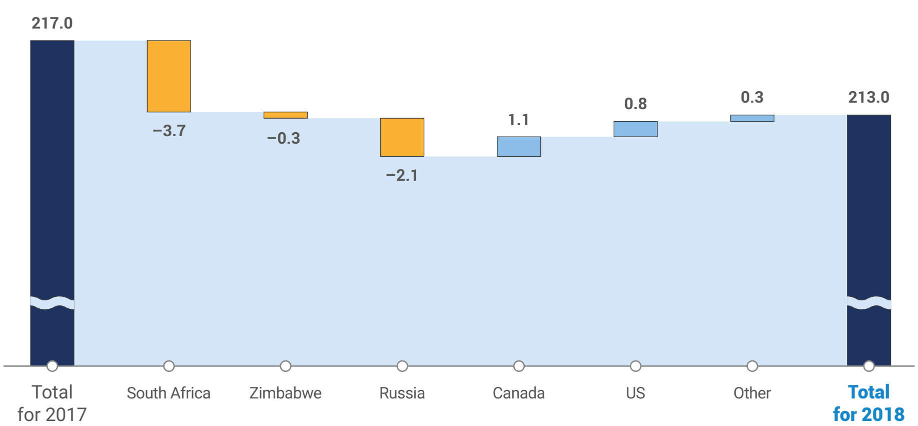
In Zimbabwe, output was close to the previous year's levels (down 0.3 t). Zimplats and Mimosa recorded a slight decline, with production returning to the 2016 rates. Unki reported a moderate growth in output.

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)*

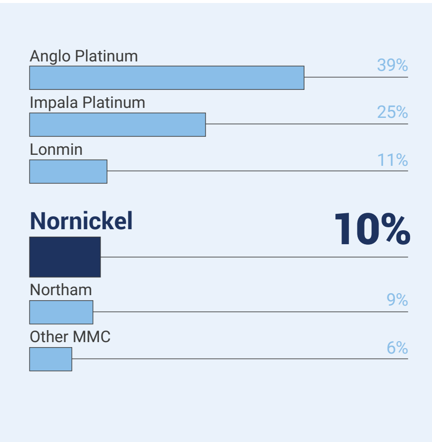


Source: *Company data*

PLATINUM

Pa

No. 4 in platinum production[1]



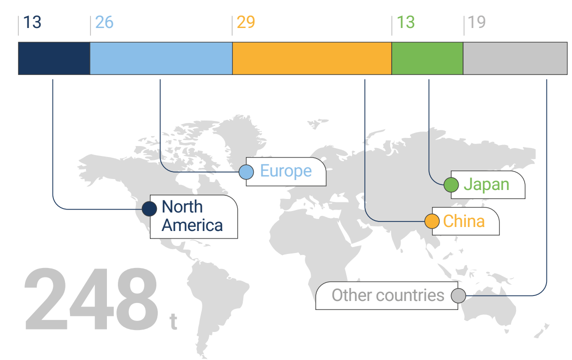
Source: *Company data*

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

Key trends in the platinum market

2018 The year saw the market gradually moving into a surplus amid a decline in consumption in the automotive and jewellery industries and weakness in investor demand. Platinum consumption by other industries also decreased, however this was largely offset by significant growth in the chemicals and glass sectors.

Platinum consumption by region *(%)*



Outlook: ocautiously positive. In 2019, demand for platinum is expected to recover modestly, supported by the tighter vehicles emission regulations, higher levels of consumption in other industries, and revitalised demand from investors.

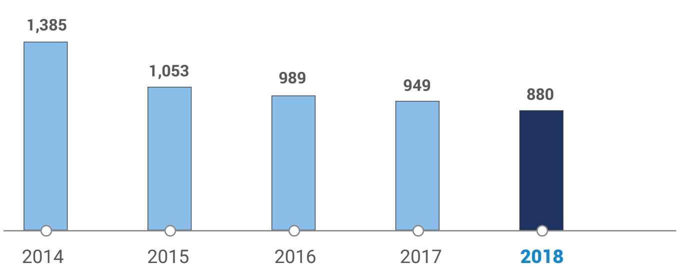
Source: *Company data*

In 2018, platinum prices faced downward pressure with the main decline registered between January and early September when the price slid from USD 1,019 per oz. to USD 774 per oz. (the average of LBMA AM and PM Fix) – the lowest since 2008. This was followed by a period of stabilisation, with the price at 794 per oz by the end of the year.

In the reporting period, platinum and gold prices moved closely together, indicative of platinum prices being highly dependent on the macroeconomic backdrop, which was largely unfavourable for precious metals last year. The pressure primarily came from the USD, which gained in value against the basket of major currencies driven by the Fed's hawkish stance on interest rates. While inflation expectations were low, investors were in no rush to move to the safe havens of precious metals.

Steady growth in the stock market between February and early October (S&P 500 up 9%) and high bond market yields (the average yield on 10-year US Treasuries in the reporting period was 2.9% against

Average annual platinum prices *(USD/oz)*



Source: *LBMA Platinum price*

2.3% a year earlier) diverted investor attention from precious metals.

On top of that, platinum consumption in the Chinese jewellery industry was hit by the threat of a trade war and economic slowdown in China.

Despite the general trend, the period from March through June and especially December saw platinum price lagging behind gold which resulted in a widening gold-platinum spread. While at the year's outset platinum traded 30% lower against gold, by the end of 2018 the gap reached as much as 40%, driven by the platinum market fundamentals and speculative pressure.

The main fundamental drivers included a drop in platinum consumption by the automotive industry due to reduced share of diesel passenger cars in the key markets (primarily, in Western Europe), no awaited recovery in demand from Chinese jewellers, and primary production not being too receptive to low prices.

Speculation was another big negative factor, with investors betting on a downward metal price trend. Between March and September, short positions in platinum on NYMEX increased threefold to 87 tonnes, falling back later to the levels observed at the beginning of the year. At the same time, long positions remained stable during the entire reporting period. Despite the record-low prices, investor demand was weak, with the outflow of investments from ETFs putting additional pressure on the price.

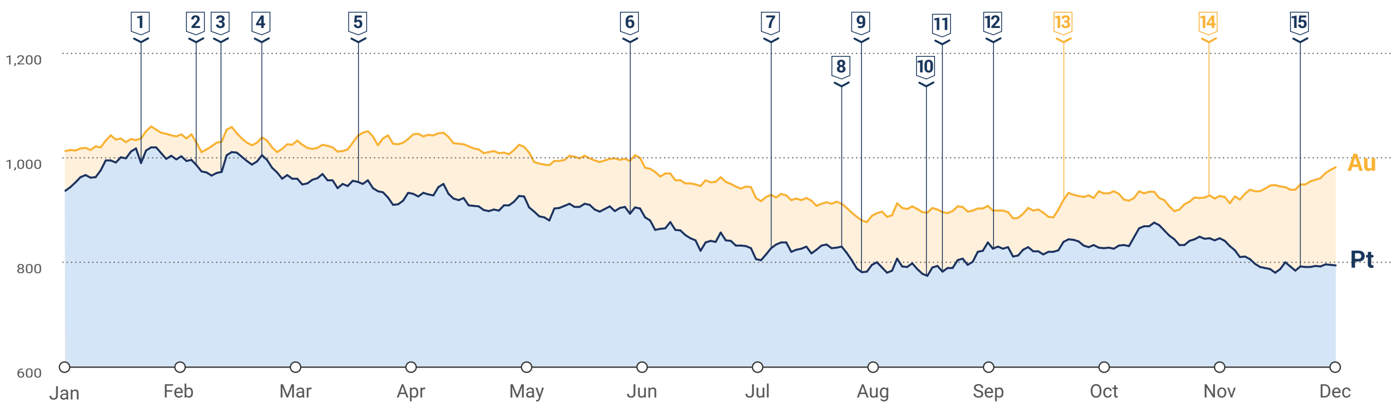
The prevailing negative sentiment dragged down the average platinum price in 2018 to 14-year lows (USD 880 per oz), down 7% from the previous year.

The platinum price stood at

USD 794 per oz.

at the end of 2018

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



1 › Speculative long positions on NYMEX reached the annual peak

2 › Dow Jones sank 11%

3 › Dow Jones regained 8%

4 › US released weak car sales data for February

5, 7, 14, 19 › US Federal Reserve raised interest rate

7 › US imposed first round of tariffs on Chinese goods

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

9 › The US Dollar Index reached local highs of 97 p.

10 › EU introduced the new WLTP emissions test cycle

11 › Long speculative positions on NYMEX hit the year's lows

13 › Dow Jones reached all-time high

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

Source: *LBMA, Company data*

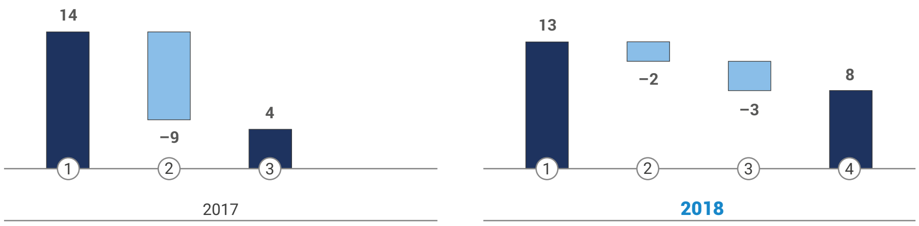
Market balance

The platinum market saw a surplus in 2018 as production of platinum exceeded consumption, though part of the extra supply was absorbed by demand from investors.

8 t

of surplus in the platinum market in 2018

Platinum market balance *(t)*



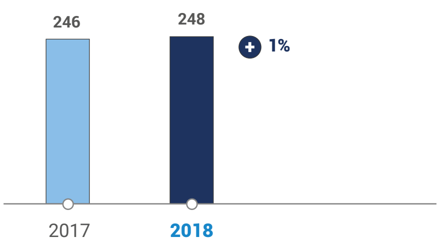
2017:
1. Platinum production and consumption balance
2. Inflow to ETFs and retail investments
3. Demand and supply balance

2018:
1. Platinum production and consumption balance
2. Inflow to ETFs and retail investments
3. Reserve accumulation
4. Demand and supply balance

Source: *Company data*

Consumption

Platinum consumption *(t)*

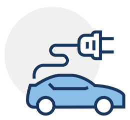


Source: *Company data*

1%

growth in the industrial consumption of platinum in 2018

Industrial consumption of platinum in 2018 rose to 248 t, up by 2 t (or 1%) y-o-y.



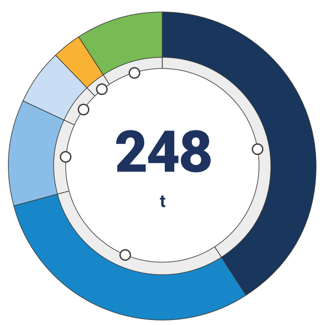
The automotive industry is the main consumer of platinum. Over 80% of platinum in this industry is used to manufacture exhaust gas catalysts for diesel vehicles.

In 2018, platinum consumption in the automotive sector decreased y-o-y by 5.6 t, which mainly had to do with a decreased share of diesel vehicles in their key market – Europe. The market share of diesel cars in Europe (27 countries) dropped from 44% to 36% y-o-y, the lowest since 2001.

Diesel engines are giving way to petrol-based solutions, and more expensive vehicles utilise hybrids (combining petrol and electric engines). Lower platinum consumption by car makers was partially offset by increased manufacturing of heavy-duty vehicles (up 2% y-o-y), catalytic devices of which still rely on platinum.

Diesel engines, together with hybrids, are the key and most cost-efficient solutions to achieve the EU's targets for reducing CO_2 emissions to 95 g/km by 2020. New diesel cars comply with the existing environmental

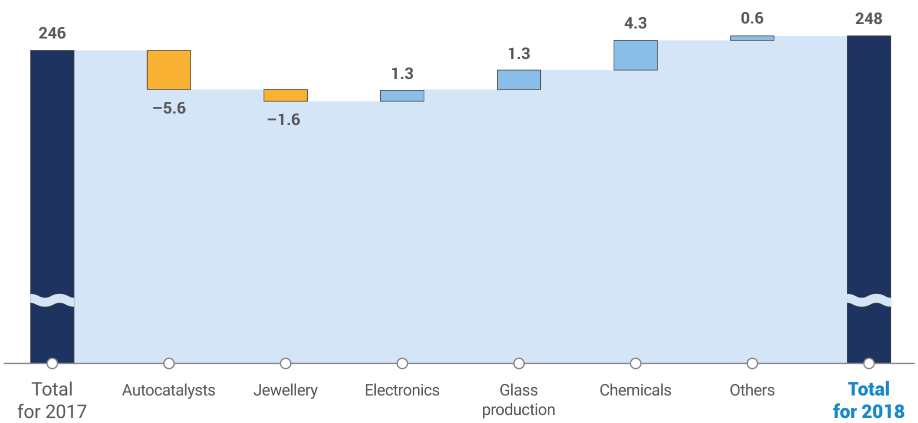
Platinum consumption in 2018 by industry *(%)*



	%	t
Exhaust treatment systems	41	101.6
Jewellery	30	74.0
Chemical catalysts	11	26.8
Glass production	6	14.5
Electronics	3	8.5
Other	9	22.4

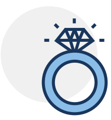
Source: *Company data*

Platinum consumption by application area *(t)*



Source: *Company data*

requirements, and automakers are working hard to restore confidence towards them, which may result in increased platinum consumption in the automotive industry.



The second biggest platinum consumer is **the jewellery industry**, accounting for a third of the demand. The reporting period saw a sustained declining trend of platinum consumption in the industry (down 1.6 t) that set in during the previous years. The decrease was primarily driven by lower jewellery demand in China due to consumers switching to other forms of investing and the falling demand for luxury goods amid fears about the country's economic performance. While China is currently facing growing competition in the platinum jewellery sector from gold items, other major markets (India, Japan, USA, and Europe) are enjoying increased platinum jewellery sales.

Chemicals. In 2018, primary platinum consumption in industrial catalyst manufacturing increased by 4.3 t, following the ramp-up of oil processing in Japan and other countries in Asia, growth of chemicals production in Western Europe and China, including the launch of new plants to produce nitric acid, paraxylene, silicone and other basic chemicals.

Glass. Platinum is needed to produce glass fibre and optical glass. In the reporting period, the industry's demand for platinum continued to grow (up 3.1 t), in line with the trend observed over the past five years. In recent years, glass fibre has been used in construction, renewable energy (as material for wind power plants), as well as in the automotive industry, where some metal parts of the car body are increasingly replaced by glass fibre equivalents. This accelerated the pace

The second biggest platinum consumer is **the jewellery industry**, accounting for **a third of the demand** at which new glass fibre manufacturing facilities were put into operation – first and foremost in China. Moreover, platinum is used along with rhodium in glass melting machines to produce LCD screens for many electronic devices. The robust growth in the consumer electronics sector over the recent years has led to the opening of many new LCD production facilities in Asia. An increase in the rhodium price premium to platinum is expected to potentially force glass melting equipment manufacturers to switch to higher platinum content alloys.

Electronics. The electronics industry saw a modest rise in platinum consumption (up 1.3 t) triggered by an increase in the platinum-based hard drive production due to the expansion of remote data storage capacities. However, in the personal computer sector hard drives are phased out for solid-state drives, which ensure better performance in PCs and mobile devices, but are too expensive to be used in data storage and processing centres.

Fuel cell production in recent years, platinum consumption in proton-exchange fuel cells, used in motor vehicles and stationary power plants, has been on the rise, reaching about 1.5 t in 2018. Major automakers like Toyota, Daimler, and Hyundai have launched sales of fuel cell vehicles (FCV), while China is actively developing fuel cell-powered buses manufactured by Yutong and other companies.

FCVs, just as the fully electric cars powered by rechargeable batteries, produce zero emissions, but unlike them have a larger ranger (500 km and over) and can be refuelled faster.

The Japanese government has announced plans to boost FCV production in the run-up to the Tokyo Olympics in 2020. Meanwhile, China expects to increase the number of FCVs to 50,000 by 2025, bringing it to 1 mln by 2030. With each fuel cell containing about 20 g of platinum, the industry is well positioned to become a major consumer of the metal in the next 5–10 years. On top of that, several cities in China have declared themselves "hydrogen cities", with city authorities introducing special FCV and hydrogen energy support measures.

Investments. Platinum is also widely used as an investment instrument. Physical investments may vary from coins and smaller bars to investments in ETFs that accumulate large amounts of platinum in the form of standard-sized bars. In 2018, the demand for platinum bars from retail investors slightly rose (up 6 t) due to low prices and expectations of their growth. During the year, the investments in platinum ETFs fell by 7 t to 76 t.

1.5 t

consumption of platinum for fuel cell production in 2018

Each fuel cell contains

20 g of platinum

FCVs, just as the fully electric cars powered by rechargeable batteries, **produce zero emissions**

Production

Global production of primary refined platinum in 2018 decreased by 3 t (down 2%) y-o-y to 191 t.

In the reporting period, supply from South Africa, the world's largest platinum producer, declined slightly (down 0.6 t). Anglo American Platinum reduced output of refined metal, despite a significant growth in production both at own projects and under joint venture arrangements, as well as increased feedstock purchases from third parties. This was due to repairs at two smelters, which prevented the company from processing the entire volume of ore mined. 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 technical problems in smelting, boosted refined metal production in 2018, and Northam Platinum significantly increased output thanks to processing the ore and concentrate inventories at the new smelter launched in the reporting period.

Russia recorded lower output (down 1.7 t), with continued production decline at the alluvial deposits in the Far East driven by the depletion of the mineral resource base. The negative trend was exacerbated by lower output from MMC Norilsk Nickel due to the termination of the third-party feedstock processing.

In Zimbabwe, output was close to the levels of previous years (down 0.2 t). A slight decline was recorded by Zimplats and Mimosa, with production returning to the 2016 rates. On the other hand, Unki reported a moderate growth in output.

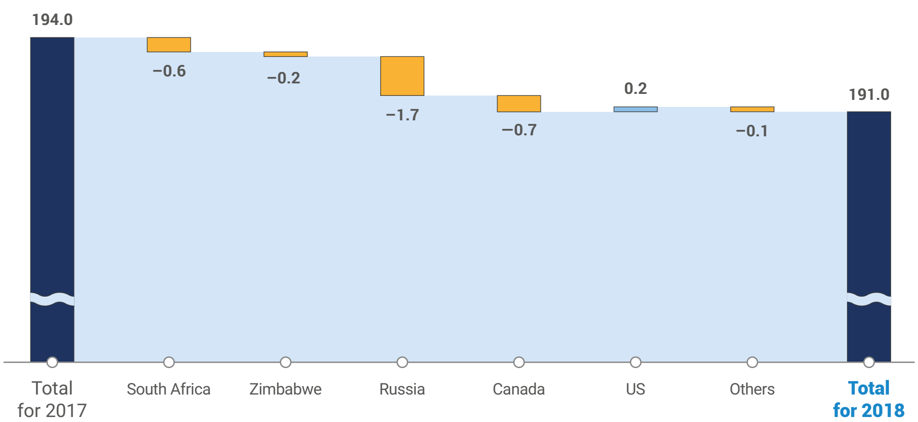
Primary platinum production in Canada dropped by 0.7 t mainly due to lower output by the Vale and Glencore assets, which was only partially offset by higher output from North American Palladium. The US saw a rise in production by 0.2 t. Sibanye-Stillwater, the only palladium producer in the country, increased output owing to the recently launched Blitz project.

The main sources of recycled platinum include used exhaust gas catalysts and jewellery scrap. Recycled output in 2018 grew by 4 t to 69 t, chiefly due to higher automotive scrap volumes. Collection of autocatalyst scrap increased on the back of high prices for steel and other PGMs and growing recycling volumes of European diesel cars with a high platinum content in the catalysts.

The growth of recycling was hampered by difficulties in using new types of silicon carbide based diesel catalysts. Being a refractory material it can damage furnaces unfit to handle it. This requires processors to sort through catalysts and separately process the material with high silicon content, taking extra time and resources.

The sources of previously accumulated platinum stockpiles include trading companies, financial institutions, and surplus inventories of consumers, while the movement of these inventories is non-transparent.

Primary platinum production in 2017-2018 *(t)*



Sources: *Company data, Wood Mackenzie*