Metals in electric car production

2017 MILESTONE

In July 2017, Nornickel signed a memorandum with BASF and began negotiations on a project to increase sales to manufacturers of batteries for electric vehicles.

“This is a pilot project. If it is successful, we can launch commercial production by 2020.”

“Today, markets are taking a new look at our products. The demand for palladium is growing. Cobalt and nickel are also benefitting from a positive trend supported by the production of batteries for electric vehicles. Accordingly, we are considering ways to increase shareholder value by adjusting our product portfolio to the requirements of new industries and new demand. We see current market expectations as somewhat inflated and do not commit ourselves to large-scale investments. Still, we are trying to be proactive in our marketing policy and proceed with what we call fine-tuning of our product lines.”

“We are an industrial company, not a venture one. For us, a responsible decision is to invest in successful technologies only.”

Vladimir Potanin
President of Nornickel

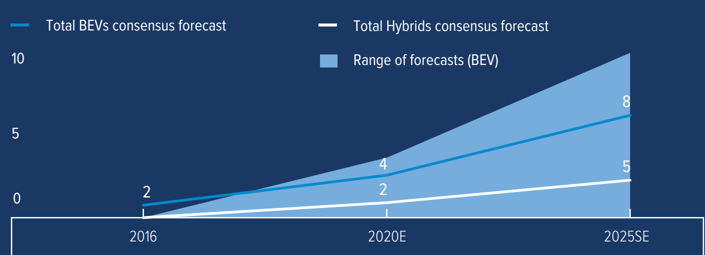
For the Company, this project is an opportunity to carve a niche in the attractive and rapidly growing market for rechargeable battery materials. Cooperation with BASF is part of Nornickel's strategy to develop environmentally-friendly technologies and make an active contribution towards improving the environment globally. Today, the Company provides manufacturers of automotive catalysts with essential chemicals capable of capturing dangerous exhaust fumes generated by petrol engines. By expanding the supply of metals for the automotive industry with its strong potential, the Company makes another step towards sustainable development.

KEY TREND IN THE GLOBAL AUTOMOTIVE INDUSTRY

The electric vehicle industry is clearly facing a period of intensive growth, which will boost long-term demand for key metals. However, so far experts have not come to a consensus on market growth projections. Sales forecasts for electric and hybrid cars vary from 2 mln cars to 11 mln cars per year by 2025.

Market outlook for 2035 is much more optimistic. BP projects the total number of EV and hybrids to grow to at least 100 mln globally. According to analysts from Carbon Tracker Initiative and Imperial College London, electric vehicles are expected to account for one third of the automotive market by 2035 and for more than a half by 2040. One of the most likely drivers of EV expansion will be government policy in many developed countries committed to introducing a broad range of incentives to promote the production of green cars, up to imposing an ultimate ban on the sale of cars with internal combustion engines. Still, this is unlikely to happen before 2025.

Consensus in Bullish on Long-term Outlook of Electric Vehicle Sales

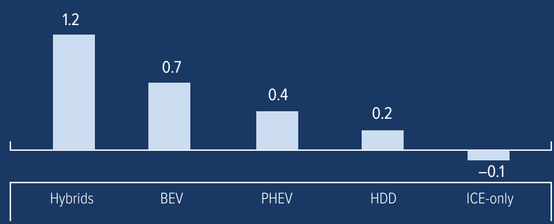


NORNICKEL'S POSITION

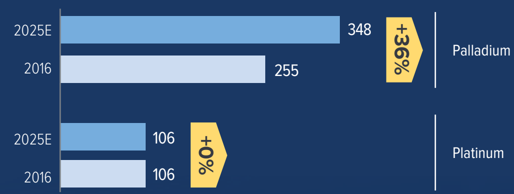
Over a short-term horizon, the Company is not planning any investments in large-scale production of materials for the electric vehicle industry, as the EV technology is still in the development phase. However, the Company is prepared to reconsider its position should the trend change.

Nornickel expects demand for nickel from manufacturers of rechargeable batteries for EV production to increase dramatically in the mid-term, but this will not be the case before 2020, when the automotive industry is ready to shift to electric vehicles. By 2025, the Company forecasts the demand for nickel in the EV market to grow to 420 kt from the current 43 kt, in addition to demand from stainless steel manufacturers, historically the largest consumers of nickel. In the mid-term, the key trend in the EV market will also be the production of hybrid vehicles that rely on both an internal combustion engine (ICE) and an electric engine. Per unit PGM consumption in hybrid cars is higher than in traditional vehicles with the same ICE volume; accordingly, we expect palladium consumption to increase by 3 mln oz by 2025.

Incremental average annual output by powertrain, 2017–2025 // m units

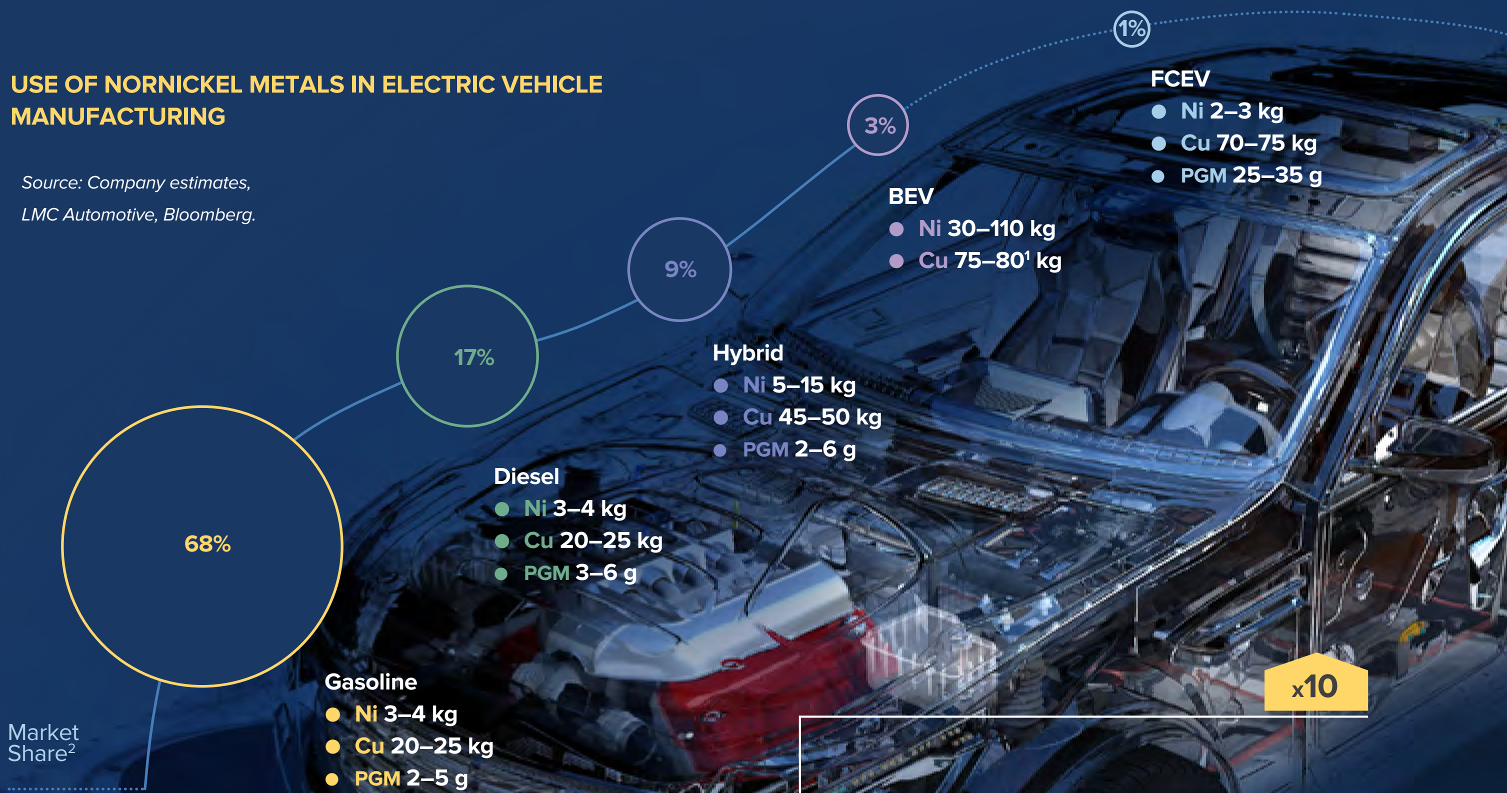


The demand for nickel in the EV market // t



USE OF NORNICKEL METALS IN ELECTRIC VEHICLE MANUFACTURING

Source: Company estimates, LMC Automotive, Bloomberg.



As compared to petrol and diesel engines, the consumption of metals produced by Nornickel in the manufacturing of EV engines is much more intensive. The process requires 2 to 27 times more of nickel, 2 to 4 times more of copper, and 12 to 17 times more of PGM (the latter are particularly important for fuel cell vehicles).

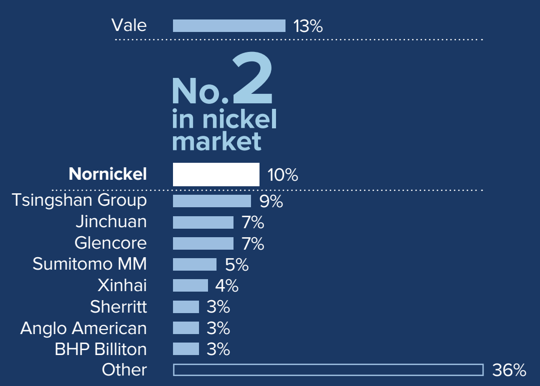
x10

By 2025, the demand for nickel in the EV market to grow to

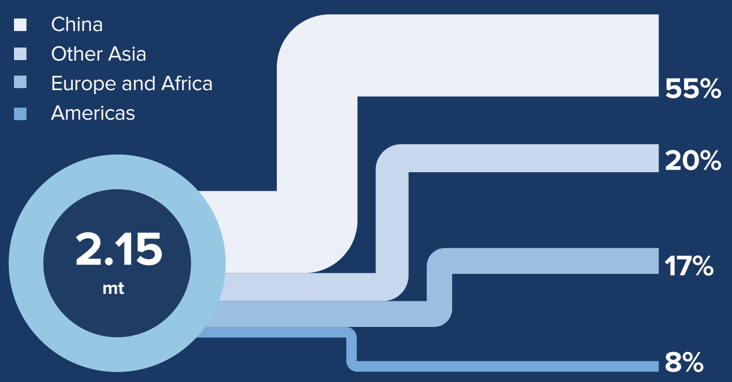
to 420 kt

[1] *Excluding additional infrastructure demand of 1–8 kg per charger.*
[2] *Expected market share in 2025 based on production.*

Nickel
Ni



Primary nickel consumption by region



Source: Company data

Key trends in the nickel market

In Q1 2017, the nickel price was highly volatile in the range of USD 9,380–11,045 per tonne reflecting a mixed news background from Indonesia and the Philippines. In early Q2 2017, it started to decline after the Indonesian government issued permits for the export of unprocessed nickel ore and Regina Lopez, Secretary of Environment and Natural Resources of the Philippines, was not re-appointed for a new term of office, which challenged the decisions made after the environmental audit of the country's mining industry. This trend was intensified by a reduction in stainless steel output in China. However, starting Q3 2017, prices began to recover backed by the news about the growth of stainless steel production in China and the launch of a large stainless steel plant in Indonesia. Early Q4 2017 saw a positive price performance amid considerable enthusiasm of the investment community about the potential increase in nickel consumption in electric cars, peaking at USD 12,830 per tonne – the highest level since June 2015. However, by the year-end 2017, there was a price correction to USD 12 thousand per tonne.

2017

Market deficit widened; demand increased in line with higher production of stainless steel in China and Indonesia and cathode materials for Li-ion batteries; production slightly went up driven by NPI output growth in Indonesia and China, which was almost entirely offset by declining production of high grade nickel.

Outlook: cautiously optimistic.

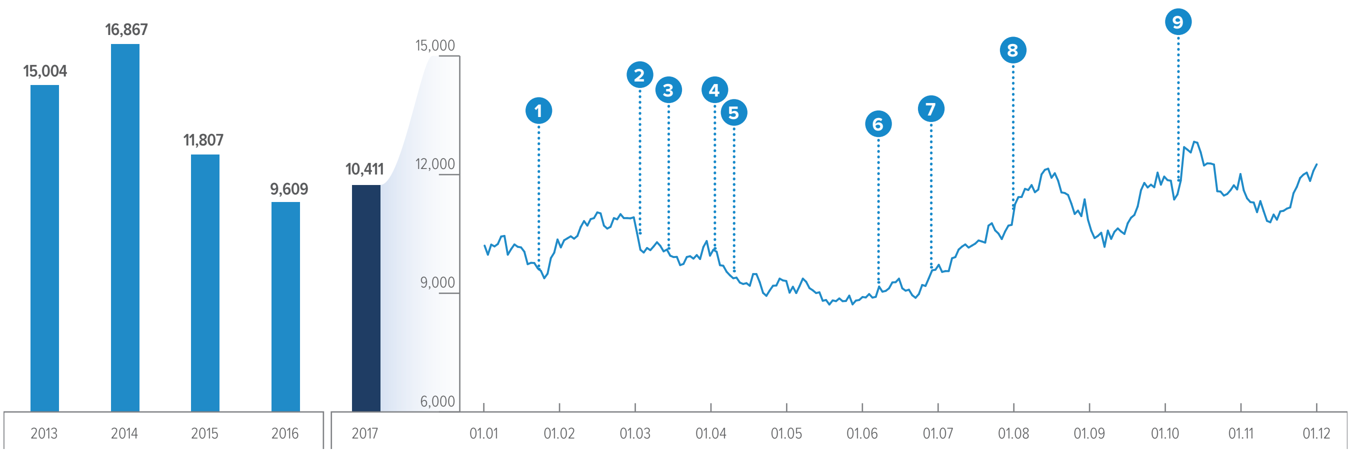
In 2018, the market deficit may go down a result of a much greater availability of high grade lateritic nickel ore.

Market balance

Following several years of surplus, the nickel market recovered the balance in 2016, with consumption outstripping production by 20 kt. In 2017, nickel shortage went up to 108 kt. The demand was mainly driven a 7% y-o-y increase in metal consumption primarily attributable to the Asian producers of stainless steel and batteries. In turn, primary nickel output gained as little as 2%. High grade nickel production declined by 6% (60 kt) largely triggered by the reconfiguration of the Company's production facilities, shutdown of sulphide ore mines in Canada, and the shortage of hydrometallurgy semi-products and sulphide concentrates on the market after the closure of loss-making mines in 2015–2017, with the Ravensthorpe shutdown coming as the last of those. Only nickel production from lateritic ore was on the rise. In 2017, low grade nickel production increased by 11%, or 100 kt y-o-y, mainly due to the Chinese and Indonesian NPI output growth.

During the year, total exchange warehouse stocks at the LME and the SHFE decreased by 55 kt to 411 kt, which is about 10 weeks of global consumption.

Key industry developments and nickel price // USD/t



Source: LME, Company data

1 Leaked data on possible easing of the ban to export ore from Indonesia and uncertainty in the Philippines after environmental audits of the mining industry;

2 Lower stainless steel output in China;

3 Permit issued by the Indonesian government to PT Antam to export up to 2.7 million wet tonnes of unprocessed nickel ore;

4 R. Lopez’s failure to be re-appointed as Secretary of the Philippines' Department of Environment and Natural Resources;

5 Permits by the Indonesian government issued to Fajar Bhakti Lintas Nusantara to export up to 1.06 million wet tonnes of unprocessed nickel ore;

6 Relaunch of Delong's stainless steel plant (China);

7 Launch of a stainless steel production line at Tsingshan plant (Indonesia):

8 Recovery of stainless steel output in China;

9 LME Week that aroused investor interest in nickel on the back of the expected electric car market growth.

Surplus/deficit in the nickel market // kt

Source: Company data

+7%

growth of consumption of primary nickel

+2%

growth of primary nickel output in 2017

Consumption

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).

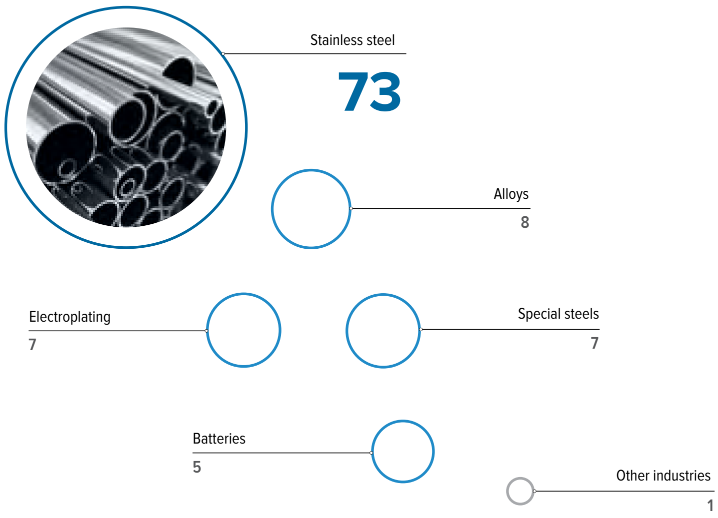
The 300 series steel has a higher nickel content (normally 8–12%, or up to 20% in a number of select grades). Nickel added in this proportion improves the steel's corrosion resistance and robustness in a wide range of temperature conditions, boosts its ductility and durability in aggressive environments, 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, energy, transportation, 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. For statistical purposes, these steels are usually grouped with the 300 series.

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.

Primary nickel consumption in 2017 by industry // %



Source: Company data

Nickel consumption is predominantly driven by the stainless steel industry (over 70% in 2017).

In 2017, the total stainless steel output increased by 6% and hit a record high of 48 mt.

China (with a share of over 50% of the global output) and Indonesia accounted for the most part of production growth. Smelting output growth in China ensued from the re-launch of Delong's capacities (over 1.1 mtpa) previously suspended after more stringent environmental controls had been imposed. Indonesia is a new steel market player with a robust growth outlook, sufficient reserves of high grade lateritic ore, growing NPI capacities and, hence, low cash cost of austenitic stainless steel.

Except for Europe, where stainless steel smelting stayed flat, nickel consumption in stainless steel making was steadily growing in 2017 across all regions. The USA was leading the charge in this segment with an 8% rise, according to our estimates.

Consumption of primary nickel by the global stainless steel producers rose by 7% to 1.57 mt as a result of an increase in the 300 series and 200 series global output by 7% and 5%, respectively, and a flat share in the use of scrap y-o-y. However, the use of high grade nickel in stainless steel smelting has not changed vs 2016 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 with higher volumes of NPI, ferronickel and metallised products with a lower nickel content.

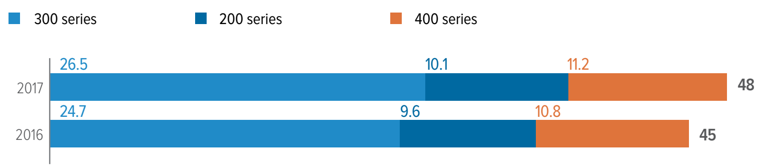
In 2017, primary nickel consumption in alloy production increased by 2%, which was mainly attributable to the recovery of demand from the oil and gas industry, and high demand from the aerospace industry.

Except for Europe nickel consumption in stainless steel making was steadily growing in 2017 across all regions.

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 2017, primary nickel consumption in the electroplating industry grew by 5% (4 kt), mainly due to demand in Asia. 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.

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

Stainless steel production by grade series // mt



Source: Company data

+6%

48

mt

record stainless steel output in 2017

Primary nickel consumption in 2017 // mt

Source: Company data

Battery

Nickel-cadmium

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.

Nickel-metal hydride

Ni-MH

Ni-MH batteries were developed in 1989 as a substitute for Ni-Cd batteries to avoid using cadmium. Producers use nickel to manufacture this type of batteries. 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.

Lithium-ion

Li-Ion

Li-Ion batteries were first commercially released in 1991 and became fairly widespread due to their high energy capacity and reliability (capacity is retained after many recharge cycles).

The key driver behind Li-Ion battery growth is electric vehicles gaining ground. Since 2014, CAGR of electric cars (hybrid and battery electric cars) has been around 46%.

The key factors driving electrification of the transport system are:

- incentives offered by the state;
- transformation of the consumer mindset;
- improved technical specifications of batterie.

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. Buyers of electric cars in a number of other European countries, including Belgium, Germany, the UK and France, enjoy considerable subsidies (ranging from EUR 4,000 to EUR 10,000) and fiscal incentives.

There are several types of lithium-ion batteries depending on the cathode materials: LCO, LFP, LMO, NCM, NCA.

LCO is largely used in portable devices. This type of the cathode material is not applied in electric cars as a result of high cobalt prices, limited capacity, and technical issues of making a high-capacity battery safe for operation. However, other types of Li-Ion batteries are widely applied in the industry. LFP and LMO tend to be replaced with other Li-Ion battery types containing nickel as a result of a higher gravimetric and volumetric capacity of NCM and NCA. It helps to increase mileage and shrink battery volume and weight. The share of nickel compounds in the total cathode material output used in Li-Ion batteries went up from 32% in 2012 to 51% in 2017.

Growing nickel consumption in Li-Ion batteries comes not only on the back of increasing share of NCM/NCA containing nickel, 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 2017 Li-Ion batteries with NCM cathodes 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 nickel-based cathode material.

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 NCM lay the groundwork for major expansion of primary nickel consumption in this industry in the long run.

LFP
Lithium Iron Phosphate
$LiFePO_4$

LMO
Lithium Manganese Oxide
$LiMn_2O_4$

LCO
Lithium Cobaltite
$LiCoO_2$

NCA
Nickel Cobalt Aluminium
$LiNi_xCo_yAl_nO_2$
(49–54% Ni)

NCM
Nickel Manganese Cobalt
$LiNi_xCo_yMn_nO_2$
(20–48% Ni)

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 2017, the major high grade nickel producers included Nornickel, Vale, Jinchuan, Glencore and Sumitomo Metal Mining.

Low grade nickel

(ferronickel, NPI and nickel oxide) is only produced from lateritic ore. In 2017, 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 2017, primary nickel production grew by 2%, or 48 kt y-o-y, driven only by an increase in low grade nickel output, which more than offset the decline in high grade nickel production that continued into 2017.

In 2017, high grade nickel output dropped by 5%, with production cuts coming from the following producers:

- Vale's Canadian refining operations after the shutdown of its Birchtree (Thompson) and Stobie (Sudbury) mines;
- Nornickel due to ongoing capacity reconfiguration;
- Chinese refined nickel producers as a result of nickel feedstock shortage following the closure of loss-making mines in 2016–2017;
- Ambatovy (Madagascar).

Production of nickel forms for cathode use saw a substantial decline, which entailed their shortage in the market.

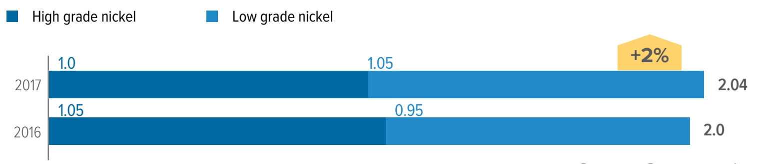
This was coupled with greater output of nickel sulphate that serves as a key feedstock for the precursors of the cathode material in Li-Ion batteries.

In 2017, low grade nickel production gained 10% globally. This was driven by NPI output increase in China and Indonesia, along with ferronickel in all major regions except Europe.

The key driver behind NPI production growth was the easing of the ban on exports of unprocessed nickel ore from Indonesia in March 2017 contributing to the availability of rich nickel ore.

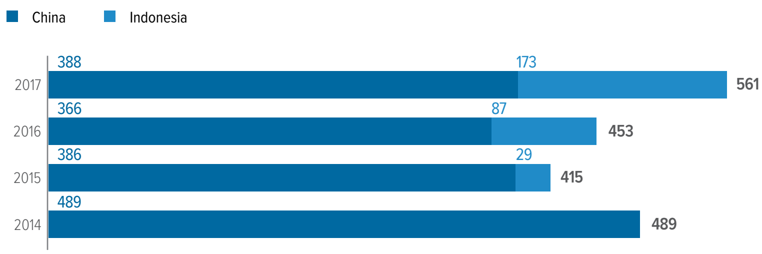
The total amount of Chinese ore imports reached the level of 2015 and exceeded 35 million wet tonnes, considering that the total nickel ore export quota issued by the Government of Indonesia exceeded 24 million wet tonnes by the end of 2017. In 2018, a major growth of NPI output is expected in China.

Primary nickel production // mt



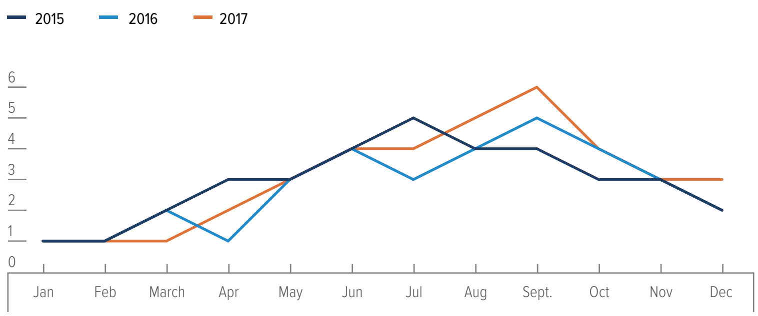
Source: Company data

NPI production // kt



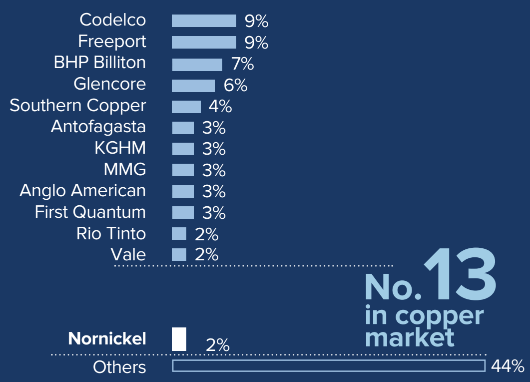
Source: Company data

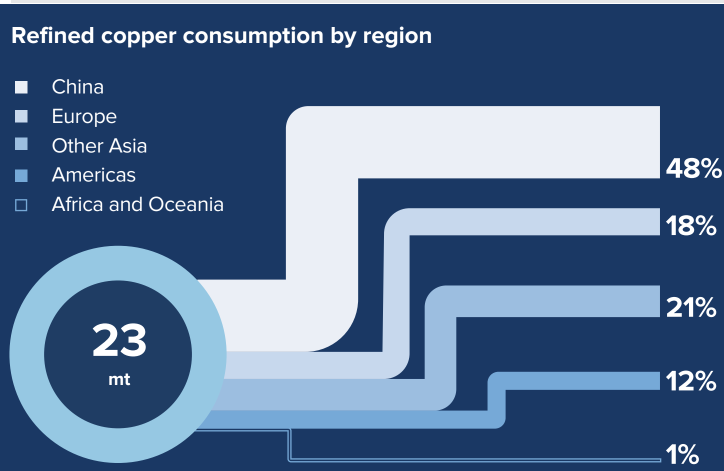
Nickel ore and concentrate imports to China // mt



Source: Company data

Copper
Cu





Source: Company data

Key trends in the copper market

Early 2017 saw a strike at the largest Chilean mine Escondida and a ban on copper concentrate exports from Indonesia driving copper prices up to USD 6,145 per tonne as at mid-February.

By early May, they plunged to USD 5,470 per tonne as a result of growing exchange inventories, data on decreased copper imports to China and the end of the strike, with the bounce-back starting in mid-May.

Despite the short-term correction in mid-September and late November, copper prices peaked at USD 7,216 per tonne by year-end, the highest since February 2014.

The price growth was supported by the analytical agencies forecasting the copper market deficit in 2018 due to reduced production along with a high demand for copper coming from the booming sector of electric vehicles and EV infrastructure, as well as the upward trend in the construction industry.

In 2017, the average copper price stood at USD 6,166 per tonne (up 27% y-o-y).

2017

The prices surged in the second half of the year with copper trading well above the cost curve due to a slump in production triggered by strikes along with a steady demand from the automotive and construction industries.

Outlook: neutral.

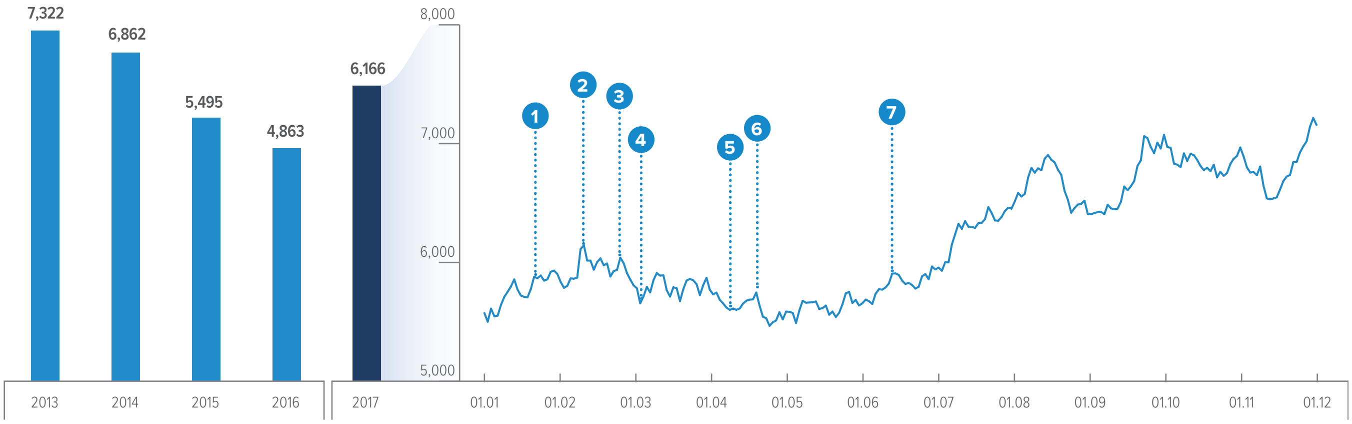
In the mid-term, the market will remain balanced; the upcoming wage talks in Chile and Peru may lead to a short-term uptick in copper prices.

Market balance

In 2017, the refined copper market that had been somewhat oversupplied for the past six years moved into a slight deficit. It stood at as little as 0.2% of the total market volume, or 50 kt vs a 220 kt surplus in 2016.

Total exchange warehouse stocks remained virtually unchanged from late 2016 at 544 kt (548 kt as at the end of 2016), or nine days of global consumption, with off-exchange inventories going slightly down.

Key industry developments and copper price // USD/t



Source: LME (settlement)

1. Outset of a strike at the Escondida mine;
2. Ban on the concentrate exports from Indonesia;
3. Strike at the Cerro Verde mine (Peru);
4. End of a strike at the Escondida mine;
5. Permit to export copper from Indonesia issued to Freeport;
6. Data on production cuts by BHP and Anglo American;
7. WBMS reporting the market's shift to a deficit.

Surplus/deficit in the copper market // kt

Source: Company data

+27%

6,166
USD per tonne
the average copper price in 2017

7,216
USD
copper prices peaked by year-end, the highest since February 2014

Consumption

Given its high electrical and thermal conductivity, ductility and corrosion resistance, copper is widely used in various industries. Some three quarters of refined copper produced globally are 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 2017, global consumption of refined copper totalled 23.0 mt (up 2.0%, or 0.46 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 48% in 2017 due to the demand growth of 3.2%, or 0.3 mt. During the year, it kept cutting imports of refined copper while bringing in more copper feedstock. In 2017, Chinese refined copper imports dropped by 5% to 4.7 mt, while copper concentrate and scrap imports went up by 2% and 6% to 17.4 mt and 3.6 mt, respectively. China's growing consumption needs were mainly met through the local production ramp-up.

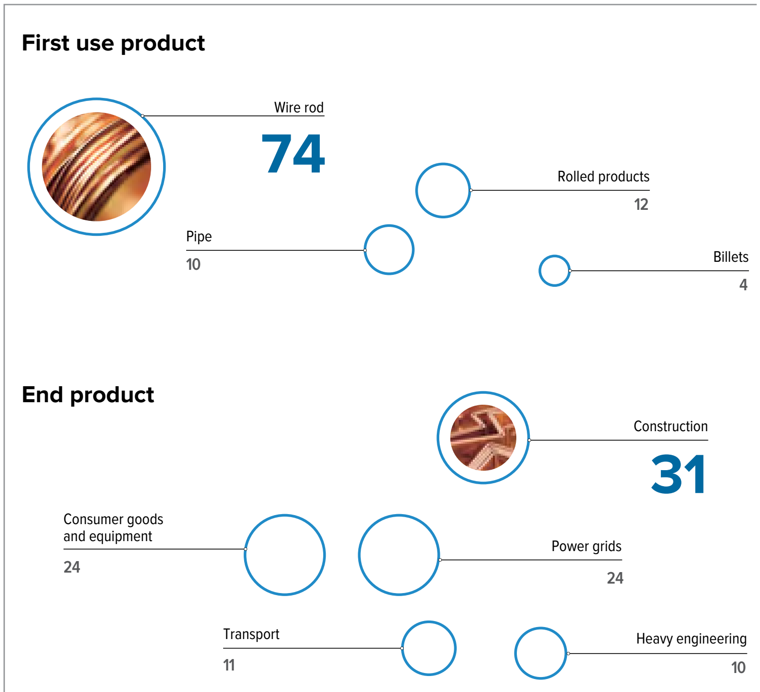
The demand for copper in developed economies saw only a slight increase in 2017, with Europe up (the Company's key market for copper cathodes) by 0.2%, North America by 0.7%, and Asia (excluding China) by 2.3%. Russian domestic copper cathode consumption in 2017 was moderately down.

+2.0%

23.0 mt

total global consumption of refined copper in 2017

Refined copper consumption by industry // %

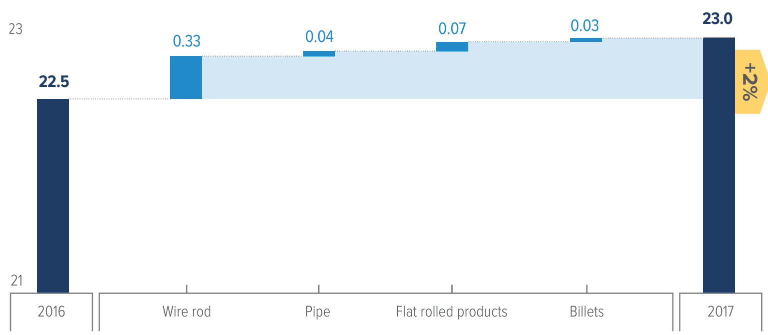


Source: Company data, Wood Mackenzie

Production

In 2017, global production of refined copper increased by 0.8%, or 0.19 mt, compared to 2016, totalling 22.9 mt. China remains the key driver behind that growth, with the national government firmly committed to the expansion of domestic smelting and refining capacities. In 2017, refined copper production in China grew by 8% to 8.9 mt, while its share in global output was 36%. Only 20% of Chinese production is local extraction, with another 80% coming from imported copper concentrates and scrap.

Changes in refined copper consumption in 2017 by industry // mt



Source: Company data, Wood Mackenzie

In the rest of Asia (excluding China), production growth was 1.4% (going slightly up in India and South Korea along with a slump in Japan). In North America, it shrank by 5.8% (marginally up in Mexico and down in the USA and Canada) and in South America – by 8.6% due to lower output in Chile. In Europe, copper production soared by 4.6% with Germany, Bulgaria and Sweden acting as the main contributors. According to preliminary estimates, Russia saw its production grow by 4% in 2017 after a 2% drop in 2016.

In 2017, global copper mine production slipped by 1.5% to 19.8 mt.

Some 3.1 mt of refined copper was produced from accumulated concentrate stockpiles and scrap on the back of higher scarp collection driven by higher copper prices.

The decline in copper production came as a result of Chilean strikes and technical issues experienced by the US producers.

In Peru, production was below the expectations due to strikes at the Cerro Verde, Cuajone and Toquepala mines in early 2017. However, higher copper output at the new Las Bambas mine operated by China's MMG drove Peruvian production up by 3%.

China, which is currently developing smaller mines, saw its production grow by 6% to 1.5 mt. In Kazakhstan, commissioning of the new Bozshakol and Aktogay mines by KAZ Minerals drove the output up by 15%. A 4% growth in African production was mainly backed by Kolwezi mine in the Democratic Republic of the Congo and Sentinel mine in Zambia.

Chile, the top global supplier of copper, saw a drop in production due to a 1.5-month strike at BHP's Escondida, the world's largest copper mine, causing over 100 kt of production losses from February to March, coupled with lower output by the state-owned Codelco driven by declining copper content at its oldest fields.

In North America, production dropped by 4% due to some technical issues at the US and Canadian mines. Australia reported reduced output at the Mount Isa and Olympic Dam mines. Indonesia saw its copper output shrink by 7% following a ban on copper concentrate exports at the beginning of 2017, which made Freeport limit its operations at the Grasberg mine.

Russian copper production grew marginally in 2017.

The actual refined copper production was above the analyst forecasts issued early in 2017 thanks to the production surge in the second half of the year. It was also backed by the increased use of scrap. At the same time, consumption growth was slightly above the expectations driving the global deficit down by 0.1 mt as compared to the initial estimates.

–1.5%

19.8 mt

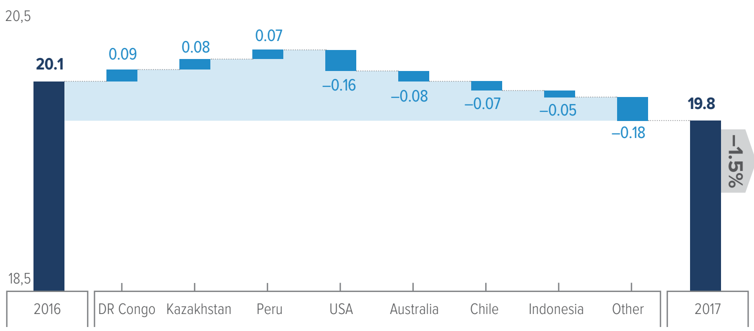
global copper mine production in 2017

+0.8%

22.9 mt

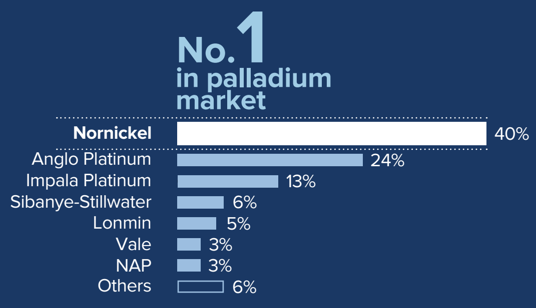
refined copper production in 2017

Copper production // mt

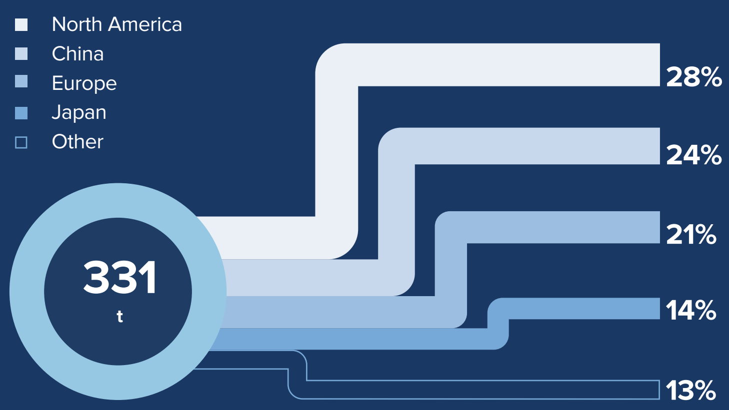


Source: Company data, Wood Mackenzie

Palladium Pd



Industrial consumption of palladium by region



Source: Company data

Key trends in the palladium market

In 2017, palladium prices went up by a staggering 42%, hitting a 16-year high of USD 1,058 per oz by the end of the year. For FY 2017, palladium was one of the strongest performing commodities in terms of price appreciation. In late September, palladium became more expensive than platinum for the first time in 16 years, with the premium reaching as much as 17% by the end of 2017.

2017

Impressive price growth on the back of strong demand from consumers and limited supply.

Outlook: positive.

Market deficit is expected to persist amid stable production volumes and upward trend in industrial consumption.

During the year, palladium prices were primarily driven by fundamentals, including the sustaining market deficit that saw palladium production lagging behind consumption. This was due to the expansion in global car-marking (the key consumer industry) as primary production and recycled output grew only moderately.

Along with the fundamental factors, palladium prices were supported by the environment on trading exchanges, which in 2017 were lacking in palladium available for spot purchases. In the futures market, backwardation settled in, with leasing rates strongly up. On the Chicago Mercantile Exchange (CME), palladium inventories were going down.

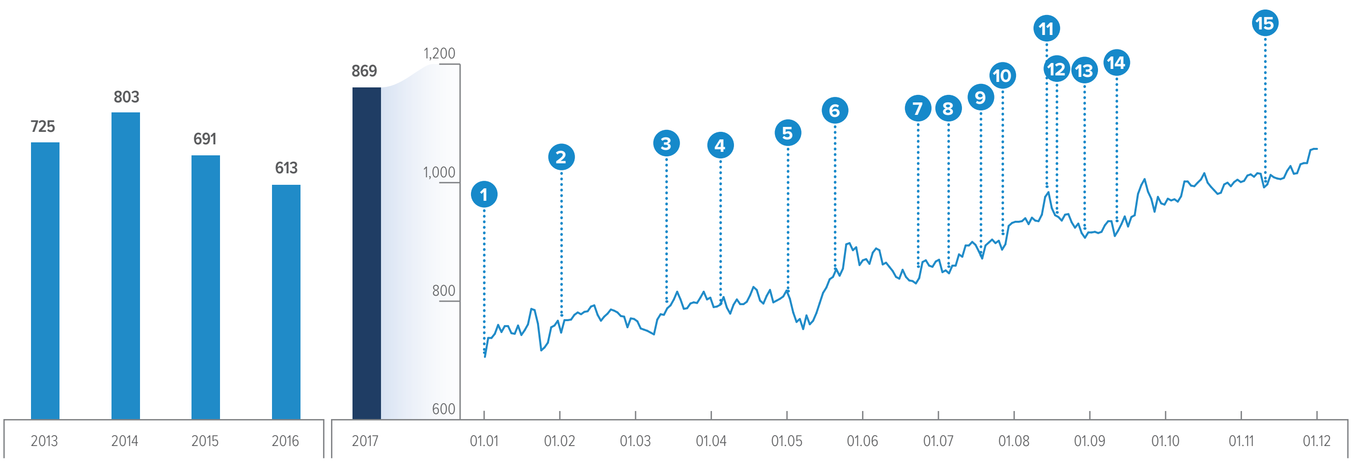
Throughout the year, prices were also driven by the weak USD against other currencies and the challenging geopolitical environment, including concerns around North Korea's nuclear programme.

Given the favourable trends described above, the average annual palladium price for 2017 was at its all-time high of USD 869 per oz.

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 partially offset by the outflow from ETFs, which, however, slowed down almost twice compared to 2016.

Key industry developments and palladium price // USD/oz



Source: LBMA, Company data

1) On 23 December 2016, China's government released the plan to implement the China 6 emission standard, one of the most stringent regulations among those in place or planned to be introduced;

2) South African producers announced a potential decline in PGM output; poor production data came from Canadian assets; Volkswagen revealed plans to switch from small diesel engines to mild hybrids;

3) City administrations of London and Paris announced plans to step up measures to control exhaust emissions into the air;

4) Demand for risky assets is up; palladium market sees strong backwardation settle in; prices enter correction as the markets wait for new PGM statistics and the results of the Platinum Week in London;

5) South Africa's Minister of Mineral Resources said that the country is planning to raise the target for black ownership in mining companies to 30%

6) China moved the deadline for quotas on electric cars to 2019;

7) South Africa's Bokoni mine will be mothballed;

8) Lonmin announced plans to raise cash from selling surplus processing capacity;

9) Chancellor Angela Merkel announced Germany's plans to support the EU initiative to ban internal combustion engine cars;

10) US Fed Chair Jannet Yellen said the regulator was planning gradual increases in its key interest rate until the end of 2017;

11) Palladium markets tested a major price level of USD 1,000 per oz;

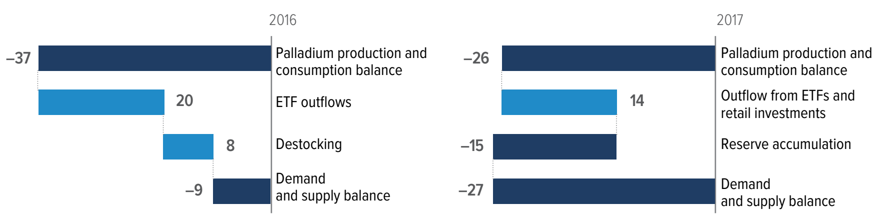
12) South Africa's Maseve mine will be put on care and maintenance;

13) US released strong car production data;

14) Additional demand for cars came in the aftermath of the Irma and Harvey hurricanes;

15) US Federal Reserve increased the interest rate; Sibanye-Stillwater announced a takeover offer for Lonmin.

Palladium market balance // t



Source: Company data

+2.4%

the expansion in global car-marking

Consumption

In 2017, industrial consumption of palladium increased by 9 t (+3%) compared to the previous year, hitting a new all-time high of 331 t.

Exhaust treatment systems account for nearly 80% 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 (at least 150,000 miles in the US), palladium has almost no substitutes 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 only 24 t annually), rhodium suffers from high price volatility and the risk of physical metal deficit.

In 2017, palladium consumption by the car-making industry went up by 8 t and reached a new record of 263 t. This was driven by three groups of factors:

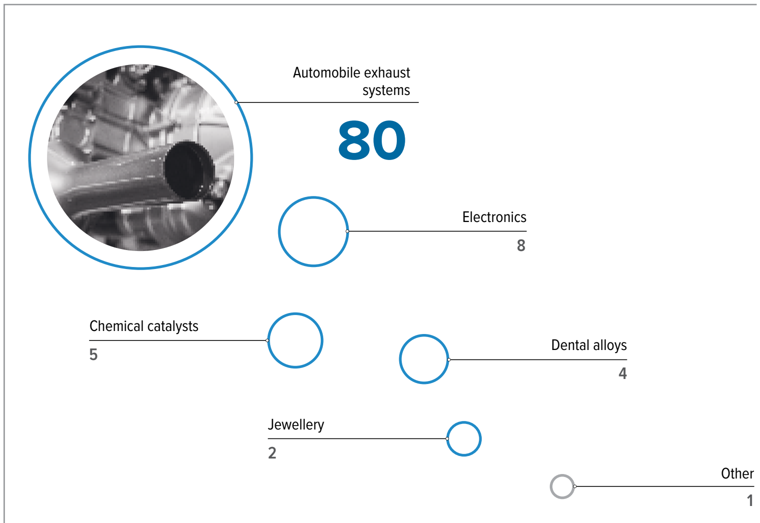
1) Strong growth of global car production.
Last year, car production around the world expanded by 3% vs the previous year. The strongest performers were China (+3%), Europe (+3%), Japan (+5%), and India (+6%), with Russia (+20%) and Brazil (+25%) also demonstrating a healthy recovery. A major contraction was seen in the US market (-8%), mainly on the back of a natural slowdown (following the

+3%

331 t

Industrial consumption of palladium in 2017 (a new all-time high)

Palladium consumption in 2017 by industry // %



Source: Company data

record-high performance of 2016) that was the result of high leverage among consumers, rising interest rates, strong discounts previously secured by car manufacturers, and weak demand from car rental companies. The decline mostly affected passenger cars; by contrast, production of SUVs and small trucks (which are more reliant on PGM) is on the rise. The optimistic economic environment in the US gives hope that the domestic car market will soon recover ground.

2) Changes in the transport structure.
The key markets for diesel cars (Western Europe and India) are replacing light diesel vehicles with petrol cars and hybrids (combining petrol and electric engines), which make greater use of palladium-based catalytic converters for exhaust gases.

3) Tougher regulations on pollutant emissions.
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 5 rollout across the country starting from the end of 2017, followed by transition to China 6 in 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 also add new enhanced requirements. In the US, 2017 marked the rollout of the Tier 3 standards designed to more than halve the fleet-average NO_x emissions. The EU nations are phasing in Real Driving Emissions (RDE) tests for cars and also made particulate filters mandatory for petrol engines, which additionally helps to expand the use of palladium in exhaust treatment systems.

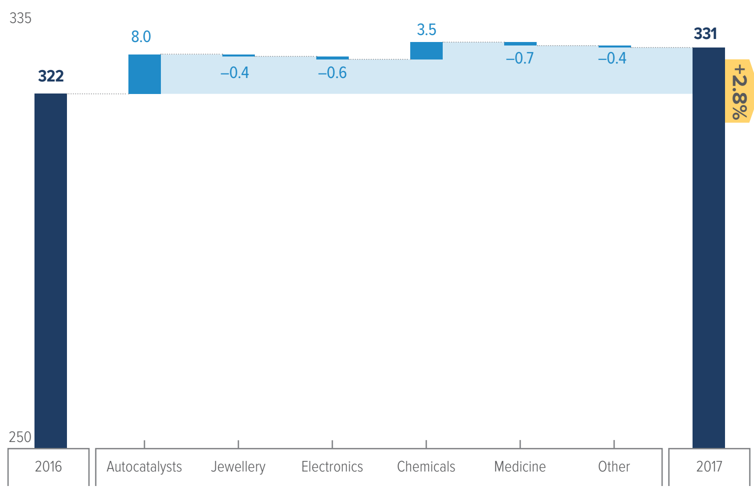
+42%

869

USD per oz

the average annual palladium price for 2017

Palladium consumption by application area // t



Source: Company data

+3%

263 t

palladium consumption by the car-making industry in 2017

Palladium consumption in the electronics industry continued a moderate downward trend in 2017 (-0.6 t): lower use of palladium in multi-layer ceramic capacitors was partially offset by an absolute increase in their production and increased use of palladium in the connectors and lead frames.

The use of palladium in chemical catalysts went up by 3.5 t (+26%) in 2017 as a result of China's new basic polymer capacities coming on stream. The trend was also supported by additional purchases of palladium by chemical businesses, which had to move away from the leasing model following price growth amid backwardation.

In the healthcare sector, palladium demand continued declining on the back of transition to alternative composites and dental scrap processing.

While palladium has a number of advantages for jewellery manufacturing, its consumption in the industry dropped by 0.4 t (5%) in 2017 because it does not have a strong brand as a jewellery metal. Today, palladium is used mainly in white gold alloys or for wedding rings (in its pure form), mainly in the European and US markets. Recently, palladium has seen expanded use as a metal for electroplating (in luxury accessories, clothing, car interior, furniture fittings, etc.), but the overall negative trend still persists.

Investment demand for palladium kept shrinking in 2017, albeit at a slower pace compared to 2016. Withdrawals from ETFs totalled 12 t. This reduction resulted from the profit taking that followed a significant price surge, coupled with investor migration to stocks and to more attractive palladium-linked futures (net long positions in palladium on the Chicago Mercantile Exchange rose by 72% last year, reaching 2.6 moz).

Retail demand for palladium coins and bars was negative in 2017 (-2 t) as a result of profit taking by retail investors, above all in the US, as prices went up. The unfavourable trend was partially offset by the US Mint issuing its first ever palladium bullion coin, a move that confirmed strong investor interest for this instrument.

Production

In 2017, primary palladium production expanded by 3% against the previous year (214 t vs 207 t).

Russia, the metal's major producer, saw a rise in output driven by the processing of copper concentrate purchased by the Company from the state-controlled Rostec corporation. Other factors at play included using up work-in-progress inventories at Polar Division and the reduction in the work-in-progress materials in transit following the now completed reconfiguration of production facilities.

South Africa, the world's No. 2 palladium producer, demonstrated a strong rise in volumes in 2017. Despite the challenging market conditions and a considerable number of unprofitable facilities, 2017 delivered a moderate rise in primary palladium production. The bulk of the growth came from Anglo American Platinum, which among other things boasted a 13% rise in palladium production at its Mogalakwena mine in the northern limb of the Bushveld Complex, which is richer in palladium compared to the western and eastern limbs. South Africa's refined palladium production was under pressure from the temporary closure of the Mototolo concentrator in August to December 2017, furnace maintenance at Impala Platinum's mines, and challenges in accessing the ore body at Northam Platinum's Zondereinde mine.

In Zimbabwe, production was marginally up, driven by the Zimplats and Mimosa mines. However, planned maintenance at the Unki concentrator in Q4 2017 brought the overall performance slightly down.

Primary palladium production in Canada declined by 3 t as a result of dwindling output at the mines of Vale and Glencore, mainly due to depletion. The negative performance was to some extent offset by the growth posted by North American Palladium. In the US, production remained virtually flat compared to 2016 (launched in 2017, the Blitz project is expected to deliver volume growth starting from 2018).

The main sources of recycled palladium are used exhaust gas autocatalysts, as well as jewellery and electronic scrap. In 2017, recycled output increased by 13 t, up to 91 t, primarily due to growing collections of electronic scrap on the back of higher palladium prices, recovery in steel prices, and also implications of the Irma and Harvey hurricanes that wiped out more than 1 mln cars in the US. Jewellery and electronic scrap volumes remained flat.

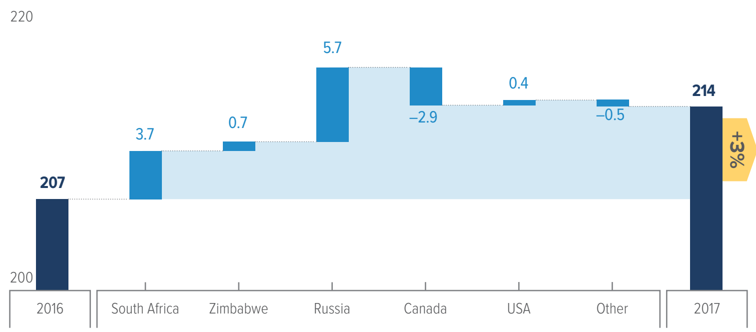
The sources of previously accumulated palladium stockpiles include trading companies, financial institutions, government reserves, and surplus inventories of consumers. In the 1990s and 2000s, Russia's palladium supply came primarily from the country's government stockpiles. In recent years, Russian stockpiles ceased to be part of the palladium supply, which points to their depletion and marks the transition towards a palladium market that is completely market-driven.

In 2017, Nornickel's Global Palladium Fund (GPF) built Pd reserves of around 0.55 moz through purchases from third parties and the Company

0.55 moz

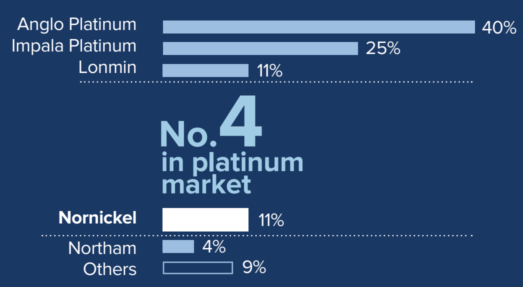
Nornickel's Global Palladium Fund (GPF) Pd reserves in 2017

Annual primary palladium output // t

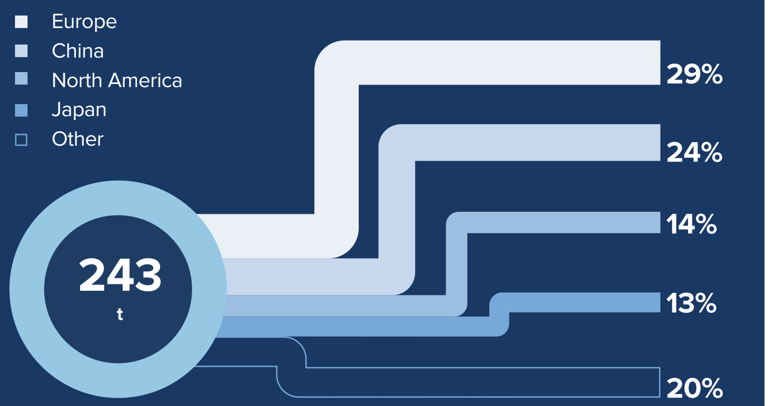


Source: Company data

Platinum
Pt



Platinum consumption by region



Source: Company data

Key trends in the platinum market

In 2017, platinum prices were trending sideways. Despite several spikes to above USD 1,000 per oz during the year, by the end of the reporting period the metal's price reverted to its starting point of USD 930 per oz.

The changes in platinum and gold prices in 2017 mostly occurred in sync, indicative of platinum prices being highly dependent on macroeconomic trends, which were largely positive during the year. The weak US dollar against other currencies and the challenging geopolitical environment, including concerns around North Korea's nuclear programme, supported precious metal prices. At the same time, they faced certain pressure due to the rally in the US stock market, which resulted in some investors migrating from metals to equities.

In March–April and September, the platinum to gold price spread was increasing, with platinum dragging. The platinum price was 20% weaker compared to gold at the year's outset, and that became 30% by the end of 2017, driven by the platinum market's fundamentals as well as by speculation.

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 of Western Europe and India, 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. They took twice as many short positions in platinum (amounting to 2 mln oz) on the Chicago Mercantile Exchange (CME) as the year before, while the number of long positions increased only by a third.

The largely negative sentiment drove the average annual platinum price for 2017 below the last year's level to its twelve-year low of USD 949 per oz.

2017

The market was balanced on the back of decreasing consumption by the automotive and jewellery industries, upward investor demand and consumption trends in other industries, and primary production growth fuelled by low prices.

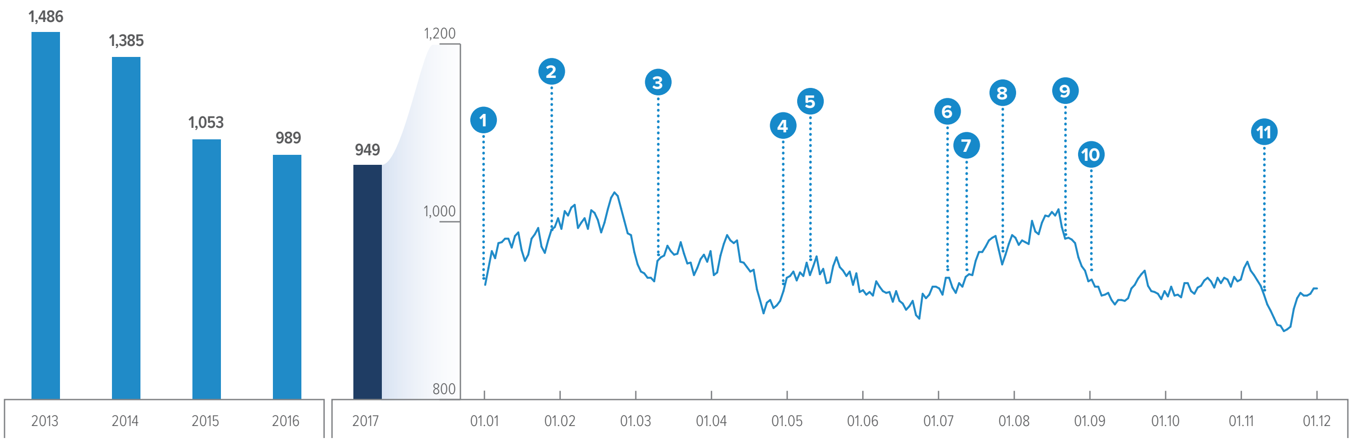
Outlook: neutral.

In 2018, the market is expected to remain more or less balanced, with a moderate recovery in demand and stable supply as the decrease in primary production would be offset by higher recycling volumes.

Market balance

The platinum market was balanced in 2017. Production of primary and recycled metal exceeded industrial and jewellery consumption, but the surplus was accumulated by ETFs and private investors in the physical market.

Key industry developments and platinum price // USD/oz



Source: LBMA price, Company data

1. On 23 December 2016, China's government released the plan to implement the China 6 emission standard, one of the most stringent regulations among those in place or planned to be introduced;

2. South African producers announced a potential decline in PGM output; poor production data came from Canadian assets; Volkswagen revealed plans to switch from small diesel engines to mild hybrids;

3. City administrations of London and Paris announced plans to step up measures to control exhaust emissions into the air;

4. US released weak statistics on car production; South Africa's Minister of Mineral Resources said that the country is planning to raise the target for black ownership in mining companies to 30%;

5. China moved the deadline for quotas on electric cars to 2019;

6. South Africa's Bokoni mine will be mothballed;

7. Lonmin announced plans to raise cash from selling surplus processing capacity;

8. Chancellor Angela Merkel announced Germany's plans to support the EU initiative to ban internal combustion engine cars;

9. South Africa's Maseve mine will be put on care and maintenance;

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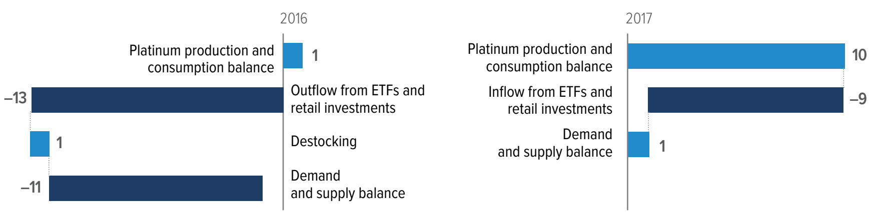
Platinum market balance // t



Source: Company data

Consumption

Industrial consumption of platinum in 2017 compared to the previous year rose slightly (by 1 t, or 0.5%) and reached 243 t.

The automotive industry is the main consumer of platinum. Over 70% of platinum in this industry is used to manufacture exhaust gas catalysts for diesel vehicles.

In 2017, platinum consumption in the automotive sector decreased y-o-y by 0.9 t, or 1%, which mainly had to do with a decreased share of diesel vehicles in their key market – Europe. By December 2017, the share of diesel sales in Germany dropped from 46% to 39% y-o-y, having hit its minimum level since 2009 at 36% in September. France also saw a continued decline in diesel vehicle sales, which amounted to 47% compared to 52% in the previous year. Five years ago, that share was three quarters of the market.

India, which is a key market that had been viewed as a bastion for diesel vehicle production, was also on the decline over the recent years, with the share of diesel sales in the country's car market having decreased twofold (from 47% to 23%) during 2012–2017.

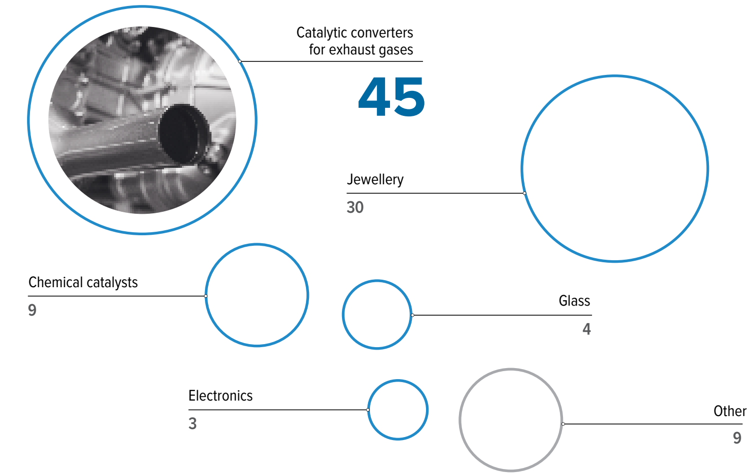
Diesel engines are giving way to petrol-based solutions, and more expensive vehicles utilise hybrids (combining petrol and electric engines). Petrol engine being a component of a hybrid necessitates wide use of palladium-based catalysts. Having the same displacement as the internal combustion engine, the hybrid uses more of the metal than a traditional petrol engine due to more frequent cold starts.

+0.5%

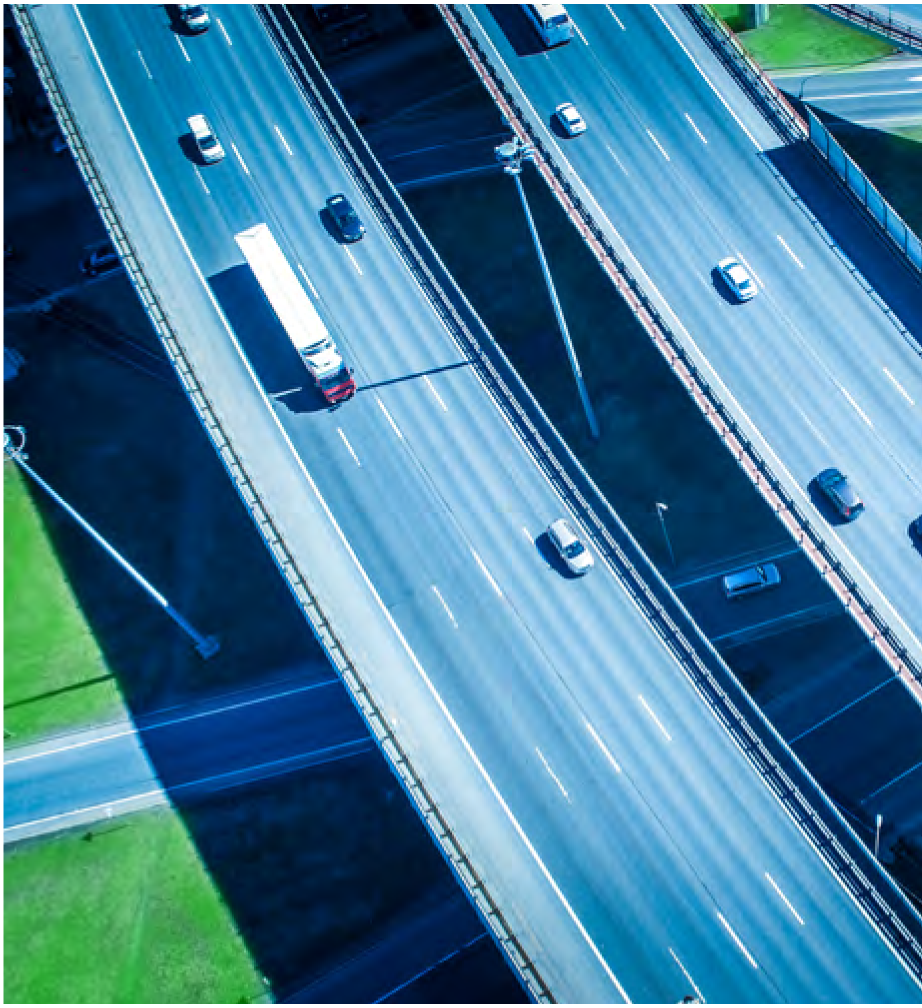
243 t

Platinum consumption in 2017

Platinum consumption in 2017 by industry // %



Source: Company data



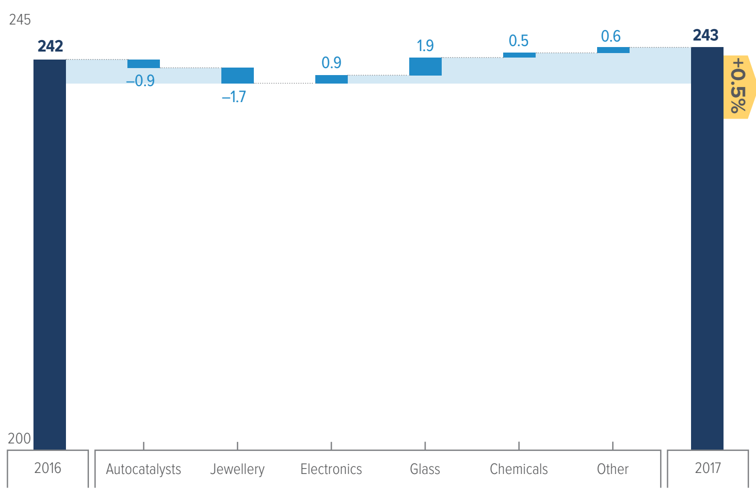
Lower platinum consumption by passenger car producers was partially offset by increased manufacturing of heavy-duty vehicles, catalytic devices of which still rely on this metal. Diesel engines, together with hybrids, are the key and most cost-efficient solutions to achieve the EU's targets for reducing CO_2 emissions to 95 g/km by 2020. New diesel cars comply with the existing environmental requirements, but the Volkswagen emissions scandal served to ingrain the public's and authorities' negative attitudes towards diesel transport, especially in the EU, where many cities are now planning to introduce a ban on old diesel cars. This gives reason to expect further declines in the share of passenger diesel cars. However, in absolute terms manufacturing of this type of vehicles will continue to show a positive trend in the near term thanks to overall growth of 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 that set in during the previous year, albeit with a lower rate (1.7 t less, or 2%). The decrease was primarily driven by lower jewellery demand in China due to consumers switching to other forms of investing. Still, China retains its high potential, especially when it comes to sales in cities with populations ranging from 150 thousand to 3 mln people.

>70%

of platinum in automotive industry is used to manufacture exhaust gas catalysts for diesel vehicles.

Platinum consumption by application area // t



Source: Company data

Despite the overall decline, the global platinum demand from jewellers was supported by India's market recovery after the roll-out of its tax reform (according to the preliminary PGI data, the country's platinum jewellery market grew by over 20%). Although not quite enough to offset the negative trend in the larger Chinese market, this did somewhat mitigate it.

In 2017, primary platinum consumption for industrial catalyst manufacturing increased by 0.5 t, following the ramp-up of oil and shale gas processing in North America, growth of chemicals production in Western Europe, and launch of plants in China to produce paraxylene (used for paint and varnish manufacturing and propane dehydrogenation purposes) as well as silicone and other basic chemicals. Nitric acid production slowdown put a damper on growth.

The glass industry needs platinum to produce glass fibre and optical glass used in the LCDs of the majority of electronic products. In 2017, the industry's demand grew significantly by 1.9 t, or 20%, supported by active expansion of LCD production capacities.

The electronics industry saw a modest growth in platinum consumption (by 0.9 t) triggered by the increase in the platinum-based hard drive component production due to the expansion of remote data storage capacities. The following years will see the advent of the new MAMR and HAMR hard drive technologies, which will greatly increase the amount of data that can be stored on a hard disk drive, breathing new life into the technology lately beleaguered by competition from solid-state drives (SSDs).

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. The 2017 y-o-y retail demand was somewhat lower (6 t), which was driven by the neutral platinum price trend and a sustained discount to gold. During the year, the investments in platinum ETFs increased by 3 t.

+2%

194 t

global production of primary platinum in 2017

+20%

1.9 t

growth of the glass industry's demand for platinum in 2017

Production

Global production of primary platinum in 2017 rose by 4 t (or 2%) y-o-y and reached 194 t.

South Africa, the metal's major producer, was affected by the mothballing of the Bokoni and Maseve mines, furnace maintenance at Impala Platinum's mines, process-related closure of the Mototolo concentrator, and challenges in accessing the ore body at the Zondereinde mine. Despite these factors, the country saw a 6.1 t rise in output driven by greater production volumes at other sites, especially at the Mogalakwena mine – Anglo American Platinum's largest asset. Sibanye-Stillwater also boasted a rise in production.

As the market walks the surplus line and prices remain low, putting the margins of many projects at risk, South African producers are being lax on curbing the supply and continue to ramp up production to achieve even lower unit cost of platinum and boost revenues.

Russia saw a moderate increase in output, as lower production at Far Eastern mines was offset by higher volumes from Norilsk Nickel, which it achieved by processing copper concentrate purchased from the state-controlled Rostec corporation, using up work-in-progress inventories at Polar Division, and reducing the work-in-progress materials in transit following the now completed reconfiguration of its production facilities.

In Zimbabwe, production was marginally up, driven by the Zimplats and Mimosa mines. However, planned maintenance at the Unki concentrator in Q4 2017 brought the overall performance slightly down.

–4%

949

USD per oz

the average annual platinum price for 2017

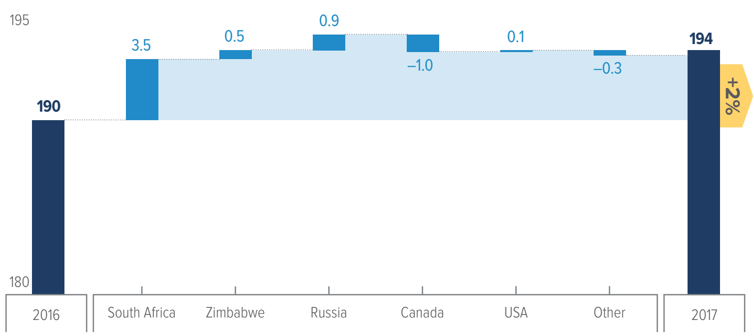
Canada sustained a significant drop in production (by 1 t, or 15%) due to lower platinum output by the Vale and Glencore assets, which was partially offset by volumes from the North American Palladium mine. In the USA, Sibanye-Stillwater's production demonstrated moderate growth, which will be bolstered by the volumes from Blitz project that was launched in 2017.

The main sources of recycled platinum are used exhaust gas catalysts and jewellery scrap. Recycled output in 2017 amounted to 6 t (up to 59 t), chiefly due to higher automotive and jewellery scrap volumes.

Collection of autocatalyst scrap increased amid the growth of prices on steel and other PGMs, as well as due to higher recycling volumes of European diesel cars with a high platinum content in the catalysts.

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 // t



Source: Company data