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# Pgm market report

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# Definitions

| | |
|---|---|
| **Europe** | EU+ (includes Turkey but excludes Russia) |
| **Japan** | Japan only |
| **North America** | USA and Canada (excludes Mexico) |
| **China** | China only |
| **RoW** | Rest of World: all countries not captured in the above |
| **Supply** | Supply figures represent sales of **primary pgm** by producers and are allocated to the region where mining took place, rather than the region of subsequent processing. |
| **Recycling** | Recycling figures represent **secondary pgm supplies** and are the quantity of metal recovered from open-loop recycling (i.e. where the original purchaser does not retain control of the pgm throughout). Outside the autocatalyst, jewellery and electronics markets, **open-loop recycling** is negligible.<br><br>**Autocatalyst recycling** represents the weight of metal recovered from end-of-life vehicles and aftermarket scrap. It does not include warranty or production scrap. It is allocated to the region where the vehicle was originally sold (but not necessarily scrapped). |
| **Gross demand** | Gross demand figures for any given application represent the sum of industry demand for new metal in that application; that is it is net of any **closed-loop recycling** (i.e. where industry participants retain ownership of the metal: an example would be recycling of spent chemical catalysts where the metal is retained to be used on fresh catalyst that replaces the spent charge).<br><br>Gross demand also includes any changes in unrefined metal stocks in the sector. Increases in unrefined stocks lead to additional demand, while reductions in stocks (including any metal released from industry, e.g. in the case of chemical plant closures) lead to lower demand.<br><br>**Autocatalyst demand** is allocated to the region where the vehicle is manufactured and is accounted for at the time of vehicle production. It includes emissions catalysts on vehicles, motorcycles and three-wheelers, and non-road mobile machinery. (Fuel cell vehicles are counted under industrial demand.)<br><br>**Jewellery demand** is allocated to the region where the finished jewellery is manufactured, not sold. |
| **Net demand** | Gross demand less open-loop recycling. |
| **Movements in stocks** | This figure gives the overall market balance in any one year and reflects the extent of stocks that must be mobilised to balance the market in that year. It is thus a proxy for changes in stocks held by fabricators, dealers, banks and depositories, but excludes stocks held by primary and secondary refiners and final consumers. A positive figure (market surplus) thus reflects an increase in global market stocks. A negative value (market deficit) indicates a decrease in global market stocks. |

# Platinum summary

## Supply and demand in 2020

The platinum market remained in deficit in 2020, with sharply lower supplies, and strong investment demand.

Autocatalyst consumption plunged by 22%, with steep falls in European diesel car production.

Industrial purchasing was more resilient, especially in China, where petrochemical and glass expansions went ahead.

Chinese jewellery demand slumped to a twenty-year low, although record gold prices encouraged some retailers to stock more platinum.

Japan saw heavy bar purchasing in the first half of 2020, while ETF investment turned strongly positive in the second half.

Primary platinum supplies shrank by 20%, due to processing outages and pandemic-related disruption in South Africa.

Auto recycling contracted sharply on weak diesel scrap volumes in Europe and processing capacity constraints.

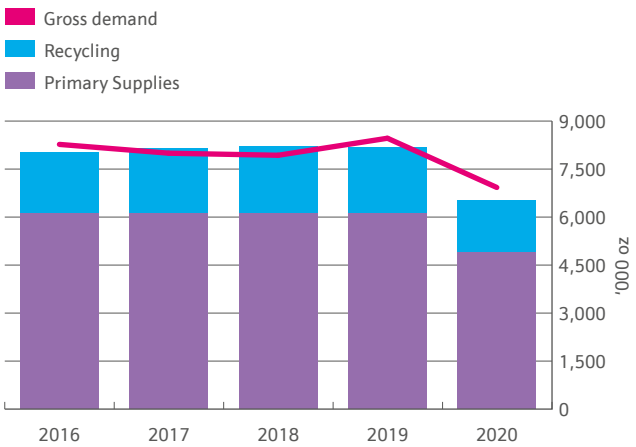



**Figure 1** Platinum supply and demand

**Platinum supply and demand fell steeply in 2020, as the Covid-19 pandemic triggered temporary closures of mines and automotive plants, disrupted the collection of pgm-containing scrap, and hit consumer purchasing of new cars and jewellery. World primary supplies contracted by 20%, with outages at Anglo American Platinum's converter plant adding to Covid-related disruption. Autocatalyst demand plunged by 22%, as diesel car production in Europe fell steeply, while sales of platinum to Chinese jewellery manufacturers slumped to a twenty-year low of less than 1 million oz. However, industrial demand was more resilient: new plant construction by Chinese petrochemical and glass companies proceeded on schedule, and low prices stimulated some advance purchasing for future projects. Price trends were also supportive of physical investment: Japanese bar demand surged after yen-denominated prices hit seventeen-year lows, while ETF investors in the US and Europe added to their platinum positions. Overall, changes in supply and demand were nearly identical, leaving the market in continued moderate deficit.**

Our supply and demand estimates for 2020 are based on information available at the end of October 2020. With a second wave of Covid-19 gathering pace across much of Europe and North America, there remains some uncertainty about the impact on supply and demand in the final two months of the year. Final estimates for 2020 will be published in the forthcoming May 2021 edition of this report.

Following several years of surplus over the last decade, the platinum market is theoretically well-supplied, despite deficits in 2019–2020 (Figure 1). Nevertheless, the market recorded periods of unusual tightness last year. This was primarily associated with Covid-related changes in regional supply, demand and metal flows, especially in the first half of the year. Lockdowns in Europe and the USA reduced demand for platinum sponge (the form of metal typically required by Western industrial and automotive buyers), but purchasing of platinum ingot in Asia remained buoyant. In March 2020, steep falls in the platinum price stimulated record buying on the Shanghai Gold Exchange (SGE), while retail purchasing of investment bars in Japan also set an all-time high for a single month.

"In March, steep falls in the platinum price stimulated record buying on the Shanghai Gold Exchange"

| Supply '000 oz | 2018 | 2019 | 2020 |
|---|---|---|---|
| South Africa | 4,467 | 4,398 | 3,199 |
| Russia | 687 | 721 | 662 |
| Others | 972 | 958 | 1,027 |
| **Total primary supply** | **6,126** | **6,077** | **4,888** |

| Demand '000 oz | 2018 | 2019 | 2020 |
|---|---|---|---|
| Autocatalyst | 3,017 | 2,858 | 2,224 |
| Jewellery | 2,258 | 2,056 | 1,581 |
| Industrial | 2,585 | 2,415 | 2,214 |
| Investment | 67 | 1,131 | 901 |
| **Total gross demand** | **7,927** | **8,460** | **6,920** |
| Recycling | -2,066 | -2,082 | -1,642 |
| **Total net demand** | **5,861** | **6,378** | **5,278** |
| Movements in stocks | 265 | -301 | -390 |

**Table 1** Platinum supply and demand

This exceptional activity occurred at a time when some pgm refineries were operating at reduced rates, and many commercial aircraft were grounded, affecting deliveries of metal from both secondary and primary refiners. It resulted in highly unusual shortages of ingot stocks in platinum's traditional trading hubs in Europe, and in turn triggered a steep rise in lease rates to highs of over 10% during March and April.

Buying on the SGE in particular continued at elevated levels throughout much of 2020: between January and November, over 1.2 million oz of platinum was bought on the exchange, double the 2019 level (Figure 2). While this was partly a function of pandemic-related disruption to other supply routes, it also reflected strong underlying industrial demand, particularly in the petrochemical and glass sectors. Planned capacity upgrades in China largely proceeded on schedule, and some companies took the opportunity to buy metal at lower prices ahead of expansions slated for the 2021–2022 period.

"Demand continued to modestly outpace new supply during 2020, widening the deficit to nearly 400,000 oz"

Ingot shortages caused by strong demand from Asia had a significant impact on the platinum futures market. At the peak of the first pandemic wave, a lack of Nymex deliverable bars and limited airfreight capacity impaired the physical transfer of metal to Nymex vaults to settle contract obligations. This caused Nymex futures prices to move to a significant premium to London spot price, and ultimately eventually spurred large increases in platinum inventories in Nymex-approved warehouses in North America, which reached a record 657,000 oz in October 2020. This removal of liquidity from the market helped to support platinum lease rates close to 2% for much of the year.

We believe that higher lease rates primarily reflected mismatches in the location and form of metal availability, rather than any underlying shortage of platinum. Nevertheless, our market balance figures show that demand continued to modestly outpace new supply during 2020, with the deficit widening slightly to nearly 400,000 oz.

"The potential for greater platinum use in gasoline cars and fuel cells boosted investor sentiment"

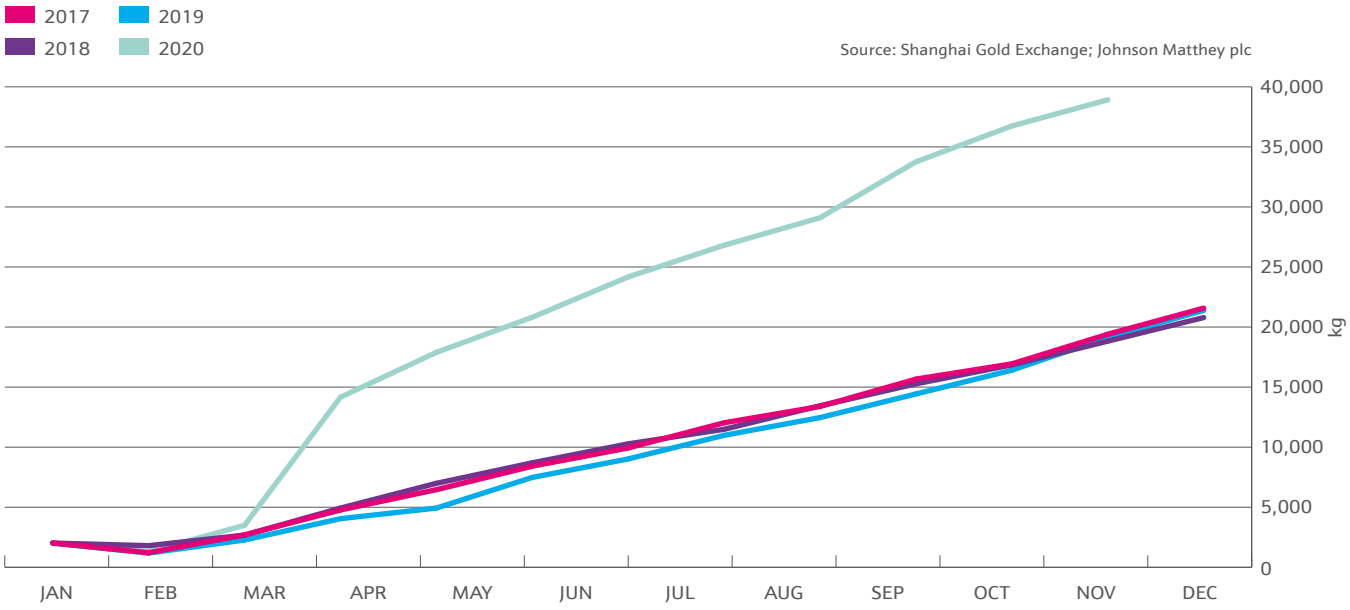



**Figure 2** Cumulative SGE platinum sales

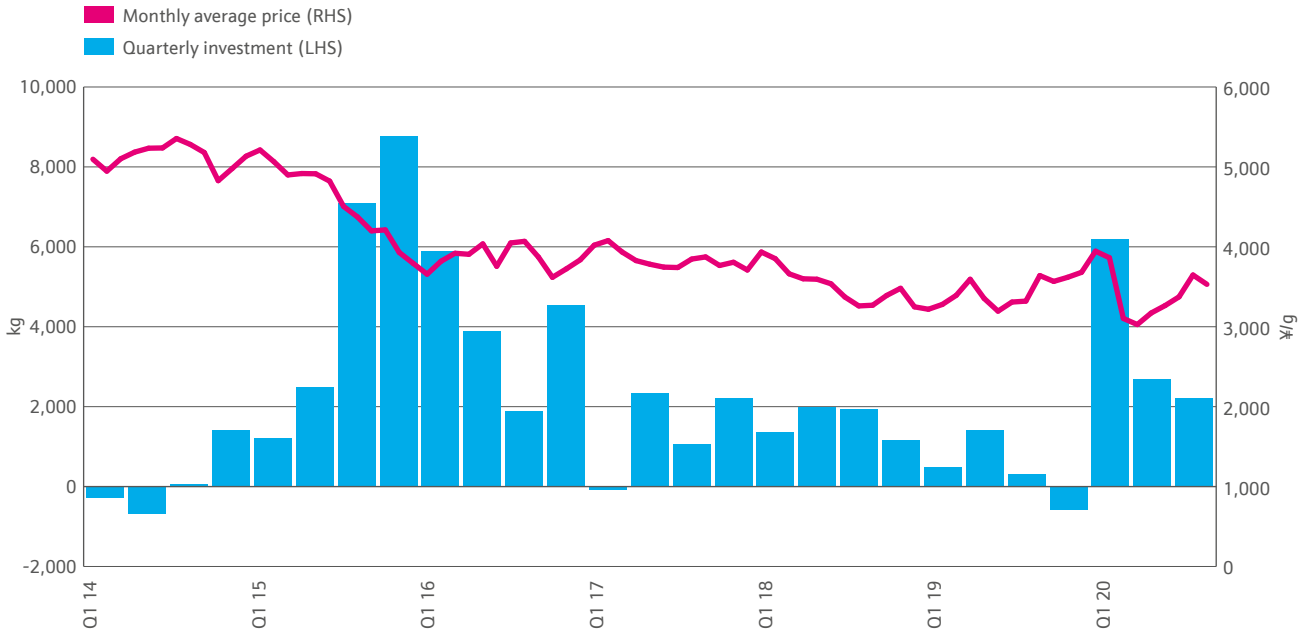



**Figure 3** Japanese platinum bar investment

## Investment demand

Investment demand has been a key driver behind the move into deficit in the past two years. In Japan, purchases of physical investment bars set an all-time record for a single month in March 2020, as the daily retail platinum price plunged through the key ¥3,000 level, briefly touching a seventeen-year low of just over ¥2,500 per gram.

This activity was consistent with past investor behaviour in the Japanese market: declines in price tend to stimulate buying, especially when important psychological price levels are breached. In addition, platinum's discount to gold widened dramatically during 2020, nearly doubling between January and August to a peak differential of ¥4,000 per gram. This may have reinforced investor perceptions that low platinum prices represented a buying opportunity, encouraging purchasers to continue accumulating metal during the second and third quarter even as the price rose back towards ¥3,500 (Figure 3). Towards the year end, demand eased and even turned temporarily negative as the platinum price moved above ¥3,800 per gram. Nevertheless, we estimate that total investment demand in Japan exceeded 340,000 oz in 2020 – a four-year high. (Note: the prices quoted above are Japanese retail prices, i.e. net of sales tax, which is currently levied at a rate of 10%.)

Global ETF holdings were relatively stable in the first half of 2020. Rand weakness provided some profit-taking opportunities to South African investors, but this was broadly offset by renewed purchasing in Europe and North America. During the third quarter, there was a return to significant buying in all regions except Japan: between July and September, total ETF holdings rose by nearly half a million ounces to a record 3.8 million oz (Figure 4). Some of this was probably 'safe haven' buying spilling over from gold, but platinum also benefited from improving sentiment based on the potential for increased use in gasoline autocatalysts and fuel cells.

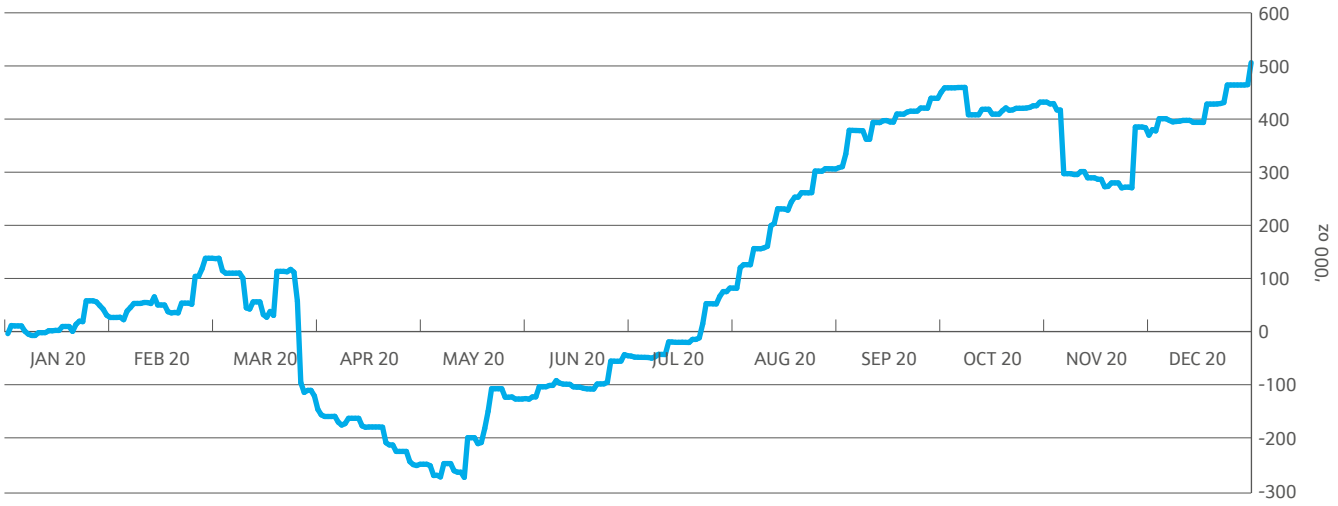



**Figure 4** Net change in platinum ETF holdings in 2020

## Autocatalyst demand

While the prospect of platinum substitution in gasoline vehicles already appears to have influenced investor behaviour, it has not yet had a material impact on automotive demand. Platinum's traditional applications in the light and heavy duty diesel sectors continued to account for the vast majority of automotive consumption in 2020. The Covid-19 pandemic intensified pre-existing weakness in the key European diesel car market, while heavy duty truck producers slashed production volumes in all major markets except China. As a result, platinum auto demand contracted by 22% to 2.2 million oz, the lowest level since the Global Financial Crisis (Figure 5).

In Europe, by far the largest regional user of platinum in autocatalysts, demand dropped to a twenty-year low of under 1 million oz. Starting in the second week of March, lockdowns triggered a collapse in new car sales and temporary shutdowns at most major European car plants: as a result, European car production shrank by nearly 40% in the first half of 2020 versus the same period of 2019.

From mid-year, the sector began to recover gradually, and at the time of writing, European light vehicle production in calendar 2020 was estimated at around 15.4 million units, down 20% on the previous year. However, diesel was more heavily impacted than the gasoline or battery electric segments (Figure 6). Output of diesel cars plunged by a quarter to around 5.5 million vehicles, representing a share of just 36% of a market where as recently as five years ago diesel cars accounted for half of all production.

The impact on platinum demand was exacerbated by a further modest decline in the average pgm content of European diesel aftertreatment systems. In this region, platinum-containing diesel particulate filters (DPFs) are gradually being displaced by non-pgm 'SCRF' bricks, which perform both NOx reduction and particulate filtration. However, all diesel vehicles sold in Europe continue to require at least one pgm-containing catalyst brick, usually a diesel oxidation catalyst or a NOx storage catalyst.

India, previously the world's second largest light duty diesel market, saw diesel car output collapse by nearly two-thirds in 2020. Even before the Covid-19 pandemic, the Indian diesel sector was already facing strong headwinds. Indian car sales and output slumped during the first two months of 2020, following a government clampdown on 'non-banking financial corporations' which have in the past been an important source of financing for big-ticket purchases. At the same time, automakers were rationalising their diesel car offerings ahead of the introduction of Bharat VI (BSVI) emissions legislation in April 2020. The new regulations require the addition of complex and expensive NOx control technology to diesel aftertreatment systems. The additional cost has made diesel uneconomic in smaller vehicle segments and some Indian car companies appear to have withdrawn from the diesel sector completely. As a result, platinum consumption on Indian diesel cars halved in 2020, despite an increase in average loadings due to the implementation of BSVI standards.

| Gross demand '000 oz | 2018 | 2019 | 2020 |
|---|---|---|---|
| Europe | 1,452 | 1,291 | 955 |
| Japan | 365 | 357 | 283 |
| North America | 321 | 333 | 241 |
| China | 148 | 155 | 191 |
| Rest of World | 731 | 722 | 554 |
| **Total** | **3,017** | **2,858** | **2,224** |

**Table 2** Platinum demand: Autocatalyst

Globally, the only bright spot for platinum use in automotive applications was in the heavy duty sector in India and China, and even here the gains were relatively modest. Pgm catalysts became mandatory on all trucks sold in India from April 2020, following the introduction of BSVI, but the impact was dampened by an approximately 50% drop in Indian heavy vehicle output.

China also saw a modest increase in platinum use by the heavy duty sector, as a small but increasing number of heavy duty trucks were equipped with platinum-containing catalyst systems capable of meeting China VI limits. From July 2021, these stricter standards will be enforced nationwide on all heavy vehicles.

Most trucks in China have diesel powertrains, but there is a growing market for heavy vehicles with compressed natural gas

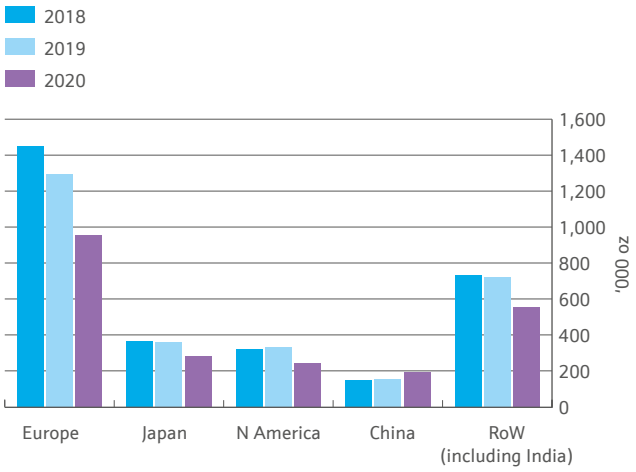



**Figure 5** Autocatalyst demand for platinum (gross)

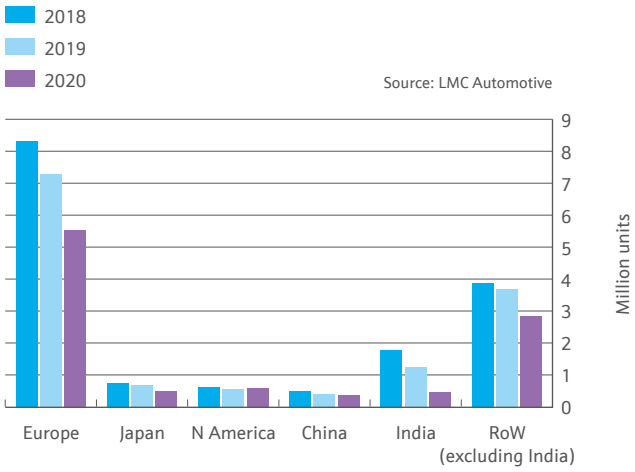



**Figure 6** Light duty diesel vehicle production by region

(CNG) engines. These have been subject to China VI legislation since July 2019. CNG trucks are fitted with conventional three-way catalysts, but pgm loadings are significantly heavier than for comparable gasoline vehicles. With palladium and rhodium prices at all-time highs, some CNG truck producers began to adopt tri-metallic three-way catalysts (containing platinum, palladium and rhodium) during 2020.

In light duty gasoline applications, platinum consumption in 2020 was mainly confined to a handful of Japanese car companies which have historically retained some platinum in their gasoline catalyst mix. Demand from these automakers declined in line with Covid-related drops in vehicle production. However, a combination of pandemic-induced financial stress and high palladium prices appears to have sparked a shift in car companies' attitudes to substitution. Many automakers now have firm plans to adopt tri-metallic or platinum-rhodium catalysts for some gasoline applications, or have expressed a strong interest in implementing this technology in future.

In 2020, substitution was limited to the fitment of platinum-containing catalysts on a small number of models, mainly in the cooler 'underfloor' position where catalyst bricks typically have lower pgm loadings. The contribution to total platinum consumption was marginal and was in any case outweighed by the impact of declining vehicle production. To date, there has been only extremely limited use of platinum-containing catalysts in the hotter 'close-coupled' position close to the engine (where pgm loadings are much higher). Wider adoption of this technology is anticipated in future (see page 21–22).

## Industrial demand

While demand in the autocatalyst sector was severely impacted by the Covid-19 pandemic, consumption of platinum in its major industrial applications in the petrochemical, petroleum refining and glass industries was relatively robust (Figure 7). In particular, demand from China was remarkably buoyant, with expansions proceeding and some industrial consumers bringing forward their platinum purchases to take advantage of low prices.

The impact of the Covid-19 pandemic has been extremely variable between different industrial applications and between regions. In China, 2020 was the final year of the Thirteenth Five-Year Plan, a key pillar of which was to increase self-sufficiency in the petroleum refining and chemicals industries. Over the past three to four years this has been highly supportive of platinum catalyst demand in processes such as catalytic reforming, propane dehydrogenation and paraxylene production. Because capital investment in these sectors has been motivated by the Five-Year Plan, most projects planned for 2020 were implemented on schedule and saw little or no impact from the pandemic.

"Chinese industrial demand was resilient, with new plant construction and some advance purchasing of platinum"

| Demand '000 oz | 2018 | 2019 | 2020 |
|---|---|---|---|
| Chemical | 657 | 676 | 614 |
| Electronics | 241 | 230 | 239 |
| Glass | 501 | 441 | 378 |
| Medical & biomedical | 223 | 230 | 206 |
| Petroleum | 372 | 251 | 322 |
| Other | 591 | 587 | 455 |
| **Total** | **2,585** | **2,415** | **2,214** |

**Table 3** Platinum demand: Industrial

Other Chinese government programmes have also been supportive of platinum demand, including recent liberalisation of the oil market to create more space for independent refineries and petrochemicals producers, and the 'Belt and Road' initiative which is intended to stimulate regional and global infrastructure development. These are expected to drive further capacity expansion during the 2021–22 period. The purchase of platinum for large petrochemical complexes typically takes place a few months ahead of plant commissioning, but during the first half of 2020 some companies took advantage of low prices to secure their metal requirements a year or more in advance.

While strong platinum demand in the Chinese chemical and petroleum sectors has largely been independent of the Covid crisis, some sectors have enjoyed enhanced demand for their products as a direct result of the pandemic. This is particularly true of companies supplying personal protective equipment (PPE) and their raw material suppliers. Platinum catalysts are employed in the production of medical-grade silicones, as well as in propane dehydrogenation (PDH); propane is a feedstock for the production of polypropylene, used in nonwoven fabrics for PPE items including masks and biohazard suits.

In contrast, demand from the European and North American petroleum and chemicals sectors contracted in 2020, as a reduction in capacity utilisation resulted in longer catalyst lifetimes and hence a decline in 'top-up' demand (metal purchases to cover losses, both in-process and during the refining of spent catalyst, which in these regions accounts for

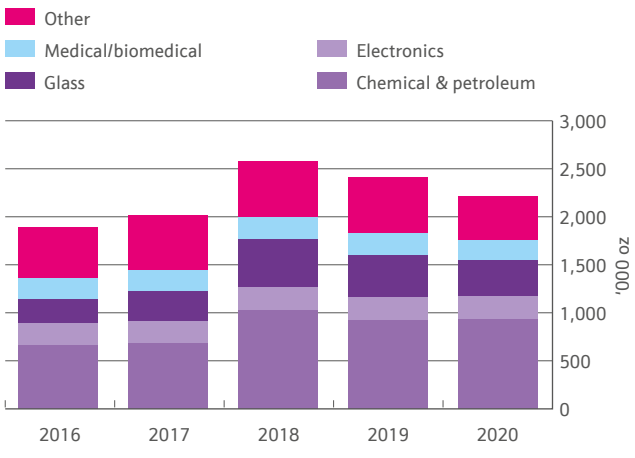



**Figure 7** Industrial demand for platinum

## "Increases in home working have supported sales of hard disks to data centres"

a large proportion of total platinum demand). In addition, we allow for the return of some platinum to the market in North America, following an explosion at an East Coast refinery which resulted in its closure. In the Rest of World region, a decline in petrochemical plant construction caused a steep drop in platinum purchasing versus the unusually high levels seen in recent years. However, this was related more to the investment cycle than to the pandemic.

In the glass industry, planned capacity expansions by Chinese fibreglass companies went ahead, and here too some pre-buying of platinum took place for future projects. These new plants are primarily intended to produce glass fibre for the domestic market. Chinese fibreglass demand remained buoyant in 2020: auto production has recovered swiftly from Covid-related shutdowns, while infrastructure-related projects have been a target of post-lockdown government stimulus. In particular, there has been strong investment in the wind sector (which uses glass fibre-reinforced materials in blades for wind turbines), as part of the Belt and Road initiative to create a wind grid across Asia. Consumption of fibreglass in 5G telecommunications infrastructure also remains buoyant.

Elsewhere in the glass sector, the development of supply chains for Covid-19 vaccines has stimulated investment in platinum-containing equipment to produce speciality glass vials. However, platinum purchasing by display glass manufacturers fell steeply in 2020, reflecting rationalisation in the LCD industry. This left overall platinum demand from the glass sector down by 14%, although consumption remained strong relative to historic use in this application.

In the electronics sector, the largest end-use application for platinum is in hard disks, where it is used in the magnetic coating that enables large quantities of data to be stored on a small surface area. The market for hard disks has been resilient in the face of Covid-19, despite short-term disruption to the production and shipment of components and finished devices in early 2020. Producers and distributors started the year with relatively lean inventories, following trade tensions between the USA and China, so once lockdowns ended and supply-chain disruption eased, significant pent-up demand for hard disks and drives was released.

The pandemic has been the catalyst for some wide-reaching changes in work and social behaviour which have been positive for the electronics industry generally and for the hard disk sector in particular. A dramatic increase in home working has driven an expansion in 'cloud' storage requirements, supporting sales of hard disks to data centres. Overall, we estimate that platinum consumption in hard disks rose by around 5% in 2020.

Among other pgm applications, sectors closely linked to transport were the most severely affected by the Covid-19 pandemic. The use of platinum in aero engine turbine blades fell by nearly 50%, as Airbus and Boeing slashed aircraft production by around 40%, and lower fleet utilisation resulted in a significant fall in engine refurbishment activity. Much of the platinum demand in aviation applications arises from periodic engine maintenance, during which turbine blades may be removed and either replaced or recoated. With passenger kilometres estimated to have fallen by around two-thirds in 2020, fewer aircraft underwent maintenance last year, while more were retired, leading to increased recovery of platinum during the removal of engines from decommissioned planes. In the road transport sector, use of pgm in components such as spark plugs, oxygen sensors and NOx sensors dropped by around 15%, broadly following trends in vehicle production.

### Jewellery demand

We estimate that gross demand for platinum jewellery fell by around 23% in 2020, but recycling also dropped, leaving net jewellery consumption down 19% (Figure 8). Demand for platinum jewellery in its largest market, China, was exceptionally weak during the first half of 2020, due to extended store closures, low footfall following the reopening of retail outlets during February and March, and consumers' reluctance to spend on luxury goods. However, platinum jewellery fabrication picked up strongly in the third quarter, as record gold prices encouraged Chinese retailers to devote more counter space to platinum instead of karat gold. This was partly as a means of reducing the cost of holding stock, but also a response to very weak consumer demand for karat gold jewellery.

| | Gross | | | Recycling | | | Net | | |
|---|---|---|---|---|---|---|---|---|---|
| **Demand '000 oz** | **2018** | **2019** | **2020** | **2018** | **2019** | **2020** | **2018** | **2019** | **2020** |
| Europe | 191 | 190 | 157 | -5 | -5 | -5 | 186 | 185 | 152 |
| Japan | 293 | 294 | 247 | -185 | -175 | -140 | 108 | 119 | 107 |
| North America | 224 | 201 | 153 | 0 | 0 | 0 | 224 | 201 | 153 |
| China | 1,316 | 1,119 | 842 | -505 | -465 | -295 | 811 | 654 | 547 |
| Rest of World | 234 | 252 | 182 | -4 | -5 | -4 | 230 | 247 | 178 |
| **Total** | **2,258** | **2,056** | **1,581** | **-699** | **-650** | **-444** | **1,559** | **1,406** | **1,137** |

**Table 4** Platinum demand: Jewellery

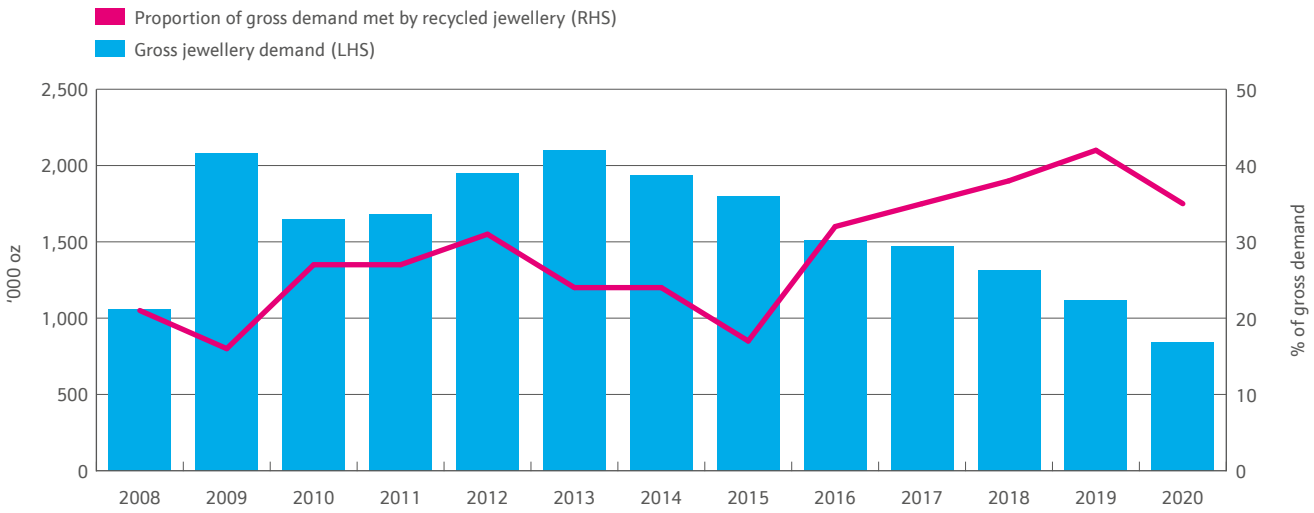



**Figure 8** Chinese platinum jewellery demand & recycling

At October 2020 metal prices, the precious metal value of a platinum jewellery item was around 15-20% lower than that of an equivalent karat gold piece. For the Chinese consumer, the retail price differential was even greater, because karat gold jewellery in China is typically sold by the piece (at a premium to the intrinsic metal value) whereas platinum items are priced based on their weight. It is not yet clear whether this price advantage, combined with greater visibility in shop counters, will ultimately be converted into higher retail demand – although there were reports of an uptick in sales of platinum fashion jewellery in the final quarter of 2020.

China is by far the most price-sensitive jewellery market worldwide, due to local jewellery pricing conventions and the relatively low margins earned by fabricators and distributors. Elsewhere, demand trends in 2020 were primarily driven by changes in consumer spending and behaviour, along with reduced retail footfall due to lockdowns and restrictions on travel. The Japanese market fared somewhat better than other regional markets, with bridal jewellery less heavily impacted than most fashion jewellery segments. Fabricators have also reported that sales of Kihei platinum chain have been resilient, in comparison to demand for comparable gold products. Kihei is a type of plain precious metal neckchain that is often purchased for its intrinsic metal value as well as for adornment.

## Primary supplies

Global platinum supplies fell by 20% in 2020, in the wake of a five-week national lockdown in South Africa that began on 26th March. This resulted in most South African platinum mining operations being placed on temporary care and maintenance for part of the lockdown period, and the idling of many smelting and refining facilities.

From early April, the South African government authorised some limited open-cast mining operations, and on 16th April, the mining sector received the go-ahead to reopen mines at 50% of normal production levels (conditional upon strict safety procedures including screening and testing workers).

A return to 100% of normal production was permitted from the beginning of June, but many mines experienced a slow and prolonged ramp-up, due to capacity constraints created by physical distancing and infection control measures, and labour shortages caused by delays in the return of migrant workers. The reopening process was particularly complex for deeper shafts where the platinum reefs are extracted using conventional labour-intensive methods, because physical distancing measures are challenging to implement in this setting. Nevertheless, by the end of the third quarter, many shallower mines were operating near-normally, and most deeper operations had recovered to at least 90% of usual production levels.

Refined output from the main South African producers saw unusually large fluctuations during 2020, as the impact of mine closures was exacerbated by interruptions at processing plants. In the second quarter, refined platinum production at Anglo American Platinum fell by nearly 70% versus the previous year, following outages at both the Phase A and Phase B units at the Anglo Converter Plant (ACP). With no operational converting capacity, Anglo was obliged to declare force majeure, both to customers and to the third-party mines with whom it has concentrate offtake or toll-refining agreements.

The Phase A unit was taken off-line for ten months for a complete rebuild, while temporary repairs were undertaken at the Phase B converter, enabling it to resume operations after a two-month shutdown. During the outage, inventories of semi-processed pgm-containing materials accumulated at Anglo's concentrators and smelters, as well as at third-party mines that were unable to deliver their concentrate. However, Covid-related mine closures overlapped with the ACP shutdown, and this helped limit the build-up of inventory.

Although the repaired Phase B converter was operational for much of the second half, there was some continued disruption due to on-going maintenance, and the unit was closed for safety reasons in early November. Anglo was subsequently able to recommission the rebuilt Phase A unit ahead of schedule in early December, but the group nevertheless ended 2020 with excess pipeline inventory

containing over 1 million oz of pgm. Processing of this backlog will contribute to supplies in 2021 and 2022.

Impala Platinum also saw some significant pipeline fluctuations during the year. The company entered the lockdown period with significant excess pipeline inventory, following smelter maintenance during the second half of 2019. The processing of this backlog helped to support refined output during the second and third quarters of 2020.

Overall, we estimate that underlying South African mine production of platinum fell by around 17% last year. However, after making an allowance for inventory changes, we show a 27% decline in supplies (which we define as deliveries of newly mined platinum to the market), to approximately 3.2 million oz.

Zimbabwe's mining sector was also affected by the pandemic, but pgm production was much less disrupted than in South Africa. All Zimbabwe's platinum mines are mechanised and received government dispensation to operate during the country's lockdown period. We estimate that platinum supplies rose slightly to around 490,000 oz in 2020.

Elsewhere, disruption to mine production due to Covid-19 appears to have been more limited than in South Africa. Norilsk Nickel has reported no pandemic-related interruptions at its mining operations and no changes to its production plans. Platinum output declined moderately in 2020, reflecting the depletion of pgm-rich surface materials that have contributed materially to output during recent years.

In Canada, where mining was designated by the government as an essential business, Vale and Glencore saw little direct Covid impact on their Sudbury nickel mines, which produce platinum as by-products. However, scheduled and unscheduled maintenance at Vale's Sudbury mines and surface plants led to a dip in both ore and metal production during the second half. Sibanye-Stillwater's Montana, USA, mines operated normally, although there was some pandemic-related loss in productivity, and work on expansion projects was postponed. Overall, we estimate that platinum supplies from North America fell by 3% in 2020.

## Secondary supplies

Secondary supplies experienced significant Covid-19 related disruption. Platinum recoveries fell by around 21%, reflecting a steep fall in the amount of autocatalyst and jewellery scrap being collected. In addition, the autocatalyst recycling sector faced specific supply chain and technical challenges which impacted platinum more than the other autocatalyst pgm.

New vehicle registrations are an important factor determining the availability of autocatalyst scrap, so a significant fall in global heavy and light duty vehicle sales (down by an estimated 22% and 17% respectively) has had a negative impact on autocatalyst scrap volumes. Lockdowns and travel restrictions have affected driving activity, reducing wear-and-tear and accidental damage, with the result that fewer vehicles needed replacing in 2020, especially in the fleet and car rental sector. Moreover, a combination of economic uncertainty and rising lead-times

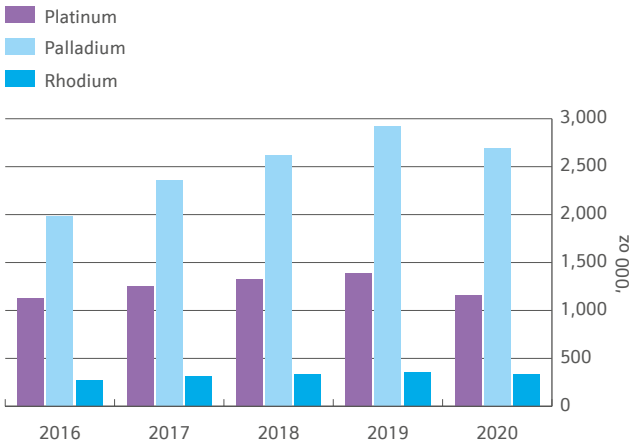



**Figure 9** Autocatalyst recovery by metal

for the delivery of new vehicles has encouraged individuals and companies to extend leases on existing vehicles, or to buy second-hand instead. This in turn has reduced the pool of used cars, driving prices up significantly in some regions – notably in the USA and Europe – and encouraging owners to postpone deregistering vehicles that might normally have been scrapped.

In addition to falling numbers of scrapped vehicles, there was also significant disruption to the collection of autocatalyst scrap. During Covid-19-related lockdowns, some scrap yards were closed, while collectors experienced difficulties with transporting scrap material, particularly where this involved crossing international borders (catalyst scrap is often shipped to refineries in different countries or even continents). Cross-border collection of scrap was particularly problematic in Europe, especially during the first pandemic wave.

During 2020, it appears that the recovery of platinum from spent autocatalysts fell much more sharply than that of palladium or rhodium (Figure 9). This may reflect a greater Covid impact on collection in Europe, where diesel scrap volumes are larger, than in the USA, where gasoline scrap predominates (between them, these two countries account for over three quarters of all pgm recovered from spent autocatalyst). We also believe that some collectors have prioritised the recovery of higher-value and easier-to-treat palladium-rhodium catalysts. In comparison to gasoline scrap, spent diesel catalyst is less attractive to collectors and refiners because it has a lower pgm value and its silicon carbide content makes it harder to treat. Most refineries have only a limited capacity for feed containing silicon carbide, which must be blended in small quantities with other materials to reduce the carbon content to an acceptable level.

# Palladium summary

## Supply and demand in 2020

The palladium market remained in significant deficit, driving the price to all-time highs in early 2020.

A plunge in vehicle output was partly offset by higher palladium loadings on gasoline vehicles.

Consumption in chemical catalysts remained buoyant, with strong investment in new plants in China.

Other industrial demand fell sharply, due to Covid-related disruption and price-driven thrifting.

Investment demand remained negative, with further redemption of palladium ETFs.

Primary supplies were hit by mine closures and processing outages, while autocatalyst recycling also slowed.

| Supply '000 oz | 2018 | 2019 | 2020 |
|---|---|---|---|
| South Africa | 2,543 | 2,626 | 1,939 |
| Russia | 2,976 | 2,987 | 2,727 |
| Others | 1,506 | 1,504 | 1,501 |
| **Total primary supply** | **7,025** | **7,117** | **6,167** |

| Demand '000 oz | 2018 | 2019 | 2020 |
|---|---|---|---|
| Autocatalyst | 8,876 | 9,672 | 8,497 |
| Jewellery | 148 | 130 | 93 |
| Industrial | 1,902 | 1,702 | 1,490 |
| Investment | -574 | -87 | -186 |
| **Total gross demand** | **10,352** | **11,417** | **9,894** |
| Recycling | -3,108 | -3,407 | -3,121 |
| **Total net demand** | **7,244** | **8,010** | **6,773** |
| Movements in stocks | -219 | -893 | -606 |

**Table 5** Palladium supply and demand

**Demand for palladium contracted sharply in 2020, reflecting Covid-related disruption in most end-use sectors, and record prices that stimulated thrifting in some industrial applications. Consumption in autocatalysts fell by 12%, although palladium benefited from rising loadings on Chinese and European cars, helping demand outperform light vehicle production (which dropped by around 16%). Sales to chemicals producers remained firm, but elsewhere industrial demand was weak, as pandemic impacts were exacerbated by price-driven substitution in the dental and electronic sectors.**

Combined primary and secondary supplies were down 12%: temporary mine closures and smelter outages hit output in South Africa, while autocatalyst recycling volumes slowed in response to lower car sales and logistical difficulties in scrap collection. Although there was some further redemption of palladium ETFs, the market remained in significant deficit (Figure 10); prices rose to all-time highs of over $2,800 in February and remained above $2,000 for much of the year.

Over the 2015–2020 period, we estimate that the cumulative palladium shortfall totalled nearly 3 million oz, even after allowing for the liquidation of ETF holdings, which returned 2.5 million oz of metal to the market over this period. Metal stocks held in the traditional trading hubs in the UK and Switzerland were significantly depleted, triggering periodic spikes in lease rates during liquidity squeezes, and steady gains in the price. From around $500 at the start of 2016, palladium climbed past $1,000 in early 2018, then through $1,500 in March 2019, finally breaching $2,000 in early 2020 on its way to all-time highs above $2,800 in February.

In March 2020, as world markets finally grasped the scale of the Covid-19 crisis, palladium was caught up

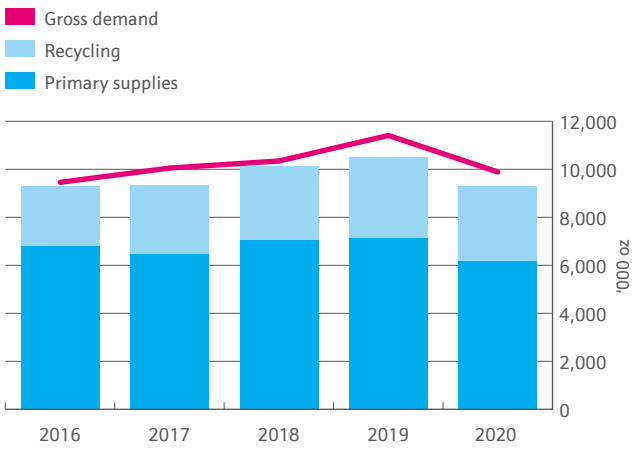



**Figure 10** Palladium supply and demand

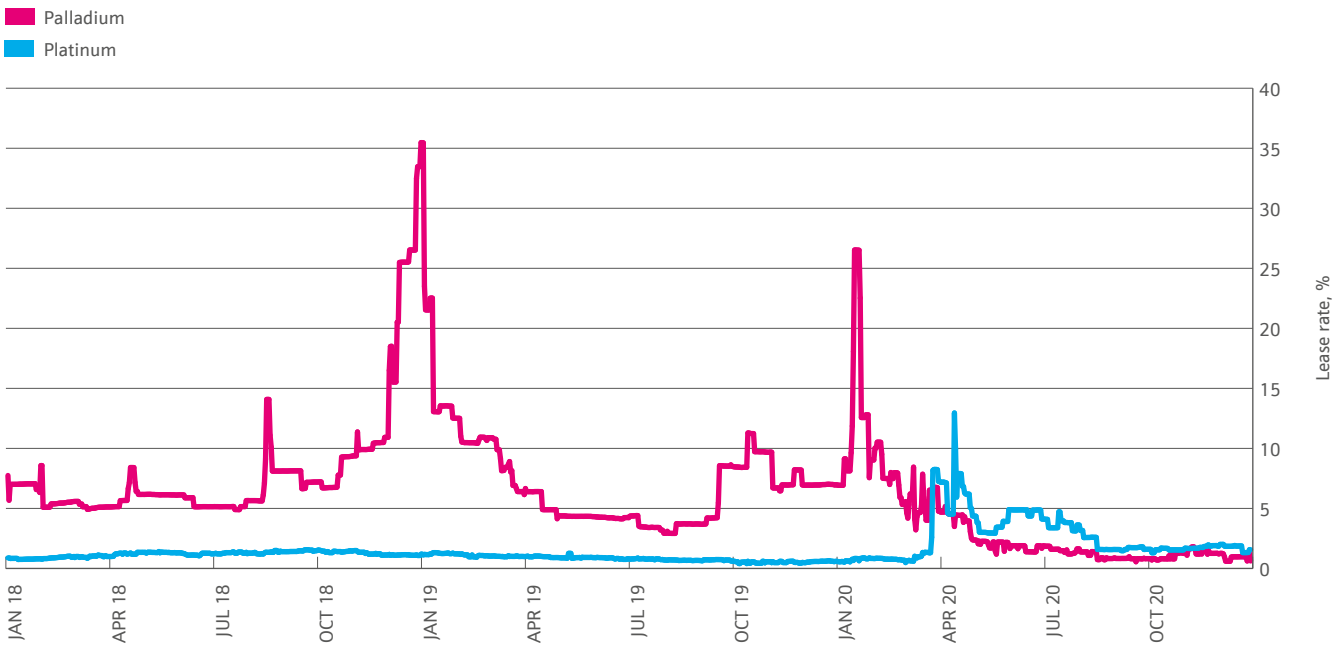



**Figure 11** Platinum and palladium lease rates (3-month)

in massive sell-offs in equities and most commodities. However, the plunge in the price – to a low of under $1,600 – was brief. Palladium recovered strongly, trading above $2,000 for much of the second half of the year.

Lease rates also surged higher in early 2020 (Figure 11), with one-month rates briefly exceeding 30% during January, reflecting exceptional tightness in the market for palladium ingot. This spike was short-lived, as the worsening Covid crisis in China led to a temporary shutdown of the entire Chinese automotive industry and a corresponding plunge in demand for palladium ingot. (Chinese purchasers typically prefer to purchase platinum and palladium in the form of ingot, whereas automotive and industrial buyers in the West usually require sponge).

Chinese auto plants resumed production during the second half of February, but from mid-March it was the turn of first European and then US automakers to shutter their plants due to Covid. This led to a collapse in demand for palladium sponge, at a time when Chinese demand (primarily for ingot) was beginning to recover. Ingot moved to a large premium, and this eventually spurred market participants in the West to convert large quantities of sponge into bars. Some of this metal was purchased by customers in Asia, but some was delivered into traditional trading hubs in Europe: over the first eight months of 2020, trade statistics suggest that inventories of palladium bars held in UK and Swiss vaults rose by over half a million ounces – the first significant increase in at least a decade (Figure 12). Some converted ingot was also delivered to Nymex warehouses in North America, following shortages of Nymex deliverable bars that led to large premiums for the Nymex futures contracts versus London prices. Nymex warehouse stocks rose to a five-year high of 138,000 oz in September 2020.

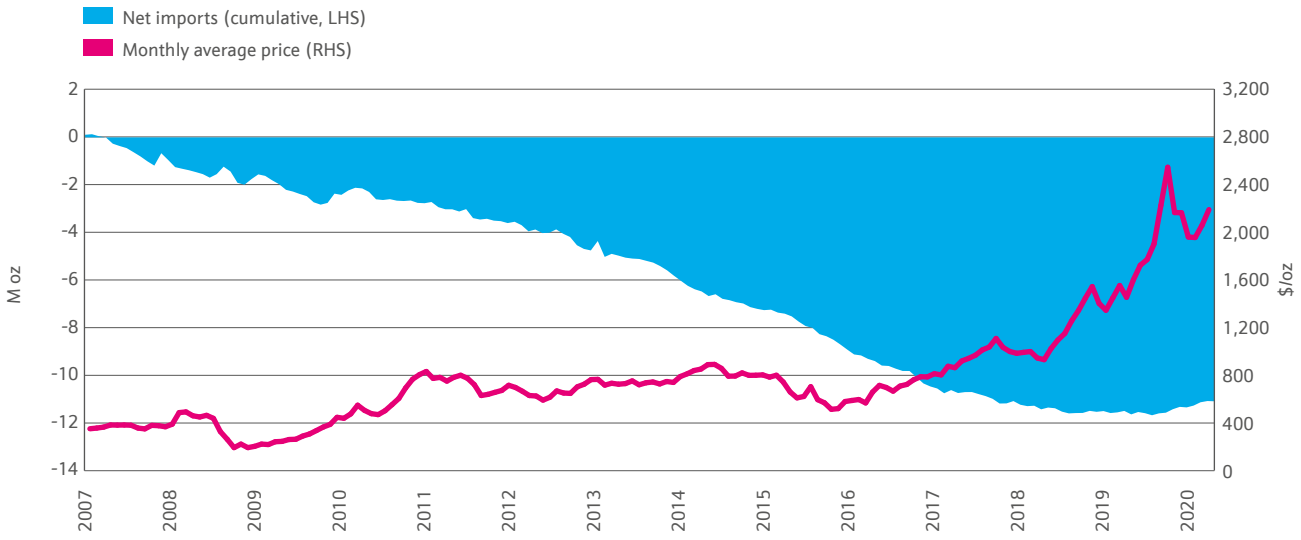



**Figure 12** Cumulative net imports of palladium into the UK and Switzerland since 2007

We believe that this increase in 'visible' market stocks primarily reflects changes in the form and location of metal inventories, rather than signalling a move out of deficit market conditions. It is likely that some of this metal came from the release of work-in-progress inventories at Western refineries.

## Secondary supplies

During 2019 and early 2020, a combination of extremely strong autocatalyst recycling volumes and capacity constraints in the secondary refining sector led to a gradual extension of refining lead-times, and a corresponding build-up in stocks of pgm-bearing scrap and semi-processed materials. The Covid crisis triggered a steep fall in scrap intakes, freeing up capacity and allowing excess inventories to be refined.

This reduction in pipeline stocks has helped to support outturns of palladium during a period of severe disruption in the auto scrap industry. In addition, high palladium prices have incentivised market participants to move scrap through the recycling network as promptly as possible. Nevertheless, there was a 8% decline in the volume of palladium recovered from automotive scrap last year, reflecting temporary interruptions in the collection and transportation of catalyst scrap, and a steep fall in new vehicle sales that has caused an underlying fall in the number of vehicles being retired.

## Primary supplies

Primary supplies also fell, although less steeply than those of platinum and rhodium. Palladium production is geographically dispersed, in that palladium-rich ores are extracted in significant quantities on three continents, whereas geological resources of the other pgm are more heavily concentrated in southern Africa. This broader geographical base helped to mitigate the impact of mine and processing plant shutdowns in South Africa on palladium supplies during 2020.

Mines in Russia and the USA have generally been less severely affected by the pandemic than operations in South Africa, partly because of less harsh government-imposed lockdowns, and partly due to the less labour-intensive nature of their mining operations. Norilsk Nickel has reported no significant Covid-related disruption at its Russian operations, although production

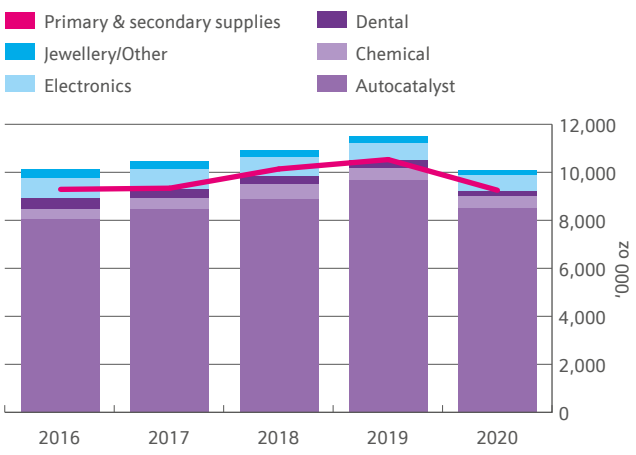



**Figure 13** Palladium demand in consuming applications (excluding investment)

"A steep decline in new vehicle sales has caused a fall in the number of vehicles being retired and recycled"

in the nine months to September 2020 fell by 8% due to the depletion of surface materials that have contributed significantly to pgm output in recent years, and refining pipeline fluctuations.

Sibanye-Stillwater's Montana, USA, operations have also operated continuously throughout the pandemic, although there has been some impact on productivity, and expansion activities have been deferred. Pgm output rose by 3% in the first three-quarters of the year. Elsewhere in North America, there was some disruption to mining operations in Canada, with the Lac des Iles palladium mine (Impala Canada) and the Raglan nickel operation (Glencore) closed for several weeks during the first epidemic wave. Overall, we estimate that North American supplies declined by around 5% last year.

In contrast, South African supplies fell by around a quarter, as the impact of Covid-related shutdowns was aggravated by a series of outages at the Anglo American Platinum converter plant (ACP), which led to a very large build-up in unprocessed pgm stocks. The decline in underlying mine production was much smaller, at around 15% (lower than the 17% decline in platinum and 20% decline in rhodium output). Anglo's Mogalakwena mine – the largest single palladium producer in South Africa – was able to operate almost continuously despite Covid measures. It has been much easier to implement infection control and physical distancing measures at highly mechanised open-pit operations such as Mogalakwena than at deep, labour-intensive operations elsewhere on the Bushveld complex. Output at Mogalakwena fell by just 2% in the first nine months of 2020, versus losses of between 10% and 40% of output at other South African mines over the same period.

Consumption of palladium in automotive and industrial applications dropped sharply last year (Figure 13). A decade-long rising trend in autocatalyst demand was cut short by an estimated 16% decline in light vehicle production, although an increase in average palladium loadings helped to soften the blow. Industrial palladium demand was also severely affected by the pandemic, although there were large variations between sectors and regions. Palladium purchasing from the Chinese petrochemicals sector was at record levels, but consumption in the dental, electronics and jewellery segments was sharply down.

## Autocatalyst demand

There was considerable variation in the pandemic's impact on regional automotive industries (Figure 14). Output of light duty vehicles in China fell by around 6% in 2020, to just over 21 million vehicles. In January, as Covid-19 cases multiplied and restrictions were imposed, Chinese automakers extended their New Year shutdowns, and some factories were idled for as long as eight weeks. Then, when production began to ramp back up, it was initially hampered by labour and component shortages. As a result, light vehicle output almost halved in the first quarter versus the same period of 2019.

| Gross demand '000 oz | 2018 | 2019 | 2020 |
|---|---|---|---|
| Europe | 1,902 | 2,061 | 1,782 |
| Japan | 875 | 905 | 760 |
| North America | 2,129 | 2,104 | 1,720 |
| China | 2,081 | 2,686 | 2,627 |
| Rest of World | 1,889 | 1,916 | 1,608 |
| **Total** | **8,876** | **9,672** | **8,497** |

**Table 6** Palladium demand: Autocatalyst

However, the industry subsequently staged a strong recovery, assisted by national and regional incentives such as vehicle replacement subsidies, scrappage schemes, and the relaxation of licence plate quotas. Production volumes in the second and third quarters were about 8% above previous-year levels.

While the impact of Covid-19 in China was largely confined to a single quarter, other regions saw a steeper downturn and a slower recovery. As the pandemic progressed across Asia, Europe and North America, many large car factories closed for a period of several weeks during March and April. The low point for global production was reached in April, when light vehicle output in all regions outside China fell below one million units – less than 20% of normal monthly volumes. During this month, only around 100,000 vehicles were produced in Europe, under 10,000 in North America, and none at all in India.

Although auto plants began to reopen in May, and activity ramped up steeply in June, most regions lost between half and two-thirds of their normal vehicle output during the second quarter, and many countries did not see any significant 'catch-up' during the second half of 2020. For the full year, light vehicle production is estimated to have fallen by around 15% in Japan, 20% in North America and the Rest of World region, and 23% in Europe.

Palladium demand fared somewhat better than light vehicle production (Figure 15). With catalyst loadings on gasoline vehicles rising versus the previous year, we estimate that global consumption of palladium in autocatalysts fell by around 12%.

In China, the rollout of China 6 models helped lift the average palladium content of a gasoline catalyst system modestly in 2020, following a much larger increase the previous year. This was despite significant efforts to reduce the cost of aftertreatment systems, with pgm thrifting programmes intensifying in response to record palladium and rhodium prices at a time of severe pandemic-related financial stress.

These thrifting efforts were facilitated by government initiatives, especially the introduction of a new, simplified vehicle conformity certification process in March 2020. This has allowed car companies to self-certify vehicles as compliant with type-approval criteria such as emissions limits, and substantially reduced the timescale required for certification. The new process – which was initially intended to be temporary, but which remains in force at the time of writing – has enabled companies to make changes to their catalyst fitment programmes more quickly than would otherwise have been the case.

During the transition to China 6 legislation, Chinese automakers almost universally chose to equip their vehicles with catalysts capable of meeting China 6b emissions limits (which are not scheduled to be enforced nationally until July 2023, although some provinces and cities have imposed them early). During 2020, some domestic Chinese car companies took advantage of the new self-certification process to switch to China 6a catalysts on certain models, where this was permitted by local regulations. However, the impact on average pgm loadings has been minor, because of the relatively small number of vehicles affected.

As well as aggressively pursuing thrifting opportunities, many car companies in China are beginning to implement substitution programmes, with the aim of replacing some of the palladium in three-way catalysts with platinum. During 2020, a small number of models were fitted with tri-metallic gasoline catalysts, mainly in the underfloor position where loadings are relatively low. While this had a negligible impact on palladium demand last year, it will become an increasingly important factor in the Chinese market going forward. We discuss the outlook for substitution in three-way catalysts in greater detail on page 22.

Thrifting and substitution have also risen up the agenda in other regions, as car companies prioritise cost-cutting in response to weak sales and high pgm prices. However, outside China,

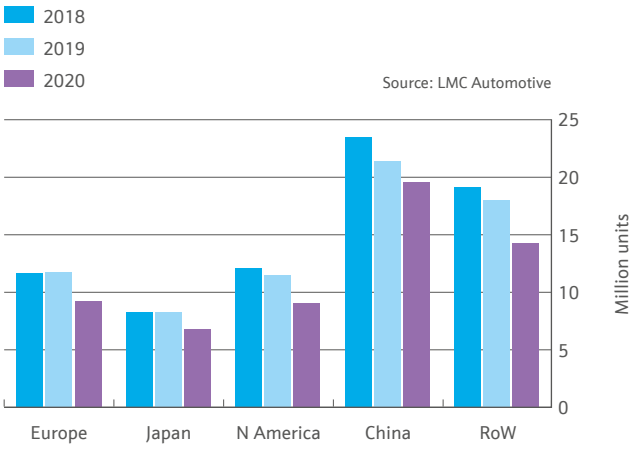



**Figure 14** Light duty gasoline vehicle production by region

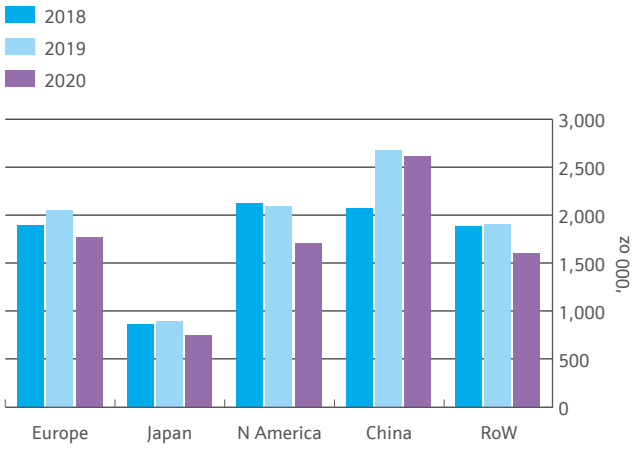



**Figure 15** Autocatalyst demand for palladium (gross)

changes to catalyst systems tend to take longer to implement and substitution had no material impact on palladium loadings during 2020. Indeed, all regions saw increases in the palladium content of gasoline aftertreatment systems in 2020, with the largest gains occurring in Europe and India, reflecting the rollout of Euro 6d and Bharat VI legislation.

In Europe, real driving emissions (RDE) testing was performed on all light vehicle models sold in Europe last year, following the extension of Euro 6d-TEMP legislation to cover all light commercial vehicle models. Meanwhile, new passenger car models launched in 2020 became subject to the full Euro 6d legislation, under which the RDE 'conformity factor' for NOx tightens from 2.1 (under 6d-TEMP) to 1.43.

During RDE testing, vehicles are driven according to random acceleration and deceleration patterns, intended to replicate the wide range of operating conditions that cars might experience during a lifetime on the road. A valid RDE test can vary within these broad parameters, making the stringency of third-party testing unpredictable; this means that automakers must ensure that emissions control equipment remains effective under most conceivable operating conditions.

The introduction of RDE and the subsequent tightening of conformity factors has dramatically increased the technical difficulty of meeting emissions standards, driving up pgm loadings substantially. We estimate that vehicles meeting full Euro 6d legislation typically contain 40–50% more palladium than comparable Euro 6 (pre-RDE) models.

In recent years, European automakers' technical capacity has largely been absorbed by the need to comply with Euro 6d legislation, at a time when many companies have diverted significant resources towards electrification of their fleet to meet $CO_2$ limits. During this period, minimising the pgm content of catalysts has generally been a secondary consideration. However, in 2020, the focus turned increasingly to cost: companies began to look more closely at opportunities to reduce the total pgm content of their systems, or to substitute some palladium with platinum, where this can be done without compromising their ability to meet current or future emissions limits. This had no real impact on pgm demand last year but will become increasingly significant going forward.

In India, the average palladium content of a gasoline car rose by more than 10% in 2020, following the implementation of Bharat VI (BSVI) legislation in April 2020. This market has moved in a single step from Euro 4 type standards to the equivalent of Euro 6 (although without RDE for the time being). BSVI significantly tightens emissions limits and has therefore been associated with a large increase in pgm loadings.

Emissions legislation is also tightening gradually in North America, with Tier 3 federal legislation requiring a higher percentage of new vehicles to meet the very stringent SULEV standards each year between 2017 and 2025. The average pgm content of a gasoline vehicle rose over a quarter between 2016 and 2020, and an upward trend in total loadings is expected to continue until at least 2025.

| Demand '000 oz | 2018 | 2019 | 2020 |
|---|---|---|---|
| Chemical | 600 | 499 | 486 |
| Dental | 358 | 313 | 239 |
| Electronics | 769 | 714 | 634 |
| Other | 175 | 176 | 131 |
| **Total** | **1,902** | **1,702** | **1,490** |

**Table 7** Palladium demand: Industrial

Because US light vehicles are typically much larger and heavier than in other regions, their emissions aftertreatment systems contain more pgm – so it is not surprising that automakers in this region have shown particular interest in the possibility of replacing some palladium with platinum. Tri-metallic catalysts were adopted for a small number of models during 2020, but to date the impact on demand has been minor.

## Industrial demand

Among palladium's industrial applications, consumption of pgm in the dental sector was particularly hard-hit. Dental procedures can be dangerous for the practitioner, because of the risk of virus transmission via both droplets and aerosols. Many procedures were deferred during the active waves of the pandemic, and some of the lost palladium demand will be foregone permanently. At the same time, high palladium prices have also been negative for the consumption of palladium-containing dental alloys, although the large Japanese market has been partly protected from price pressures due to the reimbursement of the cost of a specific palladium-rich alloy by the state healthcare insurance scheme.

Palladium consumption in the electronics sector was also hit by the pandemic, although the industry fared better than initially expected. Component supply chains in Asia were heavily disrupted during the first quarter of 2020 but the subsequent rebound was swift, and underlying consumer trends have been broadly supportive. Wider adoption of remote working practices and increased consumption of home entertainment have been positive for sales of devices such as laptop computers and games consoles, while the rollout of 5G telecommunications technology is also a positive driver for electronic components. High palladium prices have incited manufacturers to minimise palladium use where possible, for example by using electronic pastes with a lower palladium content, but there is now limited scope for further reductions due to heavy thrifting over the past two decades.

Demand for palladium from the chemicals industry has remained remarkably robust in the face of Covid disruption. Indeed, purchasing of palladium catalysts by Chinese petrochemical producers matched the all-time peak set two years ago, as planned capacity expansions went ahead despite the pandemic. This wave of expansion was primarily driven by the self-sufficiency and modernisation objectives in the thirteenth Five-Year Plan that concluded in 2020.

# Rhodium summary

## Supply and demand in 2020

The rhodium market moved deeper into deficit as supplies dropped faster than demand.

With tighter emissions limits boosting catalyst loadings, auto demand fell by less than 10%.

Purchases by glass companies plunged, as high prices stimulated thrifting.

Primary supplies contracted sharply due to mine disruption and processing outages in South Africa.

The rhodium price surged to an all-time record of $17,000 in December 2020.

**The rhodium market deficit doubled in 2020, as a contraction in primary supplies greatly exceeded falls in autocatalyst and industrial demand. South African supplies were heavily impacted by pandemic-related mine disruption, exacerbated by processing plant outages. Meanwhile, tightening emissions legislation helped limit the decline in autocatalyst demand to under 10%, significantly outperforming light vehicle production (down around 16%). Chemicals demand remained firm, but glass demand plunged to the lowest level for at least two decades, as high prices stimulated thrifting of rhodium from glass-making alloys. The price spiked in early 2020, on availability issues and force majeure at Anglo American Platinum, before easing as Covid-related disruption spread globally. However, as the year ended, another processing outage at Anglo pushed the price to new all-time highs.**

Rhodium has seen extraordinary price movements over the last two years, climbing from below $3,000 in January 2019 to a new record of $17,000 at the end of December 2020. The market saw extreme volatility during 2020: in March, rhodium lost nearly two-thirds of its value, collapsing from a (then record) high of $13,800 to a low of $5,500 over a period of less than two weeks. However, as auto production began to recover from Covid-related disruption, rhodium embarked on another steep climb in August, surpassing its March peak by late September, and surging above $15,000 in November after Anglo American Platinum announced a new closure at its converter plant (ACP). Although the ACP resumed operations in early December, rhodium continued to surge higher, reaching $17,000 on 31st December.

These extreme price movements reflect a combination of low market liquidity, a fundamental supply deficit, and relatively inelastic demand. Rhodium has only a handful of industrial uses, primarily in the autocatalyst, chemical and glass sectors,

| Supply '000 oz | 2018 | 2019 | 2020 |
|---|---|---|---|
| South Africa | 618 | 624 | 450 |
| Russia | 69 | 68 | 65 |
| Others | 69 | 68 | 68 |
| **Total primary supply** | **756** | **760** | **583** |

| Demand '000 oz | 2018 | 2019 | 2020 |
|---|---|---|---|
| Autocatalyst | 885 | 1,023 | 925 |
| Other | 158 | 132 | 80 |
| **Total gross demand** | **1,043** | **1,155** | **1,005** |
| Recycling | -331 | -357 | -338 |
| **Total net demand** | **712** | **798** | **667** |
| Movements in stocks | 44 | -38 | -84 |

**Table 8** Rhodium supply and demand

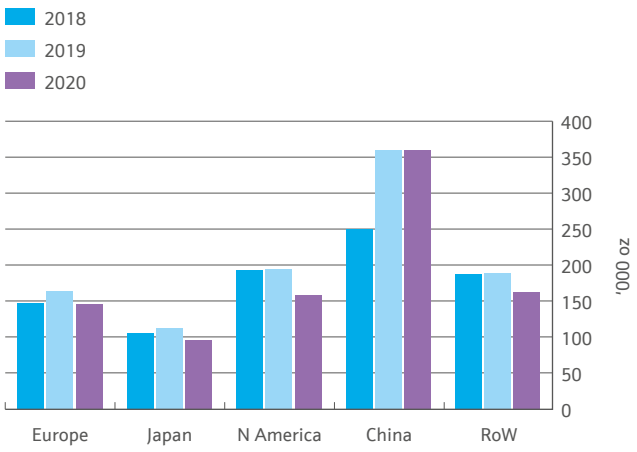



**Figure 16** Autocatalyst demand for rhodium (gross)

but it is difficult to replace in these applications because of its unique chemical and physical properties. Meanwhile, global supply is highly concentrated in South Africa, where the UG2 reef has unusually high rhodium grades compared with other sources of pgm. Most UG2 ore is extracted from underground mining operations, often at considerable depth, using labour-intensive mining methods. Rhodium supplies were therefore heavily affected by disruption at South African mining and processing operations in 2020.

Only the glass sector is able to flex its rhodium usage to any significant degree, by varying the rhodium content of the platinum-rhodium alloys used in glass-making equipment. During periods of lower rhodium prices, glass alloys may contain up to 20% rhodium, but it is possible to reduce the rhodium content to 10% (and sometimes below), albeit at the cost of reduced alloy performance and a shorter working life for the equipment concerned. Thrifting led to a steep fall in rhodium demand from the glass sector in 2020, to levels not seen since the early 1990s.

## Autocatalyst demand

In the automotive industry, use of rhodium is primarily driven by emissions legislation: rhodium remains far and away the best catalyst for aftertreatment of gasoline NOx emissions. With NOx emissions limits continuing to tighten in major global markets, and the implementation of Real Driving Emissions (RDE) testing in Europe, rhodium loadings on gasoline vehicles have risen significantly over the past three years. Globally, we estimate that the average rhodium content of a light gasoline vehicle in 2020 was up by nearly 10% versus the previous year, and by more than 40% since 2017.

Loading increases have been especially significant in Europe and China. Under Euro 6d legislation, being implemented in phases between 2017 and 2022, RDE testing has been rolled out and is being made progressively more stringent. This has been positive for demand for all the autocatalyst pgm, but the impact has been greatest for rhodium, because RDE focuses on NOx emissions.

In China, the implementation of China 6 legislation began in mid-2019 in many Chinese cities and regions, leading to large increases in the palladium and rhodium content of gasoline cars that year. There was further growth in average loadings during 2020, in line with the continuing rollout of new China 6 models. While Chinese automakers are now making significant efforts to reduce the cost of aftertreatment systems, only limited rhodium thrifting has been achieved to date.

| Demand '000 oz | 2018 | 2019 | 2020 |
|---|---|---|---|
| Chemical | 63 | 60 | 56 |
| Electronics | 5 | 6 | 6 |
| Glass | 103 | 45 | 7 |
| Other | -13 | 21 | 11 |
| **Total** | **158** | **132** | **80** |

**Table 9** Rhodium demand: Industrial

These loading gains were partly offset by steep declines in light vehicle output, leaving world autocatalyst consumption down by less than 10% in 2020 (Figure 16). This fall in demand was concentrated in the first half of the year, with a collapse in Chinese car output in February, and in major Western auto markets in March and April. Although this coincided with interruptions to pgm mining in South Africa and a force majeure declaration by Anglo American Platinum, the drop in vehicle production was enough to bring some temporary relief to the rhodium market: availability improved and the price stabilised in a $7,000–$9,000 range between April and early August. Market liquidity was also supported by efforts by autocatalyst recyclers and secondary pgm refiners to reduce inventories of both untreated scrap and semi-refined materials (partly offsetting the impact of lower vehicle scrappage activity).

However, a steep recovery in vehicle production (particularly in China, where output was above year-ago levels for most months in Q2 and Q3 – Figure 17) gradually absorbed any surplus liquidity and, from August, rhodium availability came under intense pressure once again, driving the price to a series of all-time highs.

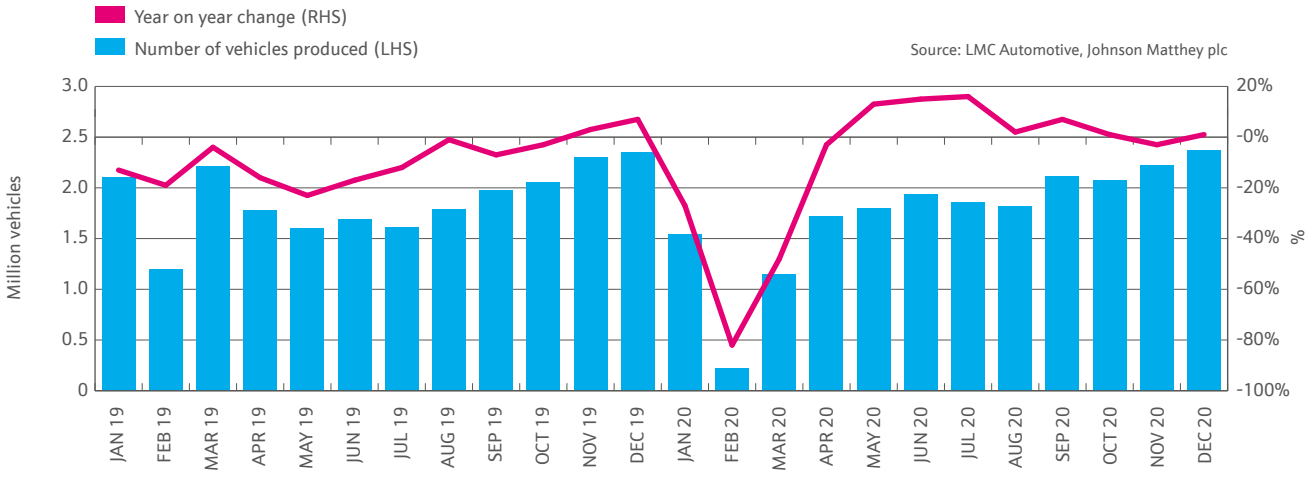



**Figure 17** Monthly light vehicle production – China

# Pgm outlook

## Supply and demand in 2021

Pgm supply and demand are forecast to bounce back in a V-shaped recovery in 2021.

Autocatalyst demand will recover strongly, on higher car output and stricter emissions limits for trucks in China.

Industrial consumption will remain robust, with pgm use in chemicals production set to reach an all-time high.

South African supplies will be boosted by the refining of backlogs following Anglo converter outages in 2020.

Autocatalyst recoveries should rebound as world vehicle markets and recycling networks return to normal.

"With supply and demand moving in tandem, market fundamentals should be little changed in 2021. We expect the palladium and rhodium markets to remain in deficit; for platinum, the direction of the market balance will depend on the behaviour of jewellery consumers and, above all, investors"

**Supply and demand for pgm should recover towards pre-pandemic levels during 2021, assuming Covid-19 disruption eases. South African supplies will be augmented by the refining of a backlog of semi-processed pgm that accumulated following outages at Anglo American Platinum's converter plant last year. We also expect a rebound in recycling, although platinum volumes may remain depressed by capacity constraints on the processing of diesel catalyst scrap. On the demand front, automotive pgm demand is set to rise by approximately 13%, reflecting a strong recovery in light vehicle production, and the implementation of China VI legislation enforcing the use of pgm catalysts on heavy duty diesel trucks. Industrial demand should remain robust, with pgm purchasing by chemical manufacturers set to reach record highs, and most other applications recovering from Covid-related dips.**

With supply and demand moving in tandem, market fundamentals should be little changed in 2021 compared to the past two years. We expect the palladium and rhodium markets to remain in deficit; for platinum, the direction of the market balance will depend on the behaviour of jewellery consumers and, above all, investors. There were some glimpses of improvement in the Chinese jewellery market in the second half of 2020, but it is not yet clear whether this can be sustained. In the investment sector, platinum holdings have grown by over 2 million oz in the past two years. However, there may be potential for further buying, in response to platinum's large discount to gold, and the prospect of additional use in gasoline autocatalysts and fuel cells. However, if investment falls significantly below 2019–2020 levels, the platinum market could move back into balance, or even into surplus.

### Autocatalyst demand

At the time of writing, global auto pgm demand is on course to rise by around 13% to just over 13 million oz in 2021, slightly below the record 2019 level but still the second-highest global total ever recorded. This is based on industry forecasts of a strong recovery in vehicle production, combined with our expectation of higher pgm loadings on heavy duty diesel (HDD) vehicles in China, where new HDD emissions limits will be enforced nationwide from mid-2021.

Use of pgm in light duty applications in China is expected to be flat to slightly down this year, despite an improvement in passenger car output, and the full, nationwide enforcement of the first phase of China 6 legislation, including a tighter particle number limit that became effective in January 2021. Two years ago, when China 6 vehicles were first widely launched,

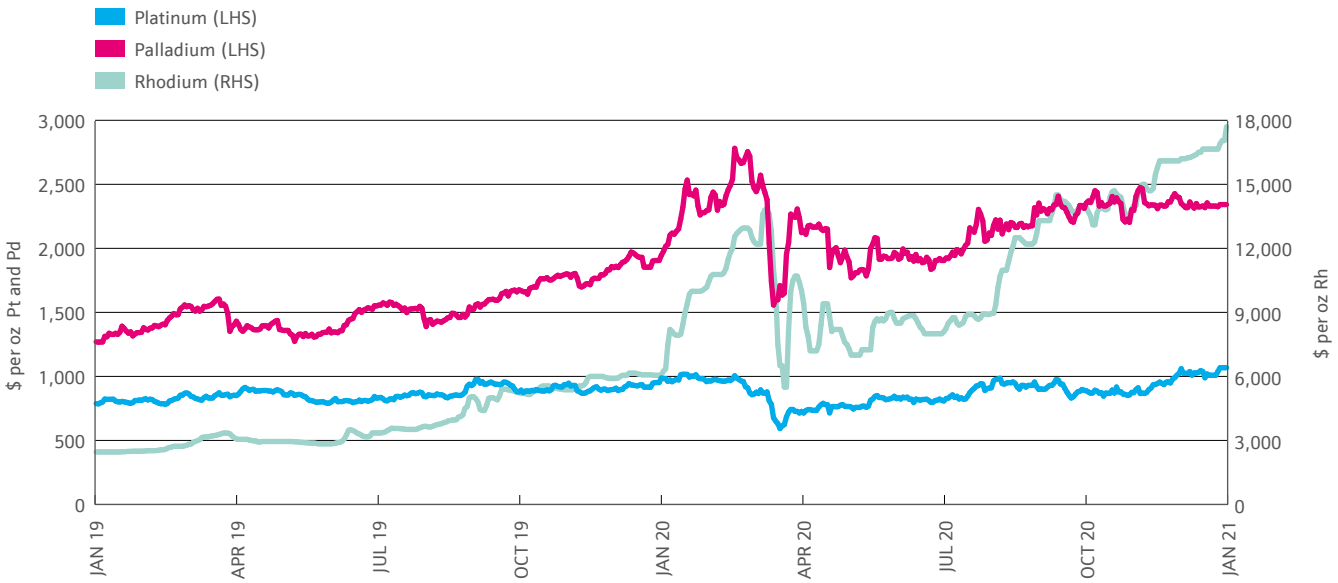



**Figure 18** Platinum, palladium and rhodium prices

almost all automakers opted to equip their cars with catalysts capable of meeting China 6b legislation, rather than the less strict China 6a limits. With some cities and provinces enforcing China 6b standards ahead of the nationwide implementation schedule, it made sense to streamline catalyst fitment and to market vehicles meeting the stricter standards nationally. At the time, pgm loadings were a secondary consideration.

Since then, palladium and rhodium prices have risen steeply (Figure 18), while automakers have experienced a period of severe financial stress due to the Covid-19 pandemic. This has encouraged sustained efforts to reduce the pgm content of Chinese gasoline vehicles, especially by domestic car companies, which typically have less advanced engine technology and less experience of meeting strict emissions standards than car companies in other major vehicle markets. These manufacturers have focused their recent efforts on improvements to engine performance to cut engine-out emissions, meaning that the catalyst has less work to do and the pgm content can be thrifted. In addition, some automakers have chosen to equip vehicles with China 6a catalysts, where this is permitted by the local legislative timetable. Overall, we expect these thrifting activities to lead to a decline of at least 5% in pgm loadings on Chinese cars in 2021, broadly offsetting forecast growth in light vehicle output.

While pgm usage in light duty applications in China will be flat at best, we expect demand in heavy duty applications to enjoy strong gains. The nationwide phase-in of China VI standards for heavy duty vehicles will be complete by July 2021, requiring all HDD vehicles to meet much stricter emissions standards. (Trucks fuelled by gasoline and compressed natural gas were already covered by China VI limits before this year, but account for only a relatively small share of the market).

Meeting China VI limits requires a complete overhaul of HDD aftertreatment systems: whereas earlier legislation could usually be met using SCR technology (often without any pgm catalyst bricks at all), the new standards require much greater use of diesel oxidation catalysts (DOC) and diesel particulate filters (DPFs). As a result, pgm loadings on Chinese HDD vehicles will approximately treble this year, with platinum accounting for most of this increase.

Both Europe and North America are forecast to see double-digit growth in light vehicle production this year, although volumes are not expected to return to pre-Covid levels until at least 2022. In contrast to China, pgm loadings in these markets are still rising, reflecting ongoing tightening of emissions standards under Euro 6d and US Federal Tier 3 legislation. As a result, US and European pgm use in light duty applications could approach or even match pre-pandemic demand, despite lower vehicle volumes.

> "A recovery in vehicle output and higher pgm loadings on Chinese trucks should boost auto demand by around 13%"

Platinum's share of global pgm use in automotive applications has fallen steadily over the past fifteen years, initially due to the adoption of palladium-rhodium catalysts in almost all gasoline cars, and more recently due to a decline in diesel market share. In 2005, platinum accounted for nearly half of all pgm consumed in autocatalysts; by last year that share had fallen to below 20% (Figure 19).

This trend will begin to reverse in 2021, when we expect platinum's share of autocatalyst pgm consumption to increase modestly, to around 21%. This year, growth will come primarily from the HDD sector, where we expect platinum demand to surge by 50%, reflecting tighter legislation in China and double-digit growth in truck output in most major markets.

Looking further ahead, growth in platinum's share of demand is likely to be driven by the light duty sector, as automakers substitute some palladium with platinum in gasoline catalysts,

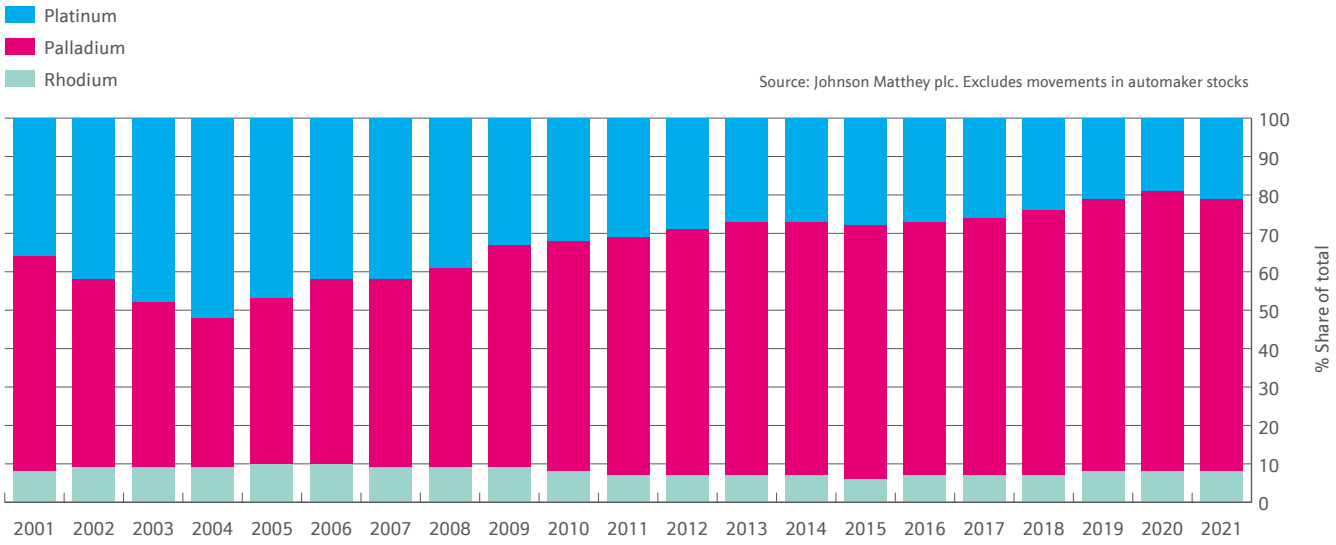



**Figure 19** Share of autocatalyst pgm demand by metal

motivated by the need to reduce aftertreatment system costs. As we reported in our review of 2020 on page 9, there has already been some adoption of tri-metal catalysts on gasoline cars, primarily in the cooler underfloor position where pgm loadings are comparatively light. This year, we should see some additional use of platinum-containing formulations in the hotter 'closed-coupled' location, where catalyst bricks tend to have much higher loadings. While the near-term impact on platinum demand will be limited, we expect to see increased adoption of tri-metal close-coupled bricks in future years.

"Automakers will continue to substitute some palladium with platinum in gasoline catalysts, to reduce costs"

However, the rollout of tri-metal catalyst technology remains subject to significant technical and commercial uncertainties, and there will probably be large regional variations in uptake. Individual automakers appear to be taking very different approaches, with some aggressively pursuing substitution, while others are more risk-averse, or prefer to focus on thrifting the overall pgm content of their catalysts. The potential gains from substitution will vary between models and between regions; the commercial incentives for substitution are perhaps greatest in North America, where vehicle size and catalyst loadings are typically much higher than the global average.

Technical considerations will also play an important role in determining the speed and extent of platinum adoption. In catalyst development and qualification, accelerated-ageing protocols are used to simulate how the catalyst will perform over the lifetime of the vehicle. These tests differ both by region and to some extent between automakers. In China and the USA, ageing protocols tend to be relatively benign for catalyst durability and stability, with lower testing speeds limiting the peak temperatures to which the catalyst is exposed. This tends to facilitate the use of platinum.

In contrast, ageing protocols used by European automakers are harsher, to reflect higher real-world driving speeds in this region. Because the catalyst is exposed to high temperatures for a longer period, substitution of platinum is more challenging. In addition, European automakers remain cautious about making significant changes to catalyst formulations, given the ongoing complexities of meeting real driving emissions (RDE) and in-service conformity requirements. Nevertheless, some car companies in this region are pursuing substitution opportunities, in the expectation that technology development will address technical challenges and minimise compliance risk.

Rhodium's share of autocatalyst pgm use has risen slightly over the last three years, in response to tightening emission legislation and more rigorous vehicle testing protocols that have made compliance with NOx limits considerably more challenging. Substitution of palladium with platinum is not expected to have a material impact on rhodium use in gasoline vehicles, because the latter is by far the most effective catalyst for NOx reduction. Rhodium loadings continue to edge upwards in Europe and North America, as a higher proportion of vehicles meet Euro 6d and SULEV standards. However, we expect Chinese automakers to achieve some modest rhodium thrifting this year and next, ahead of the introduction of RDE testing in 2023. While the precise details of the Chinese RDE protocol have not yet been confirmed, the European experience suggests that rhodium loadings may need to rise again to ensure compliance with RDE testing under China 6b legislation.

## Industrial demand

Demand for pgm in industrial applications was unusually strong over the 2018–2020 period, reflecting heavy investment in chemical, petroleum and fibreglass applications in China (Figure 20). This was driven by a combination of factors, including increasing domestic demand for consumer goods and vehicles, an emphasis on self-sufficiency in the thirteenth Five-Year Plan (which ended in 2020), and liberalisation of the petroleum market which encouraged the development of independent refineries. Technology choices have also been positive for pgm demand in China, with some producers

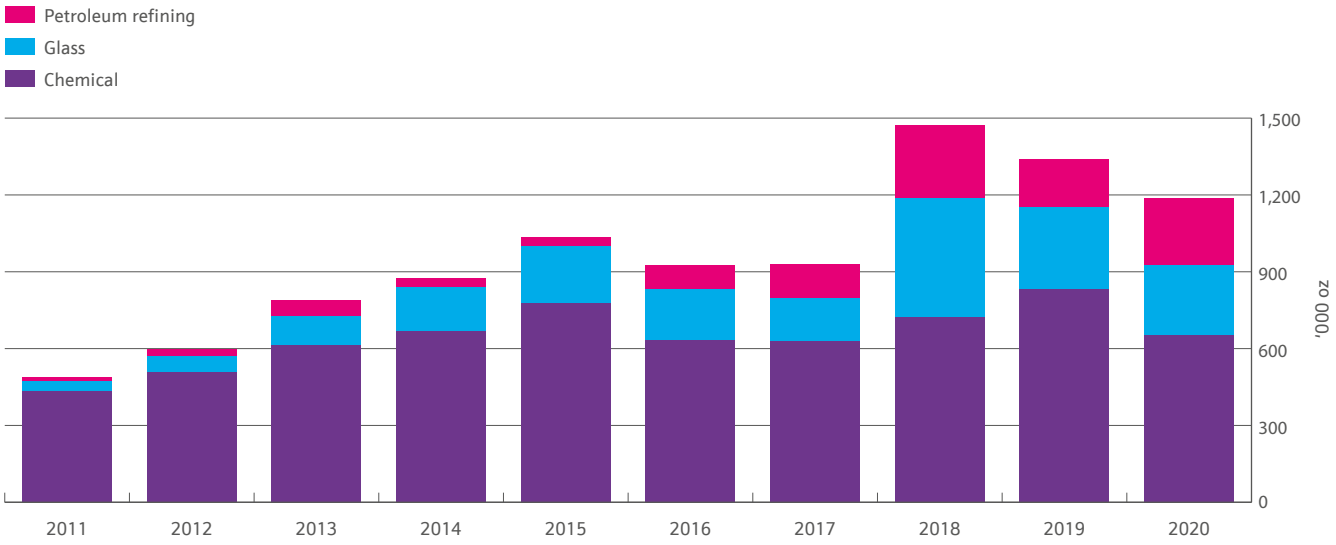



**Figure 20** Chinese pgm demand in chemicals, glass and petroleum refining

adopting pgm-catalysed routes in preference to non-pgm alternatives, usually due to feedstock availability or licensing considerations. For example, China uses palladium catalysts to produce mono-ethylene glycol (MEG) from domestically produced coal, and a ruthenium catalyst to produce caprolactam to avoid licensing foreign technology.

In 2021, industrial demand for pgm should again be robust, with most applications staging a strong recovery from Covid-related disruption last year. Indeed, there is potential for pgm purchasing by chemical manufacturers to reach a new all-time peak. We expect continuing investment in large integrated petrochemical complexes, stimulating purchases of platinum catalyst for new paraxylene capacity, and rhodium for acetic acid production. We also anticipate further capacity expansion in processes including coal-to-MEG (palladium), caprolactam and catalytic wet air oxidation (ruthenium).

Like caprolactam, CWAO typically uses a ruthenium catalyst in China. It is used to purify wastewater streams from petrochemical complexes or pharmaceutical manufacturing; aromatic compounds from these processes can be harmful to local ecosystems and must be oxidised to $CO_2$ and water. There exist a variety of routes for achieving this, involving both pgm and base metal technology, but Chinese manufacturers typically prefer a ruthenium catalyst for its greater stability, longer lifetime and good activity.

In contrast, we expect demand for pgm in the petroleum refining sector to decline this year. While there is still some ongoing investment in new capacity, mainly in China and the Rest of World region, much of the metal required for this year's expansions was bought in 2020 during periods of low platinum prices. There is also some risk that weak gasoline demand will lead to the closure of some older, less efficient refineries in Europe or North America.

Purchasing of pgm by the glass industry is expected to remain firm in 2021. Chinese demand for glass fibre has rebounded strongly following pandemic-related disruption in early 2020, supported by a recovery in the auto sector, and rising requirements for glass-fibre-reinforced materials in the wind power, telecommunications and construction sectors. We also expect something of a rebound in pgm use

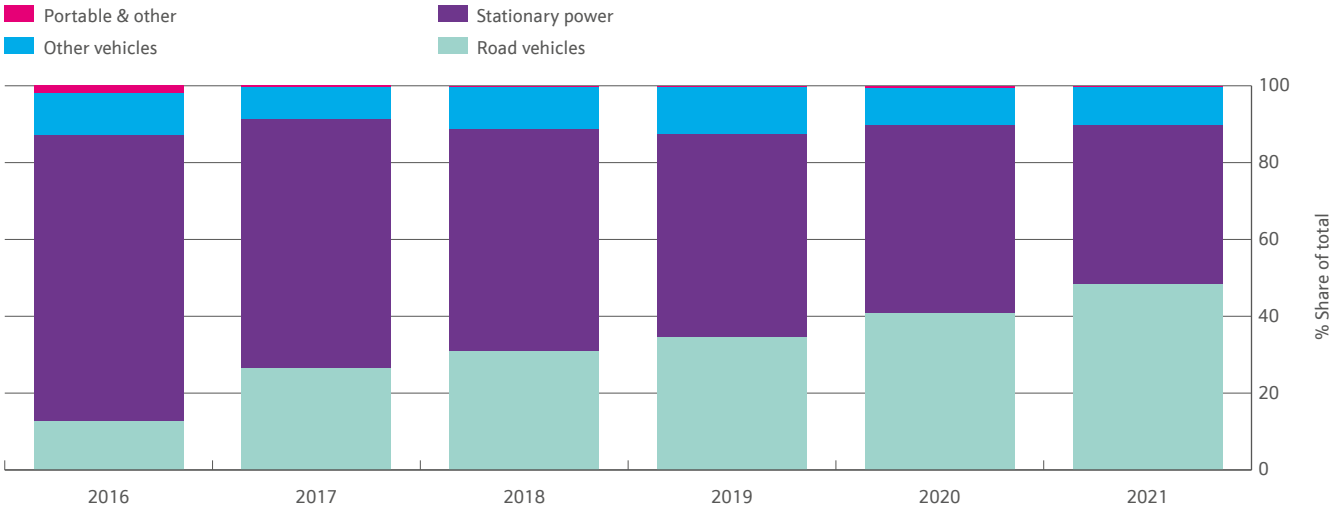



**Figure 21** Platinum in fuel cells: demand by end-use

in the electronics sector – the first increase for six years. Gains will be driven by strong demand for data storage, stimulating platinum use in hard disks, and improving market conditions for electronic components such as resistors and capacitors, which had suffered a period of soft demand following US-China trade disputes during 2019.

Our estimates for the electronics sector include demand for platinum in fuel cell applications; this is predicted to expand by over 45% in 2021, to reach nearly 90,000 oz. Much of this year's growth will come from the road vehicle sector (Figure 21), with Toyota alone expected to produce around 30,000 fuel cell electric vehicles (FCEVs). Stationary power applications are also expected to see some growth, although there is stiff competition from fuel cell technologies that do not require platinum (mainly solid oxide fuel cells), particularly in the long-established residential fuel cell market in Japan. However, the deployment of large, modular fuel cell 'power plants' is being encouraged in South Korea in particular, and this is driving growing demand for platinum-containing technologies that offer excellent lifetime and reliability, important metrics for infrastructure equipment.

## Supplies

Combined supplies of platinum, palladium and rhodium from primary and secondary sources should recover strongly in 2021, reflecting a rebound in mined volumes following Covid-19 disruption last year, and the release of part of the work-in-progress that accumulated following outages at Anglo American Platinum's converter plant (ACP) during 2020.

Movements in these 'pipeline' (semi-refined) stocks will again obscure the underlying trend in pgm output from South Africa this year. In 2020, we estimate that pgm shipments from South Africa fell by around 27%, versus a contraction in underlying mine output of approximately 17%. This discrepancy was a consequence of two prolonged shutdowns at Anglo's ACP, which resulted in the deferral of around three months of last year's mine production into 2021 and 2022.

Assuming the recommissioning of the rebuilt Phase A converter unit proceeds as planned, and that production is uninterrupted thereafter, this year could see refined pgm output in South Africa rise by more than a third. The magnitude of this gain will depend on the pace at which Anglo can process its backlog, and the extent to which the industry is able to sustain its strong post-pandemic recovery in mining volumes. By the end of 2020, most South African mines were operating at or near normal levels, but we expect underlying production to remain below pre-Covid levels this year, due to shaft closures during the 2019–2020 period.

Primary supplies from other regions are expected to be flat or slightly up in 2021. Palladium output from Norilsk Nickel contracted during 2020, probably reflecting a lower contribution from surface materials; the company has not reported any significant disruption due to the pandemic. While Norilsk is planning a large expansion at its South Cluster operations and its Talnakh concentrator, this is not expected to contribute materially to supplies for at least another three to four years.

> "Investment in integrated petrochemical complexes in China could lift chemical demand to a new peak"

Until then, we expect Russian supplies to remain broadly stable at the levels seen in 2017–2018: approximately 2.7 million oz of palladium and 650,000 oz of platinum per annum.

The recovery of pgm from spent autocatalyst is expected to rebound strongly in 2021, assuming a continued post-Covid recovery in vehicle sales, and a return to more normal conditions in the used car market. Last year saw a fall in the deregistration of older vehicles, reflecting pandemic-driven changes in consumer behaviour: as new registrations fell, demand for used cars rose strongly, leading to a significant rise in their value. This created an incentive to keep older cars on the road for longer than usual and led to a rise in the average age of end-of-life vehicles entering scrap yards.

As these pandemic-related impacts ease, pgm recycling volumes could match the record levels seen in 2019. However, we expect capacity constraints to continue to limit the treatment of diesel particulate filter scrap, depressing platinum recoveries somewhat (see page 12). In contrast, high palladium and rhodium prices should continue to encourage the prompt movement of scrap through the recycling chain, and incentivise market participants to keep inventories of both untreated scrap and semi-refined materials as lean as possible.

With combined primary and secondary supplies expected to return to 2019 volumes, and industrial and automotive demand also forecast to bounce back to previous levels, there will be little change to underlying market dynamics this year. Both palladium and rhodium are expected to remain in deficit, while the direction of the platinum market balance will once again depend to a large extent on the behaviour of investors.

## Investment and jewellery demand

Over the last two years, there has been steady disinvestment in palladium and rhodium, but investors have added around 2 million oz to their platinum holdings. Of this, an estimated 600,000 oz was in platinum bars and coins, particularly in Japan, where low yen-denominated prices stimulated unusually strong purchasing during the first half of 2020. The remainder was in ETFs, mainly in Europe and the USA, where there has been a transformation in investor sentiment during the past two years. With gold and palladium both setting new record highs, platinum has been regarded as a good-value, low-risk alternative for investors seeking exposure to precious metals. Much US and European platinum investment is still 'out of the money', especially where holdings were acquired before the Covid-related price dip in March 2020. Unless prices rise significantly, this will continue to act as a brake on profit taking.

In 2020, it appears that demand for platinum jewellery also benefited from its relatively low price, particularly in comparison

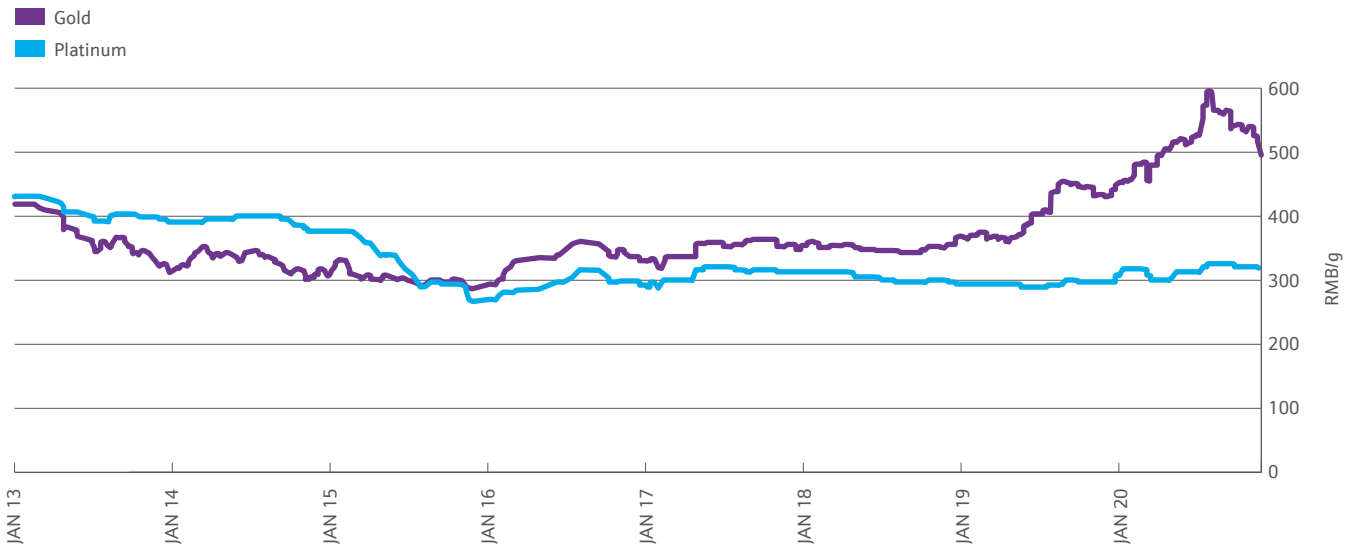



**Figure 22** Retail jewellery price (Shanghai)

with gold. This was something of a departure from historic trends. The Chinese jewellery market developed during the late 1990s and early 2000s, when platinum was usually more valuable than gold, allowing it to be marketed as the most precious metal. A prolonged period of low prices has therefore damaged platinum's reputation, especially since platinum jewellery has traditionally been priced per gram and Chinese consumers are therefore keenly aware of the underlying metal value. Over the last three to four years, growing consumer acceptance of karat gold jewellery has also eroded platinum's share of the fashion jewellery segment, while manufacturers and wholesalers have taken opportunities to make better margins by switching production away from platinum (karat gold jewellery is priced per piece, rather than based on metal weight).

However, during 2020, exceptionally strong gold prices appear to have stimulated a modest move back to platinum (Figure 22). To date, this switch has primarily been driven by financial considerations: with gold trading at close to $2,000, the cost of holding gold jewellery inventory has increased dramatically. At the same time, retail sales have plummeted; the World Gold Council estimates that gold jewellery demand in China contracted by 25% in the first nine months of 2020. This has encouraged some stores to increase the amount of display space devoted to platinum. It is not yet clear how consumers will respond: if they prove receptive, then the modest improvement in platinum fabrication demand that was seen during the second half of 2020 could continue this year. However, if consumer pull-through is weak, jewellery fabrication volumes will fall once the distribution chain has been filled.

On balance, we think most of the risk to platinum jewellery and investment demand is to the downside, and that the platinum market is likely to move towards balance, or even into surplus, in 2021.

The palladium and rhodium markets are much less dependent on investment and jewellery demand. Consumption in jewellery is insignificant, while investment has been negative for several years: by early December 2020, under 540,000 oz

"On balance, we think the risk to platinum jewellery and investment demand is to the downside"

of palladium and 15,000 oz of rhodium remained in ETFs. Even if all this metal were sold in 2021, it would probably not be enough to bring the markets back to balance.

Our estimates of pgm investment capture physical metal held in measurable, long-term, physically-backed instruments such as ETFs and 'Platinum Accumulation Plans' (the latter in Japan only); in numismatic products such as coins and wafers; and in the form of platinum bars sold over-the-counter to Japanese retail investors. We do not measure physical investment by banks, hedge funds or other market participants (except when it takes one of the forms listed above). As the palladium and rhodium markets have tightened, some metal held by these speculative players has been returned to the market; remaining holdings are unknown, but it is probably fair to assume that these holders are looking for still higher prices.

With both palladium and rhodium expected to remain in deficit in 2021, there is potential for liquidity shortages to drive prices higher. However, market tightness could ease temporarily once production resumes at Anglo's converter plant and sales of pgm return to more normal levels. We would expect industrial and automotive consumers to take advantage of any buying opportunities, but it is possible that increased availability may give the market a short-term breathing space.

This is particularly true for rhodium: the ACP outage has been less significant for the platinum and palladium markets, because these markets are more liquid, and less dependent upon South African supplies. However, any respite is likely to prove temporary, with automotive pgm demand expected to see further gains assuming world auto markets continue their post-Covid recovery over the next couple of years, but little short-term prospect of growth in primary supply.

# Platinum supply and demand

## Troy ounces

| Supply '000 oz[1] | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| South Africa | 4,572 | 4,392 | 4,450 | 4,467 | 4,398 | 3,199 |
| Russia[2] | 670 | 714 | 720 | 687 | 721 | 662 |
| North America | 354 | 370 | 368 | 346 | 351 | 339 |
| Zimbabwe[3] | 400 | 489 | 466 | 474 | 451 | 489 |
| Others[3] | 158 | 162 | 157 | 152 | 156 | 199 |
| **Total supply** | **6,154** | **6,127** | **6,161** | **6,126** | **6,077** | **4,888** |

| Demand '000 oz[4] | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| Autocatalyst[4] | 3,273 | 3,339 | 3,225 | 3,017 | 2,858 | 2,224 |
| Chemical | 502 | 477 | 453 | 657 | 676 | 614 |
| Electronics[4] | 228 | 232 | 232 | 241 | 230 | 239 |
| Glass | 227 | 247 | 314 | 501 | 441 | 378 |
| Investment | 451 | 620 | 361 | 67 | 1,131 | 901 |
| Jewellery[4] | 2,746 | 2,413 | 2,385 | 2,258 | 2,056 | 1,581 |
| Medical and biomedical[5] | 215 | 218 | 220 | 223 | 230 | 206 |
| Petroleum | 140 | 186 | 227 | 372 | 251 | 322 |
| Other | 494 | 535 | 575 | 591 | 587 | 455 |
| **Total gross demand** | **8,276** | **8,267** | **7,992** | **7,927** | **8,460** | **6,920** |

| Recycling '000 oz[6] | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| Autocatalyst | -1,147 | -1,132 | -1,249 | -1,329 | -1,392 | -1,160 |
| Electronics | -30 | -32 | -35 | -38 | -40 | -38 |
| Jewellery | -574 | -738 | -746 | -699 | -650 | -444 |
| **Total recycling** | **-1,751** | **-1,902** | **-2,030** | **-2,066** | **-2,082** | **-1,642** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Total net demand[7]** | **6,525** | **6,365** | **5,962** | **5,861** | **6,378** | **5,278** |
| Movement in stocks[8] | -371 | -238 | 199 | 265 | -301 | -390 |

# Platinum gross demand by region

## Troy ounces

| Gross demand '000 oz | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|
| Europe | Autocatalyst | 1,672 | 1,786 | 1,708 | 1,452 | 1,291 | 955 |
| | Chemical | 120 | 122 | 117 | 122 | 124 | 114 |
| | Electronics | 13 | 13 | 10 | 12 | 13 | 14 |
| | Glass | 11 | 11 | 11 | 11 | 13 | 19 |
| | Investment | -88 | 109 | 36 | -102 | 566 | 303 |
| | Jewellery | 203 | 177 | 176 | 191 | 190 | 157 |
| | Medical and biomedical | 71 | 71 | 70 | 62 | 63 | 54 |
| | Petroleum | -4 | 3 | 7 | 29 | 15 | 9 |
| | Other | 136 | 154 | 172 | 174 | 180 | 138 |
| | **Total** | **2,134** | **2,446** | **2,307** | **1,951** | **2,455** | **1,763** |

| Gross demand '000 oz | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|
| Japan | Autocatalyst | 384 | 360 | 358 | 365 | 357 | 283 |
| | Chemical | 43 | 42 | 37 | 40 | 42 | 40 |
| | Electronics | 33 | 32 | 31 | 31 | 30 | 30 |
| | Glass | 4 | 2 | 25 | 7 | 27 | 16 |
| | Investment | 700 | 543 | 171 | 220 | 32 | 344 |
| | Jewellery | 314 | 310 | 303 | 293 | 294 | 247 |
| | Medical and biomedical | 16 | 15 | 15 | 16 | 16 | 14 |
| | Petroleum | 3 | 3 | 2 | 2 | 2 | 2 |
| | Other | 80 | 77 | 79 | 79 | 79 | 67 |
| | **Total** | **1,577** | **1,384** | **1,021** | **1,053** | **879** | **1,043** |

| Gross demand '000 oz | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|
| North America | Autocatalyst | 379 | 360 | 325 | 321 | 333 | 241 |
| | Chemical | 114 | 103 | 112 | 108 | 109 | 103 |
| | Electronics | 22 | 26 | 33 | 37 | 30 | 29 |
| | Glass | 10 | 29 | 45 | 18 | 21 | 32 |
| | Investment | -32 | 109 | 127 | 66 | 156 | 580 |
| | Jewellery | 227 | 221 | 225 | 224 | 201 | 153 |

| Gross demand '000 oz | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|
| North America | Medical and biomedical | 85 | 87 | 88 | 96 | 100 | 91 |
| | Petroleum | 40 | 35 | 18 | 15 | 17 | -4 |
| | Other | 138 | 146 | 147 | 156 | 155 | 105 |
| | **Total** | **983** | **1,116** | **1,120** | **1,041** | **1,122** | **1,330** |

| Gross demand '000 oz | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|
| China | Autocatalyst | 136 | 151 | 157 | 148 | 155 | 191 |
| | Chemical | 131 | 122 | 74 | 207 | 274 | 269 |
| | Electronics | 38 | 42 | 44 | 51 | 49 | 52 |
| | Glass | 178 | 135 | 111 | 388 | 294 | 253 |
| | Investment | 0 | 0 | 0 | 0 | 0 | 0 |
| | Jewellery | 1,796 | 1,510 | 1,470 | 1,316 | 1,119 | 842 |
| | Medical and biomedical | 19 | 19 | 20 | 20 | 21 | 20 |
| | Petroleum | 32 | 76 | 120 | 254 | 157 | 235 |
| | Other | 59 | 72 | 83 | 87 | 82 | 68 |
| | **Total** | **2,389** | **2,127** | **2,079** | **2,471** | **2,151** | **1,930** |

| Gross demand '000 oz | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|
| Rest of World | Autocatalyst | 702 | 682 | 677 | 731 | 722 | 554 |
| | Chemical | 94 | 88 | 113 | 180 | 127 | 88 |
| | Electronics | 122 | 119 | 114 | 110 | 108 | 114 |
| | Glass | 24 | 70 | 122 | 77 | 86 | 58 |
| | Investment | -129 | -141 | 27 | -117 | 377 | -326 |
| | Jewellery | 206 | 195 | 211 | 234 | 252 | 182 |
| | Medical and biomedical | 24 | 26 | 27 | 29 | 30 | 27 |
| | Petroleum | 69 | 69 | 80 | 72 | 60 | 80 |
| | Other | 81 | 86 | 94 | 95 | 91 | 77 |
| | **Total** | **1,193** | **1,194** | **1,465** | **1,411** | **1,853** | **854** |
| | **Grand total** | **8,276** | **8,267** | **7,992** | **7,927** | **8,460** | **6,920** |

# Platinum supply and demand

## Tonnes

| Supply tonnes[1] | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| South Africa | 142.2 | 136.6 | 138.4 | 138.9 | 136.8 | 99.5 |
| Russia[2] | 20.8 | 22.2 | 22.4 | 21.4 | 22.4 | 20.6 |
| North America | 11.0 | 11.6 | 11.5 | 10.8 | 10.9 | 10.5 |
| Zimbabwe[3] | 12.5 | 15.2 | 14.5 | 14.7 | 14.0 | 15.2 |
| Others[3] | 4.9 | 5.0 | 4.9 | 4.7 | 4.9 | 6.2 |
| **Total supply** | **191.4** | **190.6** | **191.7** | **190.5** | **189.0** | **152.0** |

| Demand tonnes[4] | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| Autocatalyst[4] | 101.7 | 103.9 | 100.3 | 93.9 | 88.9 | 69.1 |
| Chemical | 15.6 | 14.8 | 14.1 | 20.4 | 21.0 | 19.1 |
| Electronics[4] | 7.1 | 7.2 | 7.2 | 7.6 | 7.1 | 7.3 |
| Glass | 7.0 | 7.7 | 9.8 | 15.6 | 13.7 | 11.8 |
| Investment | 14.1 | 19.3 | 11.2 | 2.1 | 35.2 | 28.0 |
| Jewellery[4] | 85.5 | 75.1 | 74.2 | 70.2 | 63.8 | 49.3 |
| Medical and biomedical[5] | 6.7 | 6.8 | 6.8 | 6.9 | 7.2 | 6.3 |
| Petroleum | 4.3 | 5.8 | 7.1 | 11.6 | 7.9 | 10.1 |
| Other | 15.4 | 16.6 | 17.9 | 18.3 | 18.3 | 14.2 |
| **Total gross demand** | **257.4** | **257.2** | **248.6** | **246.6** | **263.1** | **215.2** |

| Recycling tonnes[6] | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| Autocatalyst | -35.6 | -35.2 | -38.8 | -41.4 | -43.3 | -36.1 |
| Electronics | -0.9 | -1.0 | -1.1 | -1.2 | -1.2 | -1.2 |
| Jewellery | -17.9 | -23.0 | -23.2 | -21.7 | -20.2 | -13.8 |
| **Total recycling** | **-54.4** | **-59.2** | **-63.1** | **-64.3** | **-64.7** | **-51.1** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Total net demand[7]** | **203.0** | **198.0** | **185.5** | **182.3** | **198.4** | **164.1** |
| Movement in stocks[8] | -11.6 | -7.4 | 6.2 | 8.2 | -9.4 | -12.1 |

# Platinum gross demand by region

## Tonnes

| Gross demand tonnes | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|
| Europe | Autocatalyst | 52.0 | 55.6 | 53.1 | 45.2 | 40.1 | 29.7 |
| | Chemical | 3.7 | 3.8 | 3.6 | 3.8 | 3.9 | 3.6 |
| | Electronics | 0.4 | 0.4 | 0.3 | 0.4 | 0.4 | 0.4 |
| | Glass | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 | 0.6 |
| | Investment | -2.7 | 3.4 | 1.1 | -3.2 | 17.6 | 9.4 |
| | Jewellery | 6.3 | 5.5 | 5.5 | 5.9 | 5.9 | 4.9 |
| | Medical and biomedical | 2.2 | 2.2 | 2.2 | 1.9 | 2.0 | 1.7 |
| | Petroleum | -0.1 | 0.1 | 0.2 | 0.9 | 0.5 | 0.3 |
| | Other | 4.2 | 4.8 | 5.3 | 5.4 | 5.6 | 4.3 |
| | **Total** | **66.3** | **76.1** | **71.6** | **60.6** | **76.4** | **54.9** |

| Gross demand tonnes | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|
| Japan | Autocatalyst | 11.9 | 11.2 | 11.1 | 11.4 | 11.1 | 8.8 |
| | Chemical | 1.3 | 1.3 | 1.2 | 1.2 | 1.3 | 1.2 |
| | Electronics | 1.0 | 1.0 | 1.0 | 1.0 | 0.9 | 0.9 |
| | Glass | 0.1 | 0.1 | 0.8 | 0.2 | 0.8 | 0.5 |
| | Investment | 21.8 | 16.9 | 5.3 | 6.8 | 1.0 | 10.7 |
| | Jewellery | 9.8 | 9.6 | 9.4 | 9.1 | 9.1 | 7.7 |
| | Medical and biomedical | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.4 |
| | Petroleum | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| | Other | 2.5 | 2.4 | 2.5 | 2.5 | 2.5 | 2.1 |
| | **Total** | **49.0** | **43.1** | **31.9** | **32.8** | **27.3** | **32.4** |

| Gross demand tonnes | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|
| North America | Autocatalyst | 11.8 | 11.2 | 10.1 | 10.0 | 10.4 | 7.5 |
| | Chemical | 3.6 | 3.2 | 3.5 | 3.4 | 3.4 | 3.2 |
| | Electronics | 0.7 | 0.8 | 1.0 | 1.2 | 0.9 | 0.9 |
| | Glass | 0.3 | 0.9 | 1.4 | 0.6 | 0.7 | 1.0 |
| | Investment | -1.0 | 3.4 | 4.0 | 2.1 | 4.9 | 18.0 |
| | Jewellery | 7.1 | 6.9 | 7.0 | 7.0 | 6.2 | 4.8 |

| Gross demand tonnes | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|
| North America | Medical and biomedical | 2.6 | 2.7 | 2.7 | 3.0 | 3.1 | 2.8 |
| | Petroleum | 1.2 | 1.1 | 0.6 | 0.5 | 0.5 | -0.1 |
| | Other | 4.3 | 4.5 | 4.6 | 4.8 | 4.8 | 3.3 |
| | **Total** | **30.6** | **34.7** | **34.9** | **32.6** | **34.9** | **41.4** |

| Gross demand tonnes | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|
| China | Autocatalyst | 4.2 | 4.7 | 4.9 | 4.6 | 4.8 | 5.9 |
| | Chemical | 4.1 | 3.8 | 2.3 | 6.4 | 8.5 | 8.4 |
| | Electronics | 1.2 | 1.3 | 1.4 | 1.6 | 1.5 | 1.6 |
| | Glass | 5.6 | 4.2 | 3.5 | 12.1 | 9.1 | 7.9 |
| | Investment | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Jewellery | 55.9 | 47.0 | 45.7 | 40.9 | 34.8 | 26.2 |
| | Medical and biomedical | 0.6 | 0.6 | 0.6 | 0.6 | 0.7 | 0.6 |
| | Petroleum | 1.0 | 2.4 | 3.7 | 7.9 | 4.9 | 7.3 |
| | Other | 1.9 | 2.2 | 2.6 | 2.7 | 2.6 | 2.1 |
| | **Total** | **74.5** | **66.2** | **64.7** | **76.8** | **66.9** | **60.0** |

| Gross demand tonnes | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|
| Rest of World | Autocatalyst | 21.8 | 21.2 | 21.1 | 22.7 | 22.5 | 17.2 |
| | Chemical | 2.9 | 2.7 | 3.5 | 5.6 | 3.9 | 2.7 |
| | Electronics | 3.8 | 3.7 | 3.5 | 3.4 | 3.4 | 3.5 |
| | Glass | 0.7 | 2.2 | 3.8 | 2.4 | 2.7 | 1.8 |
| | Investment | -4.0 | -4.4 | 0.8 | -3.6 | 11.7 | -10.1 |
| | Jewellery | 6.4 | 6.1 | 6.6 | 7.3 | 7.8 | 5.7 |
| | Medical and biomedical | 0.8 | 0.8 | 0.8 | 0.9 | 0.9 | 0.8 |
| | Petroleum | 2.1 | 2.1 | 2.5 | 2.2 | 1.9 | 2.5 |
| | Other | 2.5 | 2.7 | 2.9 | 2.9 | 2.8 | 2.4 |
| | **Total** | **37.0** | **37.1** | **45.5** | **43.8** | **57.6** | **26.5** |
| | **Grand total** | **257.4** | **257.2** | **248.6** | **246.6** | **263.1** | **215.2** |

# Palladium supply and demand

## Troy ounces

| Supply '000 oz[1] | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| South Africa | 2,683 | 2,570 | 2,547 | 2,543 | 2,626 | 1,939 |
| Russia[2] | 2,434 | 2,781 | 2,452 | 2,976 | 2,987 | 2,727 |
| North America | 874 | 917 | 956 | 978 | 985 | 934 |
| Zimbabwe[3] | 320 | 396 | 386 | 393 | 379 | 388 |
| Others[3] | 144 | 129 | 131 | 135 | 140 | 179 |
| **Total supply** | **6,455** | **6,793** | **6,472** | **7,025** | **7,117** | **6,167** |

| Demand '000 oz[4] | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| Autocatalyst[4] | 7,690 | 8,042 | 8,463 | 8,876 | 9,672 | 8,497 |
| Chemical | 449 | 419 | 435 | 600 | 499 | 486 |
| Dental | 468 | 429 | 391 | 358 | 313 | 239 |
| Electronics[4] | 903 | 872 | 844 | 769 | 714 | 634 |
| Investment | -659 | -646 | -386 | -574 | -87 | -186 |
| Jewellery[4] | 220 | 189 | 167 | 148 | 130 | 93 |
| Other | 134 | 157 | 144 | 175 | 176 | 131 |
| **Total gross demand** | **9,205** | **9,462** | **10,058** | **10,352** | **11,417** | **9,894** |

| Recycling '000 oz[6] | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| Autocatalyst | -1,952 | -1,986 | -2,358 | -2,621 | -2,924 | -2,698 |
| Electronics | -475 | -481 | -479 | -475 | -471 | -414 |
| Jewellery | -46 | -21 | -21 | -12 | -12 | -9 |
| **Total recycling** | **-2,473** | **-2,488** | **-2,858** | **-3,108** | **-3,407** | **-3,121** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Total net demand[7]** | **6,732** | **6,974** | **7,200** | **7,244** | **8,010** | **6,773** |
| Movement in stocks[8] | -277 | -181 | -728 | -219 | -893 | -606 |

# Palladium gross demand by region

## Troy ounces

| Gross demand '000 oz | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|
| Europe | Autocatalyst | 1,622 | 1,637 | 1,703 | 1,902 | 2,061 | 1,782 |
| | Chemical | 74 | 74 | 75 | 64 | 67 | 47 |
| | Dental | 70 | 65 | 60 | 51 | 42 | 28 |
| | Electronics | 101 | 99 | 97 | 92 | 86 | 73 |
| | Investment | -200 | -269 | -287 | -141 | -56 | -14 |
| | Jewellery | 59 | 58 | 53 | 49 | 43 | 29 |
| | Other | 27 | 24 | 23 | 30 | 26 | 21 |
| | **Total** | **1,753** | **1,688** | **1,724** | **2,047** | **2,269** | **1,966** |

| Gross demand '000 oz | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|
| Japan | Autocatalyst | 758 | 786 | 828 | 875 | 905 | 760 |
| | Chemical | 15 | 15 | 17 | 17 | 17 | 16 |
| | Dental | 227 | 200 | 174 | 156 | 140 | 112 |
| | Electronics | 231 | 227 | 221 | 199 | 182 | 162 |
| | Investment | 4 | -3 | -3 | -1 | 1 | -1 |
| | Jewellery | 66 | 64 | 57 | 52 | 45 | 36 |
| | Other | 9 | 9 | 9 | 9 | 9 | 8 |
| | **Total** | **1,310** | **1,298** | **1,303** | **1,307** | **1,299** | **1,093** |

| Gross demand '000 oz | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|
| North America | Autocatalyst | 2,039 | 1,992 | 2,028 | 2,129 | 2,104 | 1,720 |
| | Chemical | 76 | 73 | 75 | 76 | 72 | 40 |
| | Dental | 145 | 138 | 131 | 125 | 106 | 79 |
| | Electronics | 131 | 128 | 124 | 112 | 103 | 91 |
| | Investment | -181 | -71 | -19 | -87 | -5 | -31 |
| | Jewellery | 39 | 36 | 29 | 27 | 22 | 13 |
| | Other | 60 | 46 | 44 | 44 | 45 | 32 |
| | **Total** | **2,309** | **2,342** | **2,412** | **2,426** | **2,447** | **1,944** |

| Gross demand '000 oz | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|
| China | Autocatalyst | 1,654 | 2,038 | 2,179 | 2,081 | 2,686 | 2,627 |
| | Chemical | 209 | 162 | 174 | 268 | 237 | 271 |
| | Dental | 8 | 7 | 7 | 7 | 6 | 6 |
| | Electronics | 158 | 156 | 155 | 141 | 131 | 118 |
| | Investment | 0 | 0 | 0 | 0 | 0 | 0 |
| | Jewellery | 34 | 10 | 9 | 2 | 1 | 0 |
| | Other | 17 | 45 | 51 | 72 | 73 | 54 |
| | **Total** | **2,080** | **2,418** | **2,575** | **2,571** | **3,134** | **3,076** |

| Gross demand '000 oz | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|
| Rest of World | Autocatalyst | 1,617 | 1,589 | 1,725 | 1,889 | 1,916 | 1,608 |
| | Chemical | 75 | 95 | 94 | 175 | 106 | 112 |
| | Dental | 18 | 19 | 19 | 19 | 19 | 14 |
| | Electronics | 282 | 262 | 247 | 225 | 212 | 190 |
| | Investment | -282 | -303 | -77 | -345 | -27 | -140 |
| | Jewellery | 22 | 21 | 19 | 18 | 19 | 15 |
| | Other | 21 | 33 | 17 | 20 | 23 | 16 |
| | **Total** | **1,753** | **1,716** | **2,044** | **2,001** | **2,268** | **1,815** |
| | **Grand total** | **9,205** | **9,462** | **10,058** | **10,352** | **11,417** | **9,894** |

# Palladium supply and demand

## Tonnes

| Supply tonnes[1] | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| South Africa | 83.4 | 79.9 | 79.2 | 79.1 | 81.7 | 60.3 |
| Russia[2] | 75.7 | 86.5 | 76.3 | 92.6 | 92.9 | 84.8 |
| North America | 27.2 | 28.5 | 29.7 | 30.4 | 30.6 | 29.0 |
| Zimbabwe[3] | 10.0 | 12.3 | 12.0 | 12.2 | 11.8 | 12.1 |
| Others[3] | 4.5 | 4.0 | 4.1 | 4.2 | 4.4 | 5.6 |
| **Total supply** | **200.8** | **211.2** | **201.3** | **218.5** | **221.4** | **191.8** |

| Demand tonnes[4] | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| Autocatalyst[4] | 239.1 | 250.1 | 263.3 | 276.1 | 300.8 | 264.2 |
| Chemical | 14.0 | 13.1 | 13.4 | 18.6 | 15.5 | 15.1 |
| Dental | 14.6 | 13.3 | 12.2 | 11.2 | 9.8 | 7.5 |
| Electronics[4] | 28.1 | 27.2 | 26.3 | 24.0 | 22.3 | 19.7 |
| Investment | -20.5 | -20.1 | -12.0 | -17.8 | -2.7 | -5.8 |
| Jewellery[4] | 6.9 | 5.9 | 5.2 | 4.6 | 4.0 | 2.9 |
| Other | 4.2 | 4.8 | 4.5 | 5.4 | 5.5 | 4.1 |
| **Total gross demand** | **286.4** | **294.3** | **312.9** | **322.1** | **355.2** | **307.7** |

| Recycling tonnes[6] | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| Autocatalyst | -60.7 | -61.7 | -73.4 | -81.6 | -91.0 | -83.9 |
| Electronics | -14.8 | -15.0 | -14.9 | -14.8 | -14.7 | -12.8 |
| Jewellery | -1.4 | -0.7 | -0.6 | -0.4 | -0.4 | -0.3 |
| **Total recycling** | **-76.9** | **-77.4** | **-88.9** | **-96.8** | **-106.1** | **-97.0** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Total net demand[7]** | **209.5** | **216.9** | **224.0** | **225.3** | **249.1** | **210.7** |
| Movement in stocks[8] | -8.7 | -5.7 | -22.7 | -6.8 | -27.7 | -18.9 |

# Palladium gross demand by region

## Tonnes

| Gross demand tonnes | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|
| Europe | Autocatalyst | 50.4 | 50.9 | 53.0 | 59.2 | 64.1 | 55.4 |
| | Chemical | 2.3 | 2.3 | 2.3 | 2.0 | 2.1 | 1.5 |
| | Dental | 2.2 | 2.0 | 1.9 | 1.6 | 1.3 | 0.9 |
| | Electronics | 3.1 | 3.1 | 3.0 | 2.9 | 2.7 | 2.3 |
| | Investment | -6.2 | -8.4 | -8.9 | -4.4 | -1.7 | -0.4 |
| | Jewellery | 1.8 | 1.8 | 1.6 | 1.5 | 1.3 | 0.9 |
| | Other | 0.8 | 0.7 | 0.7 | 0.9 | 0.8 | 0.7 |
| | **Total** | **54.4** | **52.4** | **53.6** | **63.7** | **70.6** | **61.3** |

| Gross demand tonnes | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|
| Japan | Autocatalyst | 23.6 | 24.4 | 25.8 | 27.2 | 28.2 | 23.6 |
| | Chemical | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| | Dental | 7.1 | 6.2 | 5.4 | 4.9 | 4.4 | 3.5 |
| | Electronics | 7.2 | 7.1 | 6.9 | 6.2 | 5.7 | 5.0 |
| | Investment | 0.1 | -0.1 | -0.1 | 0.0 | 0.0 | 0.0 |
| | Jewellery | 2.1 | 2.0 | 1.8 | 1.6 | 1.4 | 1.1 |
| | Other | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.2 |
| | **Total** | **40.9** | **40.4** | **40.6** | **40.7** | **40.5** | **33.9** |

| Gross demand tonnes | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|
| North America | Autocatalyst | 63.4 | 62.0 | 63.1 | 66.2 | 65.4 | 53.5 |
| | Chemical | 2.4 | 2.3 | 2.3 | 2.4 | 2.2 | 1.2 |
| | Dental | 4.5 | 4.3 | 4.1 | 3.9 | 3.3 | 2.5 |
| | Electronics | 4.1 | 4.0 | 3.9 | 3.5 | 3.2 | 2.8 |
| | Investment | -5.6 | -2.2 | -0.6 | -2.7 | -0.2 | -1.0 |
| | Jewellery | 1.2 | 1.1 | 0.9 | 0.8 | 0.7 | 0.4 |
| | Other | 1.9 | 1.4 | 1.4 | 1.4 | 1.4 | 1.0 |
| | **Total** | **71.9** | **72.9** | **75.1** | **75.5** | **76.0** | **60.4** |

| Gross demand tonnes | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|
| China | Autocatalyst | 51.4 | 63.4 | 67.8 | 64.7 | 83.5 | 81.7 |
| | Chemical | 6.5 | 5.0 | 5.4 | 8.3 | 7.4 | 8.4 |
| | Dental | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| | Electronics | 4.9 | 4.9 | 4.8 | 4.4 | 4.1 | 3.7 |
| | Investment | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Jewellery | 1.1 | 0.3 | 0.3 | 0.1 | 0.0 | 0.0 |
| | Other | 0.5 | 1.4 | 1.6 | 2.2 | 2.3 | 1.7 |
| | **Total** | **64.6** | **75.2** | **80.1** | **79.9** | **97.5** | **95.7** |

| Gross demand tonnes | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|
| Rest of World | Autocatalyst | 50.3 | 49.4 | 53.6 | 58.8 | 59.6 | 50.0 |
| | Chemical | 2.3 | 3.0 | 2.9 | 5.4 | 3.3 | 3.5 |
| | Dental | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.4 |
| | Electronics | 8.8 | 8.1 | 7.7 | 7.0 | 6.6 | 5.9 |
| | Investment | -8.8 | -9.4 | -2.4 | -10.7 | -0.8 | -4.4 |
| | Jewellery | 0.7 | 0.7 | 0.6 | 0.6 | 0.6 | 0.5 |
| | Other | 0.7 | 1.0 | 0.5 | 0.6 | 0.7 | 0.5 |
| | **Total** | **54.6** | **53.4** | **63.5** | **62.3** | **70.6** | **56.4** |
| | **Grand total** | **286.4** | **294.3** | **312.9** | **322.1** | **355.2** | **307.7** |

# Rhodium supply and demand

## Troy ounces

| Supply '000 oz[1] | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| South Africa | 611 | 615 | 611 | 618 | 624 | 450 |
| Russia[2] | 80 | 85 | 78 | 69 | 68 | 65 |
| North America | 22 | 24 | 24 | 21 | 21 | 21 |
| Zimbabwe[3] | 36 | 44 | 42 | 43 | 40 | 41 |
| Others[3] | 5 | 5 | 5 | 5 | 7 | 6 |
| **Total supply** | **754** | **773** | **760** | **756** | **760** | **583** |

| Demand '000 oz[4] | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| Autocatalyst[4] | 760 | 806 | 833 | 885 | 1,023 | 925 |
| Chemical | 73 | 64 | 71 | 63 | 60 | 56 |
| Electronics | 3 | 4 | 5 | 5 | 6 | 6 |
| Glass | 52 | 85 | 103 | 103 | 45 | 7 |
| Other | 30 | 41 | 20 | -13 | 21 | 11 |
| **Total gross demand** | **918** | **1,000** | **1,032** | **1,043** | **1,155** | **1,005** |

| Recycling '000 oz[6] | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| Autocatalyst | -281 | -276 | -310 | -331 | -357 | -338 |
| **Total recycling** | **-281** | **-276** | **-310** | **-331** | **-357** | **-338** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Total net demand[7]** | **637** | **724** | **722** | **712** | **798** | **667** |
| Movement in stocks[8] | 117 | 49 | 38 | 44 | -38 | -84 |

# Rhodium supply and demand

## Tonnes

| Supply tonnes[1] | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| South Africa | 19.0 | 19.1 | 19.0 | 19.2 | 19.4 | 14.0 |
| Russia[2] | 2.5 | 2.6 | 2.4 | 2.1 | 2.1 | 2.0 |
| North America | 0.8 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| Zimbabwe[3] | 1.1 | 1.4 | 1.3 | 1.3 | 1.2 | 1.3 |
| Others[3] | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| **Total supply** | **23.6** | **24.0** | **23.6** | **23.5** | **23.6** | **18.2** |

| Demand tonnes[4] | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| Autocatalyst[4] | 23.6 | 25.1 | 25.8 | 27.5 | 31.8 | 28.7 |
| Chemical | 2.3 | 2.0 | 2.3 | 2.0 | 1.9 | 1.8 |
| Electronics | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 |
| Glass | 1.7 | 2.6 | 3.1 | 3.2 | 1.4 | 0.2 |
| Other | 1.0 | 1.3 | 0.6 | -0.4 | 0.6 | 0.3 |
| **Total gross demand** | **28.7** | **31.1** | **32.0** | **32.5** | **36.0** | **31.3** |

| Recycling tonnes[6] | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| Autocatalyst | -8.7 | -8.6 | -9.6 | -10.3 | -11.1 | -10.5 |
| **Total recycling** | **-8.7** | **-8.6** | **-9.6** | **-10.3** | **-11.1** | **-10.5** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Total net demand[7]** | **20.0** | **22.5** | **22.4** | **22.2** | **24.9** | **20.8** |
| Movement in stocks[8] | 3.6 | 1.5 | 1.2 | 1.3 | -1.3 | -2.6 |

# Notes to tables

[1]**Supply** figures represent estimates of sales by the mines of primary pgm and are allocated to where the initial mining took place rather than the location of refining.

[2]Our **Russian supply** figures represent the total pgm mined in Russia and the CIS. Demand in Russia is included in the Rest of the World region.

[3]Supplies from **Zimbabwe** have been split from Others' supplies. Platinum group metals mined in Zimbabwe are currently refined in South Africa, and our supply figures represent shipments of pgm in concentrate or matte, adjusted for typical refining recoveries.

[4]**Gross demand** figures for any given application represent the sum of manufacturer demand for new metal in that application and any changes in unrefined metal stocks in that sector. Increases in unrefined stocks lead to additional demand, reductions in stock lead to a lower demand figure.

[5]Our **Medical and Biomedical** category represents combined metal demand in the medical, biomedical and dental sectors; however, pharmaceutical metal use is included under Chemical demand.

[6]**Recycling** figures represent estimates of the quantity of metal recovered from open-loop recycling (i.e. where the original purchaser does not retain control of the metal throughout). For instance, autocatalyst recycling represents the weight of metal recovered from end-of-life vehicles and aftermarket scrap in an individual region. These figures do not include warranty or production scrap. Where no recycling figures are given, open-loop recycling is negligible.

[7]**Net demand** figures are equivalent to the sum of gross demand in an application less any metal recovery from open-loop scrap in that application, whether the recycled metal is reused in that industry or sold into another application. Where no recycling figure is given for an application, gross and net demand are identical.

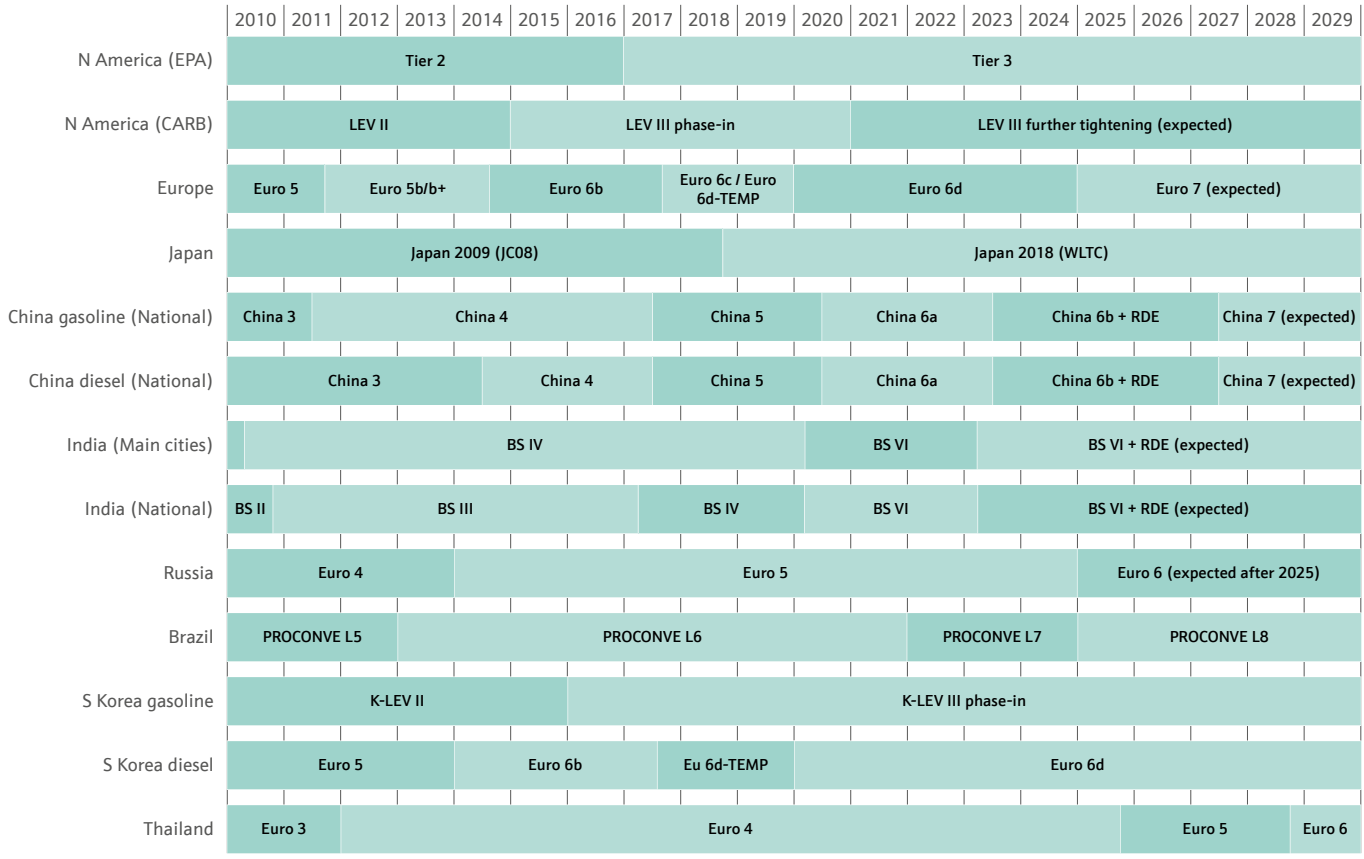
[8]**Movements in stocks** in any given year reflect changes in stocks held by fabricators, dealers, banks and depositories but excluding stocks held by primary refiners and final consumers. A positive figure (sometimes referred to as a 'surplus') reflects an increase in market stocks. A negative value (or 'deficit') indicates a decrease in market stocks.

# Glossary

| | |
|---|---|
| ASC | Ammonia slip catalyst |
| BEV | Battery electric vehicle |
| CF | Conformity factor |
| CO | Carbon monoxide |
| $CO_2$ | Carbon dioxide |
| DOC | Diesel oxidation catalyst |
| DPF | Diesel particulate filter |
| EC | European Commission |
| ELV | End-of-life vehicle |
| ETF | Exchange traded fund |
| FCEV | Fuel cell electric vehicle |
| GDI | Gasoline direct injection |
| GPF | Gasoline particulate filter |
| HC | Hydrocarbon |
| HDD | Heavy duty diesel |
| ISC | In-service conformity |
| LAB | Linear alkyl benzene |
| LDG | Light duty gasoline |
| LDD | Light duty diesel |
| LEV | Low emission vehicle |
| MLCC | Multi-layer ceramic capacitor |
| NEDC | New European Driving Cycle |
| NEV | New energy vehicle (BEV, PHEV or FCEV) |
| NOx | Oxides of nitrogen |
| NRMM | Non-road mobile machinery |
| NYMEX | New York Mercantile Exchange |
| PDH | Propane dehydrogenation |
| PHEV | Plug-in hybrid vehicle |
| PM | Particulate matter or soot |
| PN | Particle number |
| PNA | Passive NOx adsorber |
| PTA | Purified terephthalic acid |
| PX | Paraxylene |
| RDE | Real driving emissions |
| RoW | Rest of world region |
| SCR | Selective catalytic reduction |
| SCRF® | SCR integrated with a soot filter |
| SGE | Shanghai Gold Exchange |
| SUV | Sports utility vehicle |
| WLTP | Worldwide Harmonised Light Vehicle Test Procedure |
| 4E grade | Combined content of four elements: platinum, palladium, rhodium and gold |

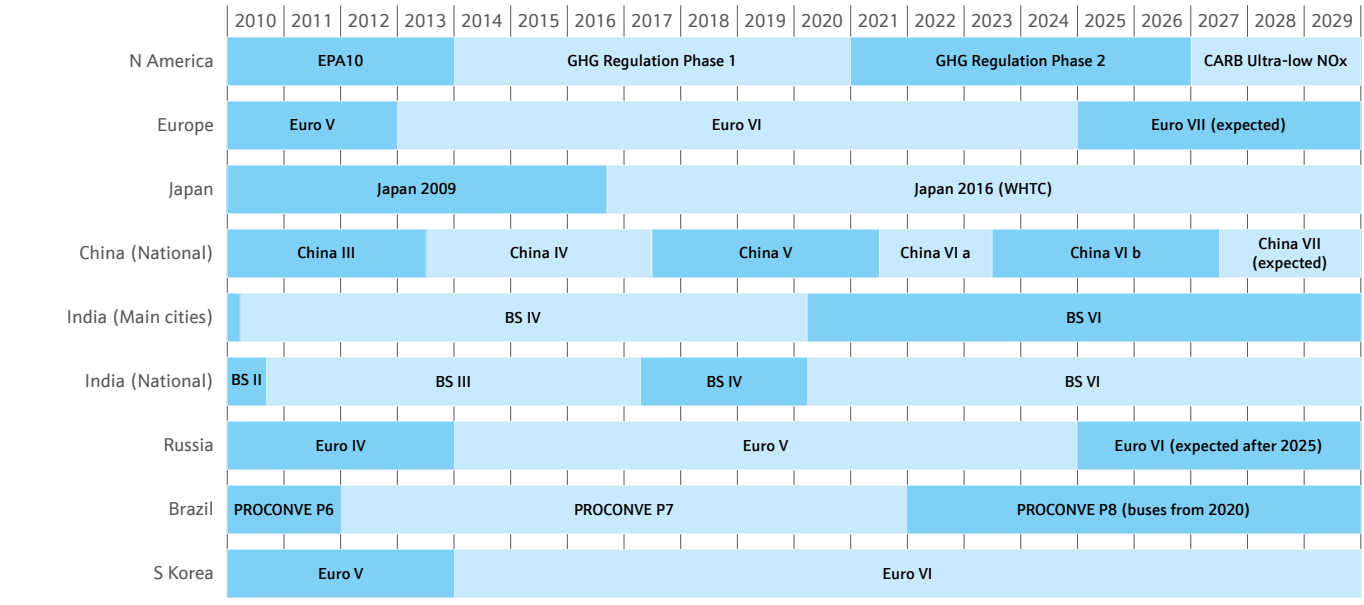
# Emissions legislation

## Light duty




Dates shown are for New Vehicle Type Approvals for passenger cars

## Heavy duty



# Euro 6 emissions legislation

**Euro 6** is a generic standard that defines emissions limits for light vehicles to be phased in on various dates and according to various tests and procedures.

**Euro 6a** was a voluntary stage which allowed vehicles to be introduced with Euro 6 type approval earlier than required. It had minimal impact on pgm demand.

**Euro 6b** applied to new type approvals for passenger cars from September 2014, and to all vehicles sold in the European market from September 2016. From this point, vehicles had to meet Euro 6 emissions limits when tested over the New European Driving Cycle (NEDC). At Euro 6b there was no change to the emissions limits for gasoline vehicles from Euro 5 limits, other than the introduction of a particle number limit on these engines (although manufacturers could apply for a three-year exemption to meet a slightly higher limit). For diesel vehicles, allowable NOx emissions over the test cycle were reduced by 56% relative to Euro 5 legislation. This had significant implications for pgm loadings on diesel vehicles.

**Euro 6c** began to be phased in from September 2017 and applied to all vehicles from September 2019. In terms of emissions limits, there are no differences between 6b and 6c for diesel engines and the only difference for gasoline engines is that 6c brings particle number emissions down for all vehicles, fully in line with those from diesel vehicles. This has implications for gasoline particulate filter (GPF) fitment.

In parallel, a new laboratory test replaced the NEDC. The Worldwide Harmonised Light Vehicle Test Procedure (WLTP) applied to new type approvals from September 2017 and to all vehicles from September 2018.

**Euro 6d** is being phased in over several years, starting in September 2017. Euro 6d differs from 6b/6c in that it changes the way in which NOx emissions and particle number (PN) emissions are tested and measured, with the introduction of Real Driving Emissions (RDE) testing, alongside laboratory testing. During RDE testing, vehicles are driven on the road according to random acceleration and deceleration patterns, with emissions measured using on-board portable emissions monitoring systems (PEMS).

**Conformity Factors** (CFs) have been introduced, which govern the multiple by which the vehicles' NOx and PN emissions can exceed the emissions limits during RDE testing. The exceedance is intended to allow a margin for measurement error using PEMS. The phase-in of CFs takes place in two stages:

In the first stage (**Euro 6d-TEMP**), a NOx CF of 2.1 and a PN CF of 1.5 were introduced for new type approvals of passenger cars from September 2017, and for new type approvals of light commercial vehicles (LCVs) from September 2018. The CFs applied to all new passenger vehicles from September 2018 for PN and September 2019 for NOx, and a year later to all new LCVs.

In the second stage (**Euro 6d**), the NOx CF is being reduced to 1.43, applying to new type approvals for passenger cars from January 2020, and to all vehicles from January 2022.

The European Commission (EC) intends to review the CFs over time as the measurement accuracy of PEMS equipment improves, with the intention of lowering them to 1.0 by 2023, allowing for no measurement error in the tests.

These transitions inevitably lead to changes in catalyst system designs and loadings.