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PGM Market Report

May 2018

The PGM Market Report is written by Alison Cowley.

Special feature on fuel cell vehicles by Margery Ryan.

Johnson Matthey's PGM market research is conducted by:

Lucy Bloxham
Stewart Brown
Laura Cole
Alison Cowley
Peter Duncan
Mikio Fujita
Luke Han
Jason Jiang
Rupen Raithatha
Margery Ryan
Elaine Shao
Fei Xiaoyan

Platinum Summary

Supply and Demand in 2017

- Gross demand for platinum contracted by 2.5% in 2017, due to sharp falls in Japanese investment buying and Chinese jewellery fabrication.
- Sales of platinum bars to Japanese investors were exceptionally strong during 2015–2016, but returned to more normal levels last year.
- Chinese platinum jewellery fabrication contracted for a fourth consecutive year as karat gold jewellery gained market share.
- There was also a small decline in consumption of platinum in autocatalysts, with European diesel car production flat and average platinum loadings down slightly.
- In contrast, industrial platinum usage was at record levels, reflecting buoyant demand from the glass and chemicals sectors.
- With mine supply flat, and some growth in recycling, the market moved into a modest surplus.

Platinum Supply and Demand '000 oz

Supply	**2016**	**2017**	**2018**
South Africa	4,392	4,459	4,410
Russia	717	692	662
Others	988	961	982
Total Supply	**6,097**	**6,112**	**6,054**
Gross Demand			
Autocatalyst	3,330	3,292	3,184
Jewellery	2,412	2,296	2,258
Industrial	1,803	2,018	2,080
Investment	620	356	245
Total Gross Demand	**8,165**	**7,962**	**7,767**
Recycling	-1,929	-1,951	-2,029
Total Net Demand	**6,236**	**6,011**	**5,738**
Movements in Stocks	-139	101	316

Global primary supplies of platinum were almost unchanged in 2017, at 6.11 million oz. Russian shipments fell slightly, with some of Norilsk's pgm being put to stock rather than sold, but this was offset by higher sales from some South African producers, particularly Anglo American Platinum. South African supplies reached 4.46 million oz, up 67,000 oz on 2016, and around 80,000 oz higher than underlying mine production. This additional metal was sourced mainly from pre-existing stocks of refined metal.

We estimate that underlying South African mine output of platinum was just under 4.4 million oz last year, slightly higher than in 2016. This figure includes metal derived from tailings retreatment operations and nickel mining, but does not include platinum mined in Zimbabwe. This increase occurred despite further shaft closures: Platinum Group Metals Ltd's Maseve mine ceased producing in mid-year, while Atlatsa Resources' Bokoni mine was mothballed at the end of September. These closures were offset by an exceptionally strong performance from Anglo's large Mogalakwena open pit, where platinum output rose by 13%, a ramp-up in production at Royal Bafokeng Platinum's Styldrift project, and incremental gains at a number of other operations.

While trends in mine output were broadly positive, last year saw some significant disruptions to processing operations, and consequently some large fluctuations in 'pipeline' (semi-processed) platinum inventories held by South African pgm producers. Anglo American Platinum began 2017 with in-process stocks above normal levels following a furnace run-out at its Waterval smelter the previous year; a high-pressure water leak at its convertor plant in June 2017 further delayed the refining of this inventory. This backlog was cleared during the second half of 2017, during which some 200,000 oz of platinum was released from stocks of work-in-progress. However, in the final quarter the suspension of concentrating activities at the Mototolo joint venture (with Glencore) led

to a build-up of ore stockpiles, deferring some platinum production from this operation into 2018.

At Impala Platinum, maintenance work was undertaken at two of the group's South African furnaces and at the Zimplats smelter in Zimbabwe. As a result, the group's in-process inventories were significantly higher than normal at the year end. Northam Platinum also accumulated some stocks of pgm in concentrate ahead of the commissioning of its new furnace at the end of 2017. In contrast, refined output from Lonmin exceeded production from its mines, as the company continued to process pgm-containing materials sourced from a clean-up of its smelter plant.

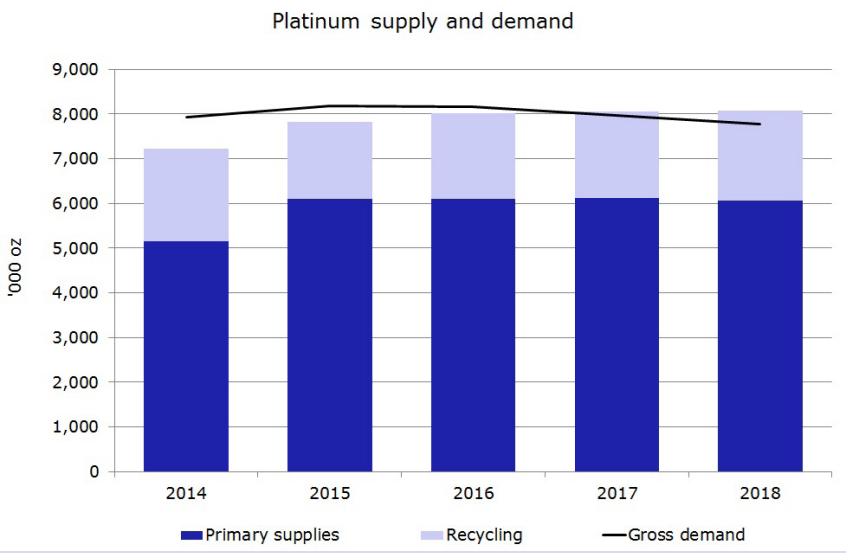
In Zimbabwe, output was broadly stable at the three pgm operations. However, our supply estimate for 2017 shows a modest year-on-year decline: the record total achieved in 2016 included an additional 20,000 oz from the smelting of a concentrate backlog at Zimplats, while matte shipments last year were affected by another smelter outage.

Russian platinum supplies totalled 692,000 oz, down 3% on the previous year, when Norilsk Nickel supplied some metal from inventories; in contrast, 2017 saw sales of Russian-origin metal fall slightly short of production. Company data shows that production from Russian feed rose by 7% to 650,000 oz, despite a weak start to the year, linked to an increase in processing timescales due to the transfer of some pgm concentrating activities from the Norilsk mine site to the company's Kola Peninsula processing complex. Meanwhile, alluvial production in the Far East of Russia stabilised following several years of steep decline.

In recent years, Norilsk Nickel's production has been augmented by the refining of pgm from old pyrrhotite concentrate stored at the Norilsk mine site. Stocks of this material have now been depleted, but in 2017 the company began to extract pgm from copper concentrate derived from mining activities in the Norilsk area in the 1980s. This material was purchased from the state-controlled corporation Rostec in December 2016.

We estimate that North American supplies totalled 336,000 oz in 2017, almost unchanged on the previous year. Both Vale and Glencore reported a decline in platinum output: this reflected lower copper and nickel production from their Canadian operations, along with changes in concentrate offtake agreements with third parties, and a move to a single furnace operation at Vale's Sudbury smelter. However, platinum output from Sibanye-Stillwater's Montana mines was up, reflecting increases in productivity at the existing operations and a small contribution from the Blitz expansion project, which achieved its first production on 29th September 2017.

Overall, primary shipments of platinum were broadly flat for a third consecutive year, at around 6.1 million oz. Secondary



"Primary shipments of platinum were broadly flat for a third consecutive year. Secondary supplies rose by just 1%."

supplies rose, although at a lower rate than we had anticipated in our previous report: up 1% to 1.95 million oz. While recoveries of platinum from autocatalyst scrap increased by 10%, matching the 2014 high of 1.28 million oz, this was largely offset by a 13% decline in jewellery recycling.

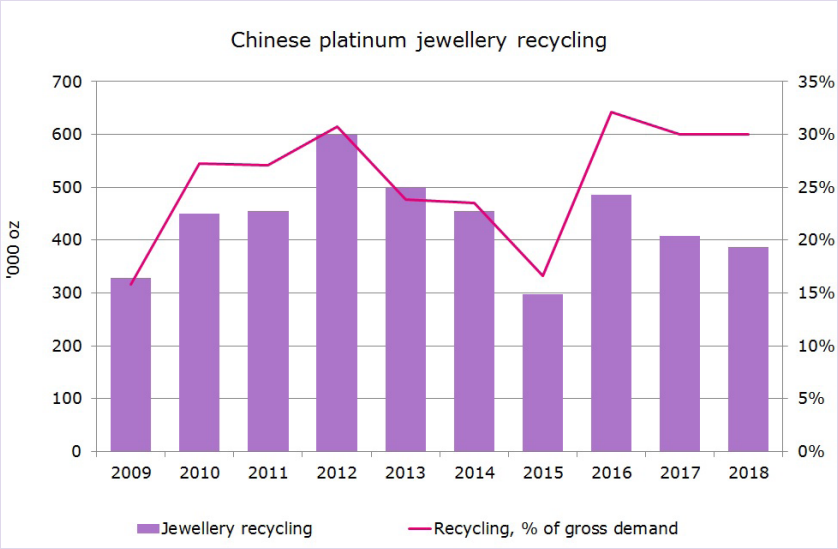
Autocatalyst scrap volumes were unusually depressed during 2015 and 2016, as weak steel prices prompted a significant decline in the number of end-of-life vehicles (ELVs) reaching scrapyards. This trend reversed last year, with some major recyclers reporting double-digit increases in the volume of catalyst scrap processed. We had expected to see significant growth in the platinum grade of spent autocatalyst, particularly in the European market, reflecting historic trends in platinum consumption on diesel vehicles. However, there was little evidence of any significant increase in platinum assays last year.

Global jewellery recycling fell by 13% to 638,000 oz in 2017, reflecting a fall in recycling in both major jewellery scrap markets, Japan and China. In Japan, the recycling of platinum jewellery surged in 2012–2013, as higher gold prices sparked a boom in precious metals recycling, but activity has since returned to more normal levels. In China, the jewellery recycling sector is undergoing some significant changes. Last year saw a decline in returns of unwanted or outdated jewellery via the 'closed loop' jewellery distribution network, following extensive destocking during 2016. In contrast, there was a notable increase in 'open loop' recycling of platinum via scrap collection booths that purchase old jewellery directly from customers.

Gross demand for platinum exceeded 8.1 million oz in both 2015 and 2016, but fell back to 7.96 million oz last year, despite a record year for industrial consumption. There was a steep fall in investment bar sales in Japan, while platinum jewellery manufacturing in China continued to contract. Autocatalyst demand was relatively stable, falling just 1% to 3.29 million oz.

Consumption of platinum on diesel catalysts was flat. World production of diesel cars rose by 3%, with gains in some major Rest of World markets such as India and Thailand, while there was also an increase in global output of catalyst-equipped heavy duty trucks. These positive volume trends directly offset a reduction in the global average platinum content of both light and heavy duty diesel catalyst systems.

In Europe, light duty diesel vehicle output was flat, but platinum usage fell by 1% as automakers began to introduce models that meet the next stage of EU emissions legislation, known as Euro 6d-TEMP. During the phase-in period of these regulations, between September 2017 and September 2020, we expect to see a progressive shift away from the use of lean NOx traps (LNTs) to control NOx, and greater adoption of selective catalytic reduction (SCR) technology. SCR will continue to be used alongside platinum-containing bricks,



"Last year saw a decline in returns of unwanted jewellery via the 'closed loop' distribution network in China. However, there was an increase in 'open loop' recycling via scrap collection booths."

Platinum Demand: Autocatalyst '000 oz									
	Gross			Recycling			Net		
	2016	2017	2018	2016	2017	2018	2016	2017	2018
Europe	1,825	1,776	1,649	-501	-544	-594	1,324	1,232	1,055
Japan	391	387	370	-66	-69	-70	325	318	300
North America	344	320	350	-470	-535	-580	-126	-215	-230
China	145	161	156	-18	-23	-28	127	138	128
Rest of World	625	648	659	-104	-108	-112	521	540	547
Total	**3,330**	**3,292**	**3,184**	**-1,159**	**-1,279**	**-1,384**	**2,171**	**2,013**	**1,800**

such as oxidation catalysts and particulate filters, but on average Euro 6d-TEMP aftertreatment systems will contain less platinum than their Euro 6b predecessors.

Demand from the heavy duty sector rose slightly, reflecting increases in both catalyst fitment and heavy duty vehicle production volumes in China and the Rest of World; this more than offset a reduction in average platinum loadings on Euro VI trucks in Europe. First-generation Euro VI catalyst systems mainly used Fe-SCR and/or Cu-SCR (based on iron and copper respectively), but some manufacturers have moved to V-SCR (based on vanadium), enabling them to thrift the platinum content of their aftertreatment systems. Globally, Europe is the only region where the adoption of V-SCR has had any measurable impact on platinum demand: vanadium is not used in trucks sold in Japan or North America, nor in any mainstream light duty applications (where lower engine temperatures make it unsuitable).

There was also some further thrifting of platinum in light duty gasoline systems, but this had only a small impact on overall demand, because this segment is dominated by palladium-rhodium catalysts. Globally, platinum accounts for under 3% of total pgm use in gasoline catalysts, mostly in Japanese-branded vehicles (produced both in Japan and at transplants in other regions).

The use of platinum in industrial applications set a new record in 2017, with buoyant demand from the chemicals and petroleum refining sectors, and exceptionally heavy purchasing by glass producers. All regions saw positive trends, but the largest growth occurred in China, where industrial demand rose by 19%. Meanwhile, investment by Chinese companies in their overseas markets, to move production closer to their customers and avoid anti-dumping penalties, also contributed to an 18% rise in industrial platinum use in the Rest of World region.

The 'Made in China 2025' initiative – designed to reduce the country's reliance on imports of chemical feedstocks – has stimulated massive investment in large new facilities integrating crude oil refining with downstream petrochemicals production, which are expected to come on stream over the next two to three years. These projects will require significant quantities of platinum, both in reforming catalysts used in petroleum refining, and in process catalysts required for the production of paraxylene. Purchasing for projects of this size may occur over a period that spans more than a single year, and this is reflected in our demand figures. In 2017, we estimate that purchasing of platinum by chemical producers exceeded half a million ounces for the fourth time in five years, while petroleum refining demand rose to a nine-year high of 219,000 oz.

Last year also saw modest growth in platinum demand in the electrical sector. Platinum usage in hard disks fell slightly, as weakness in consumer applications for hard disk drives (HDDs) outweighed expansion in the use of HDDs in 'server farms' for near-line and enterprise data storage. However, there was a significant rise in fuel cell demand, especially in transport applications: production of fuel cell cars significantly increased in 2017, while several hundred fuel cell stacks were shipped for deployment in buses in China. See page 15 for a more detailed discussion of developments in the fuel cell vehicle market.

Sales of platinum to the glass-making sector surged to over 350,000 oz in 2017, up nearly 50% and the highest since 2011. While the boom in glass demand between 2007 and 2011 was primarily a function of capacity-building in the display glass sector (LCD glass plants accounted for around three-quarters of total sales to glass-makers over that five-year period), the focus has now turned to the fibreglass segment. There has been rapid growth in global demand for

Platinum Demand: Industrial '000 oz			
	2016	**2017**	**2018**
Chemical	475	504	551
Electrical	230	234	262
Glass	246	364	346
Medical & Biomedical	218	220	223
Petroleum	176	220	202
Other	458	476	496
Total	**1,803**	**2,018**	**2,080**

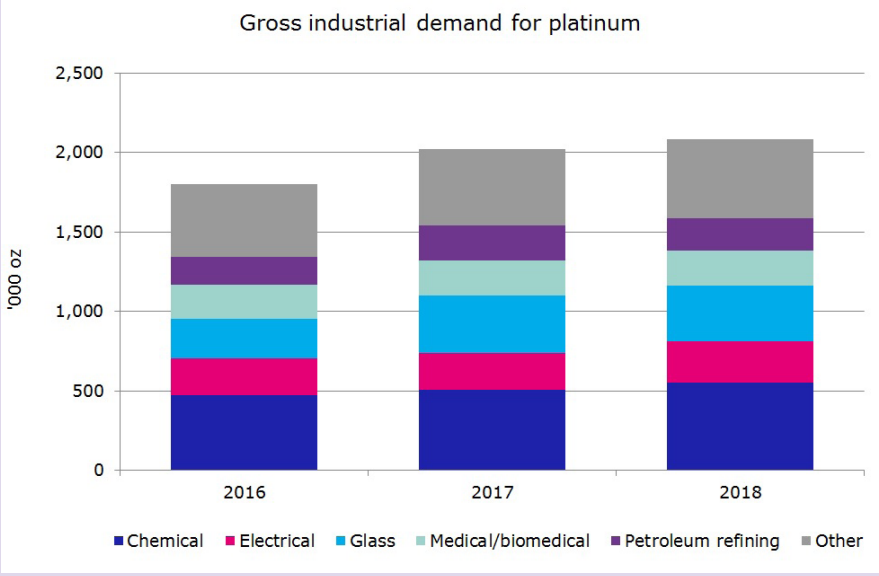
fibre-reinforced plastics, used in a wide range of applications such as vehicles, construction materials and wind turbines, and this has stimulated significant investment in new fibreglass production capacity, especially in China. While the Chinese domestic market accounts for the largest share of new investment, Chinese companies have also been adding capacity in their overseas markets, in order to avoid anti-dumping duties and to qualify for local incentives and tax reduction programmes.

Demand for platinum in other applications rose by around 4% in 2017, with rising platinum use in vehicle components such as sensors used in engine management and emissions control systems. Demand for platinum in coatings used on turbine blades and other aero engine components was also firm.

While developments in platinum's industrial markets were positive, the opposite was true in the jewellery sector, where global fabrication demand fell by 5% to 2.3 million oz. We estimate that gross purchases of platinum by Chinese jewellery manufacturers fell by 10% to 1.36 million oz last year, and were down 35% compared with the 2013 peak. This decline in platinum demand has occurred in the context of a sharp contraction in the gold jewellery market over the same period: according to World Gold Council data, Chinese gold jewellery volumes contracted by nearly a third between 2013 and 2017, despite a modest recovery in the second half of last year.

Heavy, pure-metal gold jewellery accounts for the majority of jewellery sales in China, so lower gold sales have put the jewellery industry under serious financial pressure, leading to consolidation in the distribution network and a reduction in wholesale and retail inventories. This rationalisation process has also had a significant effect on platinum demand, contributing to declines in fabrication in every year since 2013.

In the last two years, this impact has been magnified by evolving retail practices and changing consumer tastes. Retailers have responded to financial pressures by devoting increased resources to the marketing of karat gold items, on which they are able to achieve much better margins than on pure gold or platinum pieces. These marketing efforts have tapped into changes in consumer tastes, especially among younger people.



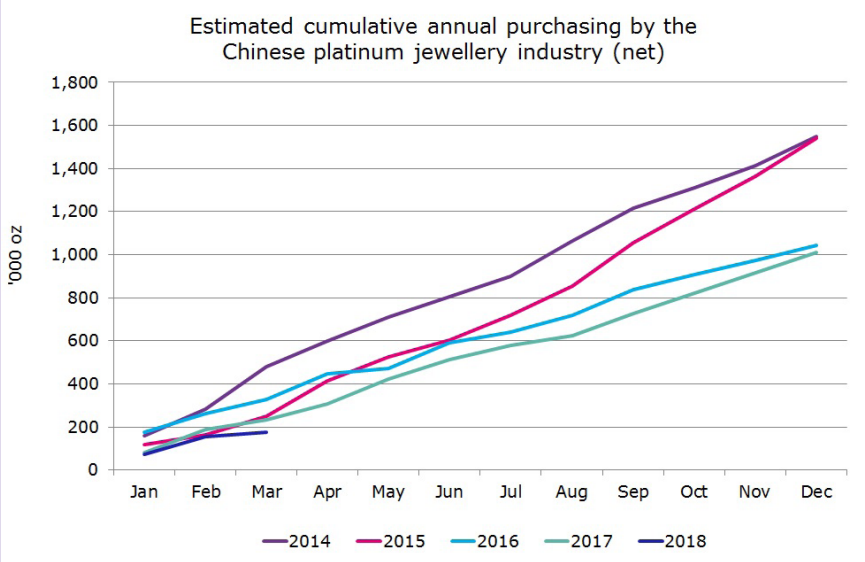
"The use of platinum in industrial applications set a new record in 2017, with buoyant demand from the chemicals and petroleum refining sectors, and exceptionally heavy purchasing by glass producers."

Platinum Demand: Jewellery '000 oz									
	Gross			Recycling			Net		
	2016	2017	2018	2016	2017	2018	2016	2017	2018
Europe	177	176	177	-5	-5	-5	172	171	172
Japan	310	309	306	-241	-222	-213	69	87	93
North America	220	238	239	-3	0	0	217	238	239
China	1,510	1,358	1,290	-485	-407	-387	1,025	951	903
Rest of World	195	215	246	-4	-4	-4	191	211	242
Total	**2,412**	**2,296**	**2,258**	**-738**	**-638**	**-609**	**1,674**	**1,658**	**1,649**

Chinese consumers have historically been wary of karat gold, because of its lower precious metal content. Pure gold or platinum items are usually sold by weight, with retailers displaying metal prices in their stores; this enables consumers to have confidence in the inherent value of their purchase, and facilitates the exchange of jewellery for newer items at a later date. In contrast, karat gold jewellery is sold by piece, usually at a much greater mark-up compared to the inherent metal value, and retailers do not usually offer exchanges on these items. In the past this created a barrier to the development of a karat gold market in China. However, it appears that younger consumers are now less concerned about exchange values than were older generations of jewellery purchasers.

Our estimates of Chinese jewellery demand are based on Johnson Matthey's twice-yearly manufacturing surveys, which confirm that fabrication volumes declined again in 2017. However, our most recent survey, covering the July to December 2017 period, suggests that there may have been some improvement in market conditions in recent months. Manufacturers' responses indicate that fabrication demand improved modestly during this six-month period compared with the second half of 2016; this represents the first year-on-year increase since 2013.

The Indian platinum jewellery market grew by 15% last year, after faltering in 2016, following severe flooding in the Chennai region (a major centre for platinum jewellery fabrication), some changes in the customs regime which caused significant uncertainty for the jewellery trade and precipitated industrial action, and the implementation of the government's 'demonetisation' policy. Although the broader context remained negative for Indian jewellery demand last year, platinum is a new market, very small relative to gold, and benefited from positive demographic factors such as rising personal wealth and an expanding middle class.

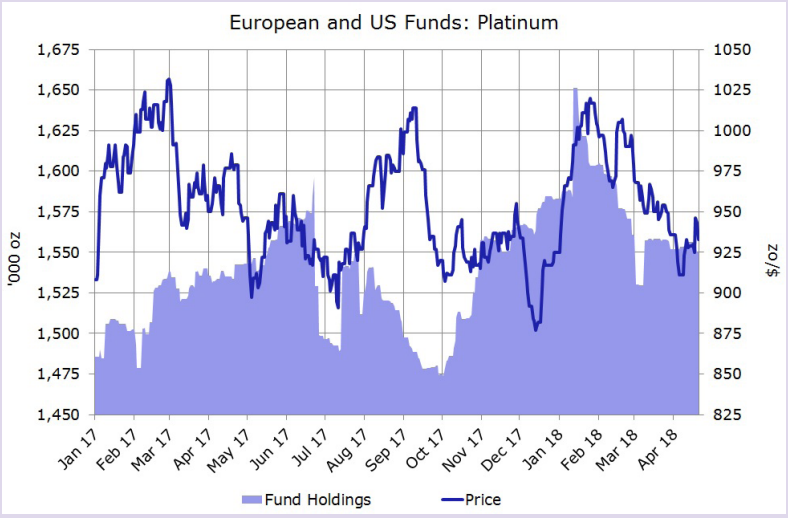


"Chinese jewellery fabrication volumes improved modestly in the second half of 2017, but net demand fell by 7% on an annual basis."

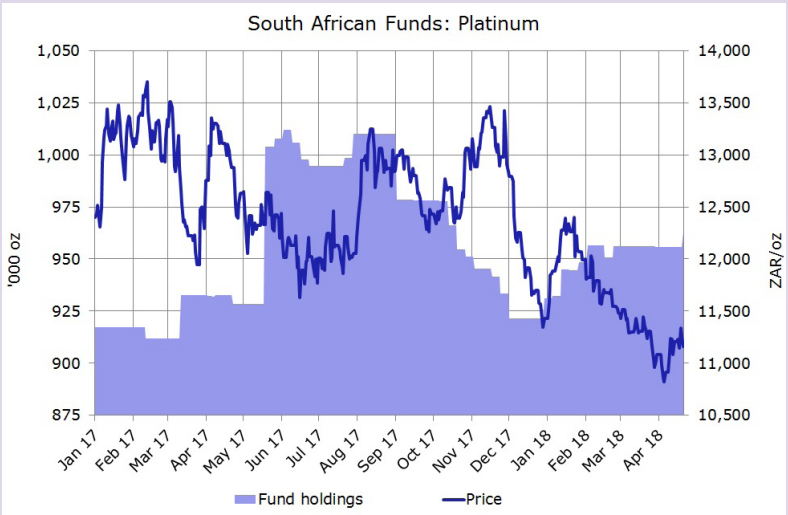
With industrial demand strong, the jewellery sector weak, and autocatalyst consumption little changed, total world demand for platinum in 'consuming' applications (i.e. excluding investment) was almost unchanged in 2017. However, investment volumes fell by over 40% to 356,000 oz, leaving global demand for platinum down 2.5%.

Most of this decline occurred in the Japanese investment bar sector, and reflected a return to more normal investor behaviour following two years of exceptionally heavy purchasing. During 2015 and 2016, a series of declines in the yen platinum price coincided with a dramatic widening of platinum's discount to gold, and triggered an unprecedented surge in Japanese platinum investment. Over this period, retail investors accumulated around 1.15 million oz of platinum, primarily in the form of investment bars purchased over-the-counter from bullion houses. This boom period came to an end in 2017, even though the price environment remained favourable for continuing investment, with yen platinum prices below the psychologically important ¥4,000 per gram level and the discount to gold at historically high levels. While bar sales remained in positive territory, activity was muted compared to the previous two years.

Global investment in platinum ETFs was positive during 2017 for the first time in three years, as holdings in South Africa stabilised after two years of heavy liquidation. Rand volatility created some buying opportunities for South African investors, especially in mid-year, but this was broadly offset by profit-taking during the final quarter, when the platinum price briefly topped R13,000 per ounce. European ETF holdings were also flat, but the amount of platinum held in North American funds rose by over 90,000 oz last year, making 2017 the best year for US ETF demand since 2010.



"The amount of platinum held in North American funds rose by over 90,000 oz in 2017, but US investors took profits in early 2018 as the price moved briefly above $1,000."



"South African ETF holdings ended 2017 almost unchanged, with purchasing in mid-year offset by profit-taking in the second half. There was a return to modest buying in early 2018."

Platinum Outlook

Supply and Demand in 2018

- The platinum market is forecast to move further into surplus in 2018, as increased industrial purchasing is outweighed by higher secondary supplies and lower demand from the autocatalyst, jewellery and investment sectors.
- Less platinum will be used in diesel aftertreatment systems in Europe, as automakers cut diesel car output and more vehicles are certified to Euro 6d-TEMP standards.
- Jewellery fabrication will also contract, although the rate of decrease should moderate as the Chinese market shows some signs of stabilising.
- These declines will be balanced by exceptionally strong industrial demand, with heavy investment in the Chinese chemical, petroleum and glass sectors.
- Overall, should investment decline again this year as we anticipate, the market surplus could widen to over 300,000 oz.

World primary supplies of platinum are unlikely to change much in 2018. In South Africa, the impact of shaft closures should be offset by incremental gains in production at other operations, along with the refining of some unprocessed inventory. Supplies from other regions will be broadly flat.

In our February 2018 report, we estimated that the release of metal from stocks of ore and work-in-progress could add as much as 150,000 oz of platinum to South African supplies this year. However, the most recent production data shows that some of this metal was in fact refined during the final quarter of 2017. We have adjusted our numbers accordingly, and now expect supplies from South Africa to fall slightly this year, to 4.41 million oz.

Our figures assume that there are no significant interruptions to mining or processing operations, and that the current backlog of unrefined materials can be treated this calendar year. Northam Platinum commissioned its new furnace in December 2017; the treatment of stockpiled concentrate should significantly boost the company's refined platinum output this year. Impala Platinum also has a backlog of semi-processed pgm, following smelter maintenance in 2017 and another furnace closure in the first quarter of this year; we assume that this metal will be refined before the year end.

Underlying mine output will see a modest impact from the closure of the Bokoni and Maseve mines in the second half of 2017, but these losses should be compensated by modest improvements elsewhere. Anglo American Platinum's Mogalakwena operation had an extremely strong first quarter, with an area of higher-grade ore being mined at its North pit, while the production build-up at Royal Bafokeng Platinum's Styldrift mine is underway. There will also be some additional production from chrome and pgm tailings treatment projects this year.

Although we believe that the short-term production outlook for the South African pgm industry is broadly flat, there are increasing risks to output going forward. The rand-denominated value of a typical basket of South African pgm appreciated significantly during the second half of last year, but has since fallen back to levels similar to those seen in early 2013. This has put producers under intense financial pressure, and has increased the likelihood of another round of shaft closures, particularly at older mines on the western Bushveld.

Output of platinum at Norilsk Nickel is expected to be similar to 2017, based on the company's most recent production outlook, but alluvial production in the Far East of Russia is likely to resume its multi-year decline. In the USA, Sibanye-Stillwater's Blitz expansion project will make a meaningful

contribution this year, helping to support platinum supplies from North America. However, underlying pgm output in Canada is expected to decline, in line with falling grades at the Sudbury nickel mines.

While mine output is expected to be lacklustre, secondary supplies will benefit from further growth in the volume of spent autocatalyst collected and processed. After a period of unusually muted activity in this sector during 2015 and 2016, especially in the large European and North American markets, there is room for further expansion in the number of vehicles being dismantled. However, growth in platinum recoveries last year was somewhat slower than we had initially projected, and significantly lagged the rate of increase in palladium and rhodium returns. In 2018, we expect this pattern to continue, with growth in platinum recycling trailing that of the other autocatalyst metals. We continue to anticipate future gains in the platinum grade of European catalyst scrap, based on the dramatic increase in loadings on diesel vehicles that occurred during the 2000–2007 period, but at present there is no evidence of this in platinum assays.

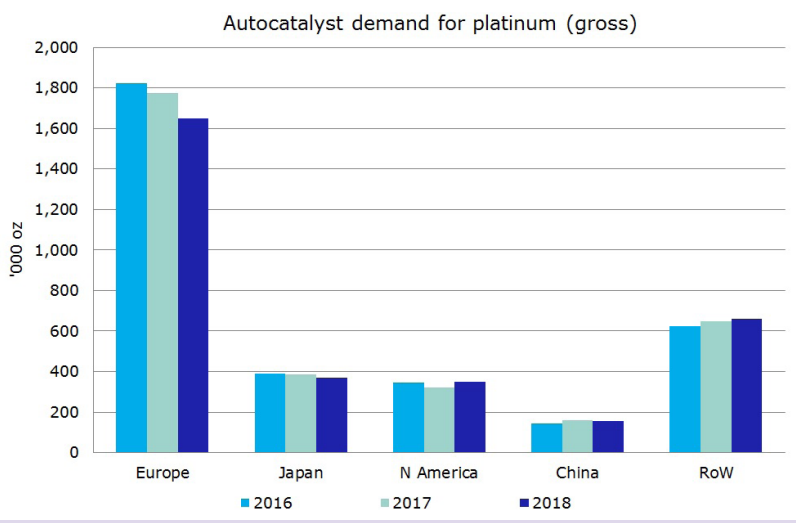
Jewellery recycling in China is expected to fall, although as a proportion of gross jewellery demand it is likely to remain above historical levels. We expect the recent trend towards a more 'open loop' recycling model to continue. Overall, we think combined primary and secondary supplies are more likely to rise than to fall, but that any gain will be modest.

Excluding investment, we expect only a small change in total gross platinum demand in 2018. Autocatalyst consumption is forecast to contract by 3%, but we do not expect further large falls in jewellery demand, and the outlook for industrial demand remains positive, with the Chinese chemicals, petroleum refining and glass sectors exceptionally buoyant.

The glass sector is forecast to enjoy another bumper year in 2018, with platinum demand expected to remain close to 350,000 oz. Purchasing by the fibreglass segment is likely to moderate somewhat, after an exceptional year in 2017, but demand from display glass manufacturers is predicted to rise to a seven-year high. Much of this buying will be for new capacity in China.

Demand for platinum in chemical and petroleum refining applications will continue to benefit from investment in large integrated petrochemical complexes in China. In addition, the consumption of platinum demand in chemical applications will be underpinned by its use in the production of speciality silicones for end-uses such as labels and packaging, medical appliances and dental impression materials. This application is unusual in that the platinum catalyst is consumed during the manufacturing process.

The electrical sector will once again be boosted by strong growth in the fuel cell segment, especially in China, where the roll-out of fuel cell vehicle programmes in a number of



"The use of platinum in autocatalysts is expected to shrink by 3% in 2018 with a fall of around 4% in average pgm loadings on European diesel cars."

cities has generated orders for significant numbers of fuel cell stacks to be delivered over the 2018–2021 period (see page 15 for our special feature on fuel cells). We also expect a return to growth in the hard disk market, where strong demand for multi-disk drives in near-line and enterprise applications is driving output of large-format disks, and rising consumption of platinum in other applications such as automotive sensors and turbine blades.

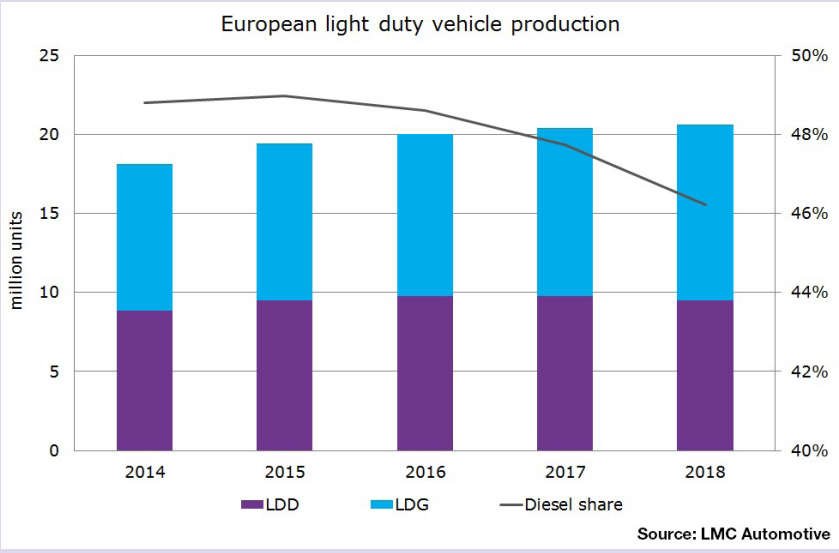
In contrast to buoyant industrial demand, the use of platinum in autocatalysts is expected to shrink by 3% in 2018. World output of light duty diesel vehicles is not forecast to change significantly, with a 2% decline in European production mostly offset by the continued recovery in the Indian diesel market. However, platinum demand will be hit by a fall of around 4% in average pgm loadings on European diesel cars.

This decline in loadings is based on changes in catalyst fitment strategy among European automakers. The phase-in of Euro 6d-TEMP regulations began in September 2017, and has resulted in a shift towards non-pgm SCR technology for NOx control, although all diesel vehicles continue to be fitted with platinum-rich catalysts for the treatment of other pollutants. Euro 6d-TEMP will apply fully to all passenger cars sold in Europe from September 2019 and to all light commercial vehicles a year later, so we anticipate another decrease in platinum loadings next year.

The next stage of European legislation, Euro 6d, will begin to take effect in January 2020, further limiting permitted NOx emissions during real driving emissions (RDE) testing. These standards are very challenging, and there is potential for some additional use of NOx traps alongside SCR; this would have a positive impact on platinum. However, we also expect to see further adoption of SCRF technology, which combines the functions of SCR and a particulate filter on a single brick and permits some reduction of pgm in the system.

Global demand for platinum in heavy duty vehicles is forecast to rise in 2018, despite another fall in European loadings, linked to the adoption of V-SCR technology in this region (see page 6). Worldwide, the proportion of heavy vehicles fitted with a pgm-containing catalyst system is expected to rise above 60% this year. This percentage is expected to grow rapidly over the next three years, as more Chinese and Indian trucks are equipped with pgm catalysts to meet China VI and Bharat VI legislation.

Consumption of platinum in light duty gasoline applications will weaken again in 2018, falling below 200,000 oz. Higher palladium prices, along with expectations of growing supply shortfalls, have motivated some renewed research into the use of platinum in this application. However, despite some positive test results for platinum-rhodium catalyst bricks in specific applications, it appears that it will be difficult



"European diesel car production is expected to fall by 2% to 9.52 million units in 2018. Diesel share will decline to 46%, from 48% three years ago."

to match existing palladium-rhodium catalysts without improvements in technology. In particular, palladium has better thermal stability than platinum under typical gasoline exhaust temperatures, which means that catalyst activity remains more consistent over time.

Global demand for platinum in jewellery will weaken again in 2018, but we expect the pace of decline to decelerate, as Indian jewellery consumption expands again, and the Chinese market shows signs of bottoming out.

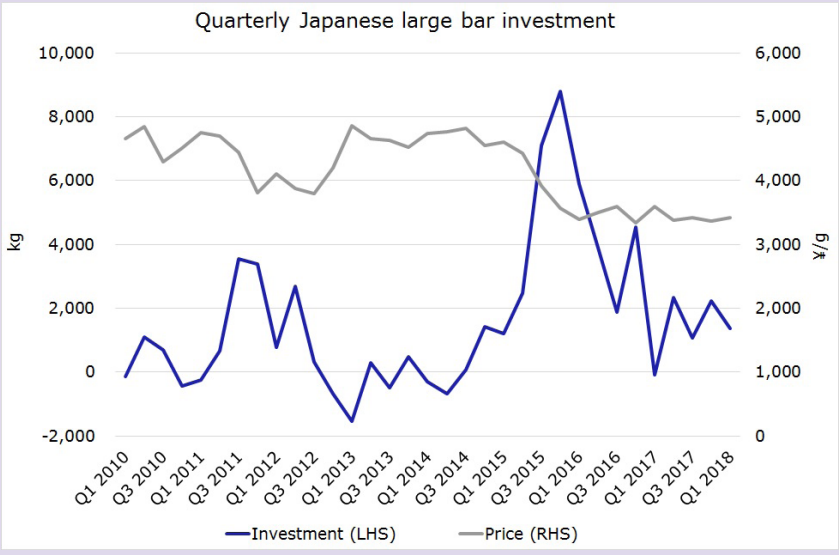
Platinum should be helped by an improved outlook for the Chinese gold jewellery market, which returned to growth in the second half of 2017 according to World Gold Council estimates. If this trend is confirmed, it will help to relieve the financial pressure on jewellery retailers, and reduce the likelihood of further rationalisation in the distribution chain.

There are also signs that the industry is working to improve the design of platinum jewellery, with the aim of moving towards 'per piece' pricing, and improving margins. This cautiously positive outlook is supported by Johnson Matthey's survey of Chinese platinum jewellery fabrication for the second half of 2017, which shows that demand improved modestly during the course of last year even though it was down on a full-year basis.

Overall, we expect total use of platinum in 'consuming applications' (i.e. excluding investment) to total 7.52 million oz in 2018, down by 1% or around 80,000 oz compared with last year. This means that investment will once again be a key factor in determining the size and the direction of change in total platinum demand.

Purchases of platinum bars by Japanese investors are forecast to decline this year, although demand should remain comfortably in positive territory, with weak prices and a historically wide discount to gold continuing to exert a positive influence. Retail investors in Japan tend to buy into declining prices and to reduce their purchasing, and even sell back to the market, during periods of rising price. This was once again demonstrated in the first quarter of 2018: in January, a rise in the retail platinum price towards ¥4,000 per gram triggered significant profit-taking, but March saw the strongest buying in nearly eighteen months as the price dropped towards ¥3,500 and the discount to gold widened.

We estimate that net demand for investment bars in Japan exceeded 40,000 oz in the first quarter, and the second quarter should see a strong start: during early April, the yen platinum price continued to weaken and the discount to gold set a new all-time record of nearly ¥1,500 per gram. While price is the primary buying signal for Japanese investors, a



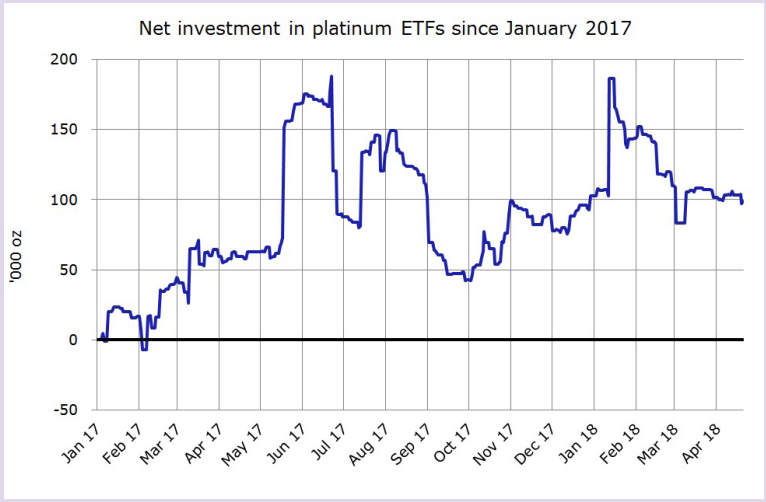
"Purchases of platinum bars by Japanese investors are forecast to decline this year, although demand should remain comfortably in positive territory."

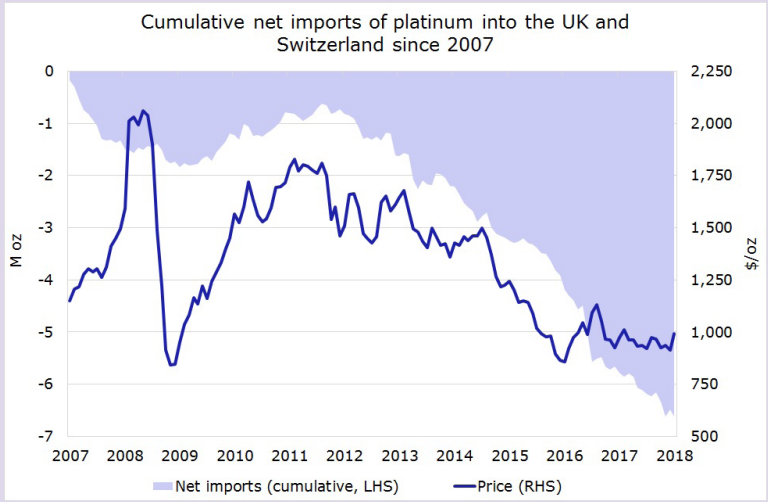
large discount to gold is seen as a sign that platinum offers particularly good value for money.

With dollar prices currently weak, it may be that there is limited scope for further declines in price, unless the yen appreciates significantly. Meanwhile, any recovery could trigger some profit-taking, leading us to be cautious in our forecast for Japanese investment bar demand for the full year. However, we expect demand to remain above 100,000 oz; in this market, profit-taking in response to price gains tends to be outweighed by purchasing into low prices, leading to a natural accumulation of metal over time.

ETF investment is also forecast to fall compared to 2017. During the first quarter, there was a return to modest buying in South Africa, as the rand strengthened and investors took advantage of weaker rand-denominated prices. European holdings also rose slightly, but US investors took profits in January and February as the price moved briefly above $1,000 per ounce. For the year as a whole, we are forecasting that ETF demand will remain weakly positive. We think that the prospect of significant profit-taking is limited while the price remains below $1,000, but there is currently little evidence of any significant resurgence in investor interest.

If we are correct in our expectations that investment demand will weaken in 2018, this will act to push the market further into surplus: we forecast that supplies will exceed demand by 316,000 oz. Our estimates of market stocks of platinum held in the UK and Switzerland show that the rate of depletion has slowed since the end of 2016, consistent with a market moving out of deficit, but we do not yet see any evidence that stocks are rising. It may be that the surplus platinum has moved into the hands of Asian buyers taking advantage of low prices to hold metal that can be supplied to consumers in due course.





"For the year as a whole, we forecast that ETF demand will remain weakly positive, but there is currently little evidence of any significant resurgence in investor interest."

"Our estimates of market stocks of platinum held in the UK and Switzerland show that the rate of depletion has slowed since the end of 2016, consistent with a market moving out of deficit."

Special Feature:

Fuel Cell Vehicles

It is not surprising that battery electric vehicles (BEVs) are the focus of so much media attention: although fewer than 1 million BEVs were sold last year, accounting for less than 1% of global light vehicle sales, this represented almost 50% growth on 2016 sales according to LMC Automotive, which anticipates a further 42% growth in BEV sales in 2018.

The recent flurry of announcements from automakers and policymakers on their plans for electrification are often interpreted in this context to mean a shift to BEVs only, but in fact the picture is much more nuanced than that. Hybrids also feature strongly in these plans, ranging from mild hybridisation of an otherwise conventional powertrain, through full hybrids to plug-in hybrids. These vehicles can offer substantial emissions reductions while still featuring internal combustion engines.

If zero tailpipe emissions are required, however, then the end-game is fully electric vehicles. But BEVs are not the only option here, of course: fuel cell vehicles (FCEVs) are also fully electric. With recent developments, particularly in China (discussed further below), FCEVs are becoming more prominent. And beyond passenger vehicles, fuel cells are increasingly seen as having a crucial role to play in the transition to clean forms of transportation.

Fuel Cell Passenger Cars

Like BEVs, FCEVs are classed as zero-emission vehicles, with the only tailpipe emission being water. This is produced by the fuel cell as it electrochemically combines hydrogen from the fuel tank with oxygen from the air intake, in the process generating an electric current to drive the motor. The process is catalysed by platinum, which lowers the operating temperature of the fuel cell. This is important in automotive applications, where the fuel cell must meet requirements for rapid start-up, frequent stop-start, and efficient operation under variable load.

The fuel cell is usually hybridised with a small traction battery pack to fulfil transient power demands, similar to the battery packs used on 'conventional' hybrid vehicles like the Prius. This arrangement is used in all the fuel cell cars on sale at the time of writing: the Toyota Mirai (thousands of which are now on the road), Honda's Clarity, and the

"Hydrogen refuelling infrastructure is being established in early markets for FCEVs in Europe, California, Japan, China and Korea."

A Toyota Mirai at a hydrogen refuelling station
(photo courtesy of ITM Power)

Hyundai ix35 Fuel Cell SUV, as well as its 2018 successor, the Nexo. A fuel cell can also work alongside an externally charged traction battery pack in a fuel cell plug-in hybrid vehicle, which is the configuration of the GLC F-Cell now in pre-production by Daimler.

So fuel cell vehicles are actually hybrid vehicles, with the fuel cell and hydrogen tank providing the same principal advantages that a conventional fuel tank and internal combustion engine (ICE) provide – rapid refuelling and long range – but without the attendant tailpipe CO_2 or pollutant emissions. This combination of the advantages of ICE and BEV is uniquely offered by FCEVs. But, with the driving range of BEVs increasing and fast-charging networks being rolled out, some commentators believe that any potential future market for FCEV is being eroded, even eliminated. A look at some of the underlying figures helps to illustrate why the picture that is emerging is more complex than a case of 'BEVs vs FCEVs'.

US Department of Energy (DOE) figures for the hydrogen refuelling stations operating in California show that FCEV refuelling rates currently average about 0.83 kg/min. Allowing for the energy lost as the fuel cell converts chemical energy to electricity, as well as other on-vehicle energy losses, this is equivalent to an electricity charging rate of over 700 kW – double that of ultra-fast BEV chargers. Improvements to refuelling technology are expected to increase the refuelling rate to the DOE's target of 1 kg/min, or the equivalent of around 850 kW. With tanks holding 5 or 6 kg of compressed hydrogen, FCEVs currently take around 6 or 7 minutes to fill from empty. A full tank gives these large passenger vehicles EPA-rated ranges in excess of 500 km, with the Honda Clarity and the Hyundai Nexo both achieving close to 600 km. This available range is retained throughout the vehicle lifetime and at low ambient temperatures.

As a result, many in the automotive industry anticipate that the future fleet will comprise a mix of BEVs and FCEVs, with BEVs the most practical and efficient option for segments where range and utilisation requirements are less taxing, and FCEVs catering to those market segments where long range and/or high rates of utilisation (requiring frequent and rapid refuelling) are desirable. The latter will be a key requirement for shared autonomous vehicles, for instance. It is thus no accident that most of the major OEMs are investing in both technologies. It is also why hydrogen refuelling infrastructure is being established in early markets for FCEVs in California, Europe, Japan, China and Korea – places which are also investing in charging networks for BEVs.

Heavy Vehicles

Electrification of heavy duty vehicles is challenging because of the large quantity of energy that has to be stored on the vehicle. The vehicles are heavy to begin with, requiring more energy to move than a smaller vehicle, and must of course be

"The fuel cell vehicle family is rapidly expanding to include several types of heavy vehicle."

The Nikola Two™ fuel cell electric semi-trailer truck
(photo courtesy of Nikola Motor Company)

able to carry cargo. Depending on application, many of these vehicles also cover long distances at high utilisation rates. This combination of load/weight, range, and utilisation makes it difficult to see how the heavy duty sector can be decarbonised without fuel cells and hydrogen.

While no practical, carbon-free energy carrier has yet been invented that matches the energy storage density of fossil fuels, compressed hydrogen comes the closest. The important metric here is marginal weight – how much weight is added to the vehicle for each additional kilowatt-hour of energy stored on-board? Energy can be added in the form of battery storage, but as the energy requirement rises, the additional weight of the battery has an increasing impact on the kerb weight of the vehicle (and eats into the weight allowance available for cargo). By comparison, the marginal weight of hydrogen to give the same number of additional kilowatt-hours is much lower, even with the weight of a larger hydrogen tank and the energy lost in conversion from hydrogen to electricity taken into account.

So, alongside the passenger cars and SUVs mentioned above, and the hydrogen-powered forklifts that have already realised commercial success in the USA, the fuel cell vehicle family is now rapidly expanding to include several types of heavy vehicle. We can expect to see the commercialisation of fuel cell buses, LDVs, trucks, trams, and trains in several markets around the world by 2030. But CO_2 regulation will not be the sole driver of these markets; as with fuel cell forklift trucks, the fuel cell variants are expected to address a market need and to compete on commercial terms with incumbent technology. Some may do so already, such as hydrogen trains for rail lines in Europe where electrification would cost too much and diesel locos are undesirable. In China, where a huge market for electric buses already exists, OEMs are developing fuel cell buses to address the need for longer range for both intra- and inter-urban routes.

Fuel Cell Vehicles in China

The Chinese Government's New Energy Vehicle programme, and the subsidies associated with it, have been very successful in stimulating the market for electric vehicles. Recent adjustments have sought to refocus the programme on quality rather than quantity, with the Government also cutting the mandated target for NEV annual production by 2020 (from 5 million to 2 million). Central Government subsidies are now awarded on a sliding scale, as a function of vehicle all-electric range. Subsidies for BEVs and PHEVs are also being reduced with a view to ultimately being phased out, while subsidies for FCEVs remain unchanged and, while not confirmed, are expected to continue beyond 2020. Far from China discovering fuel cells overnight, these changes are reflective of the country's stated industrial strategy. Fuel cell and hydrogen technology is named in both the 13th Five-Year Plan and the 'Made in China 2025' initiative.

"In China, where a huge market for electric buses already exists, OEMs are developing fuel cell buses to address the need for longer range."

One of Yutong's new fuel cell electric buses in China
(photo courtesy of Yutong)

The effect on the Chinese market has been profound. Domestic fuel cell and hydrogen R&D capability is growing rapidly, but the Chinese market is not waiting for home-grown technology. Chinese companies are forming partnerships with international fuel cell technology suppliers and significant investments are being made in fuel cell stack production capacity in China. A number of Chinese OEMs are working on fuel cell vehicle platforms, covering passenger vehicles, buses, LDVs, logistics trucks and trams – hundreds of vehicles are already being deployed. There are also local government initiatives: Rugao, Foshan, Suzhou, Taizhou, Yunfu and others have set up a 'Hydrogen Energy Town' project to promote the development of an integrated fuel cell and hydrogen industry.

A comprehensive Fuel Cell Vehicle Roadmap has been drawn up by SAE China (an English translation is available at: www.ieafuelcell.com). This envisions at least 50,000 fuel cell vehicles on the road by 2025, and 1 million by 2030. These numbers are ambitious, given the relative youth of the fuel cell vehicle industry in China, but all indications are that they should be taken seriously.

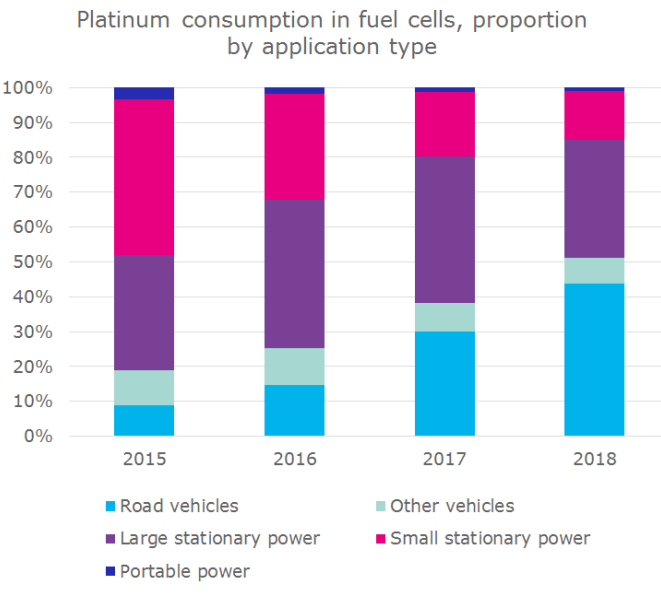
Implications for Platinum Demand

While estimated platinum consumption for fuel cell catalysts globally was less than 40,000 oz in 2017, with vehicles of all types accounting for about 40% of that, fuel cell vehicles are expected to be an important driver of future demand. Platinum is being significantly thrifted but there are currently no indications that it will be replaced in automotive fuel cell cathodes.

Economies of scale and established supply chains will be much stronger drivers of cost reduction: analysis commissioned by the US Department of Energy estimates that the cost of an automotive fuel cell system is likely to fall by around 75% through economies of scale alone, when scaling up production from around 1,000 systems to 500,000 systems per year.

Not many vehicles have to be deployed for demand to be significant. For the sake of illustration, if China has 50,000 fuel cell vehicles on its roads by 2025, and these contain on average, say, 20g of platinum each, this would be cumulative consumption of a tonne of platinum. Even at an average loading as low as 10g, a million vehicles would be a cumulative ten tonnes (320,000 oz), which is roughly 20% of the platinum that will be used on LDD vehicle catalysts in Europe this year.

The platinum is almost fully recoverable from the fuel cells once the vehicles are scrapped, but growth in demand will be driven by increasing penetration of FCEVs into the light and heavy vehicle fleets as we look towards 2030 and beyond. Many uncertainties remain, but we currently estimate that, globally, fuel cell vehicle platinum demand could reach the equivalent of 5% of autocatalyst demand in 2025.



"Growth in platinum demand will be driven by increasing penetration of FCEVs into the light and heavy vehicle fleets as we look to 2030 and beyond."

Palladium Summary

Supply and Demand in 2017

- The use of palladium in autocatalysts surged by around 450,000 oz in 2017 to a new all-time record of 8.39 million oz.
- Purchasing by chemicals producers was also at historical highs.
- With increased industrial consumption, and a fall in the rate of redemptions by ETF investors, total palladium demand rose by 8% to 10.08 million oz.
- There was significant growth in the recovery of palladium from scrapped autocatalysts.
- However, world mine supplies fell sharply, as some Russian production was held back from sale.
- This left combined primary and secondary shipments up marginally, in the face of strongly rising demand, and resulted in a widening in the market deficit to 801,000 oz.

Palladium Supply and Demand '000 oz

Supply	**2016**	**2017**	**2018**
South Africa	2,570	2,554	2,651
Russia	2,773	2,407	2,787
Others	1,417	1,410	1,442
Total Supply	**6,760**	**6,371**	**6,880**
Gross Demand			
Autocatalyst	7,941	8,391	8,565
Jewellery	191	173	167
Industrial	1,866	1,901	1,859
Investment	-646	-386	-373
Total Gross Demand	**9,352**	**10,079**	**10,218**
Recycling	-2,503	-2,907	-3,099
Total Net demand	**6,849**	**7,172**	**7,119**
Movements in Stocks	-89	-801	-239

World primary supplies of palladium fell by 6% to 6.37 million oz in 2017, reflecting sharply lower shipments from Russia. Data from Norilsk Nickel shows that the company's output of palladium from Russian feed rose by 7% to 2.73 million oz, while sales of Russian-source metal totalled around 2.4 million oz. We believe that the remaining metal was diverted to the company's Global Palladium Fund, which was set up with the aim of easing market shortages and guaranteeing metal availability for customers; the fund also purchases palladium from Russia's Central Bank and other market participants. For the purposes of our supply estimates, we have assumed that any Norilsk metal which was not sold last year will be supplied to the market over the 2018–2020 period.

This increase in output at Norilsk Nickel occurred despite a major reconfiguration of its processing flowsheet, involving the closure of the nickel smelter at the Norilsk mine site and the transfer of most nickel and pgm processing activities to the Kola peninsula. It is possible that this has resulted in some additional production from materials recovered during the decommissioning of production facilities at Norilsk. Output has also been supported by the processing of old copper concentrate, derived from mining activities in the Norilsk area during the Soviet era, and purchased from the state-controlled corporation Rostec. The refining of this material has helped compensate for a decline in the recovery of pgm from stored pyrrhotite concentrate, stocks of which have now been depleted.

Supplies of palladium from South Africa were stable in 2017, despite a new round of mine closures, and a number of maintenance outages and technical problems at processing plants. At Anglo Platinum's large open-cast operation, Mogalakwena, production of palladium in concentrate exceeded half a million ounces for the first time. Located on the northern limb of the Bushveld complex, this mine exploits the Platreef, which is unusual compared to other South

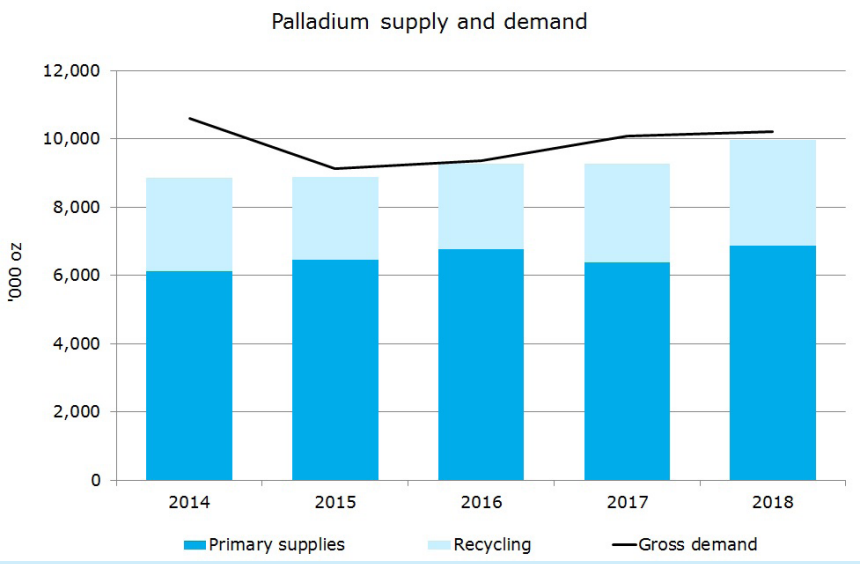
African ores in that it contains slightly more palladium than platinum. Output from Mogalakwena has risen by over 50% in the last five years, making it the single largest palladium-producing mine outside Russia.

North American palladium supplies were stable at 891,000 oz. Output from North American Palladium rose by over 30%, as underground production ramped up and the mill returned to full-time operation. However, reported pgm production from the two large Canadian nickel miners, Vale and Glencore, showed double-digit declines. This data is difficult to interpret in view of some changes in the route to market for producers in the region, but we think that there is an underlying negative trend in by-product palladium output from Canadian nickel mining: pgm grades in Sudbury ore are declining, as copper- and pgm-rich ore bodies that have been exploited during recent years are depleted. There were also changes to process flowsheets last year that resulted in the final refining of some palladium being delayed into 2018.

Secondary supplies of palladium surged in 2017, as scrap autocatalyst volumes rebounded following two years of weak activity in this sector, and the palladium content of scrap continued to rise. Globally, over 2.4 million oz of palladium was recovered from end-of-life vehicles last year, up by more than 20%. The fastest growth was seen in North America, the first region to make widespread use of palladium catalysts starting in the mid-1990s. Although emissions legislation was significantly less strict than today, palladium catalyst technology was also much less advanced, and palladium loadings were often extremely high by modern standards.

Despite growth in recycling, we now believe that combined primary and secondary supplies rose marginally in 2017, due to lower shipments from Norilsk Nickel. In contrast, demand climbed by 8%, or 726,000 oz, as autocatalyst consumption climbed to an all-time high and the rate of ETF redemptions decreased. Meanwhile, buoyant demand from the chemicals sector contributed to a firm picture for industrial offtake in 2017, despite continued thrifting and substitution in dental and electrical applications.

Consumption of palladium in autocatalysts rose by 6% to set a new record of just under 8.4 million oz – a remarkable gain considering relatively lacklustre vehicle production for the world's two largest palladium-consuming auto markets. Chinese output of gasoline (LDG) cars rose by only 1%, the slowest growth rate for at least ten years, while North American light duty gasoline production slumped by 9% as some automakers idled their plants in response to excess inventories. However, the impact of slowing vehicle volumes was easily outweighed by significant increases in the palladium content of gasoline catalyst systems in both regions.



"Despite growth in recycling, we now believe that combined primary and secondary supplies fell marginally in 2017, due to lower shipments from Norilsk Nickel."

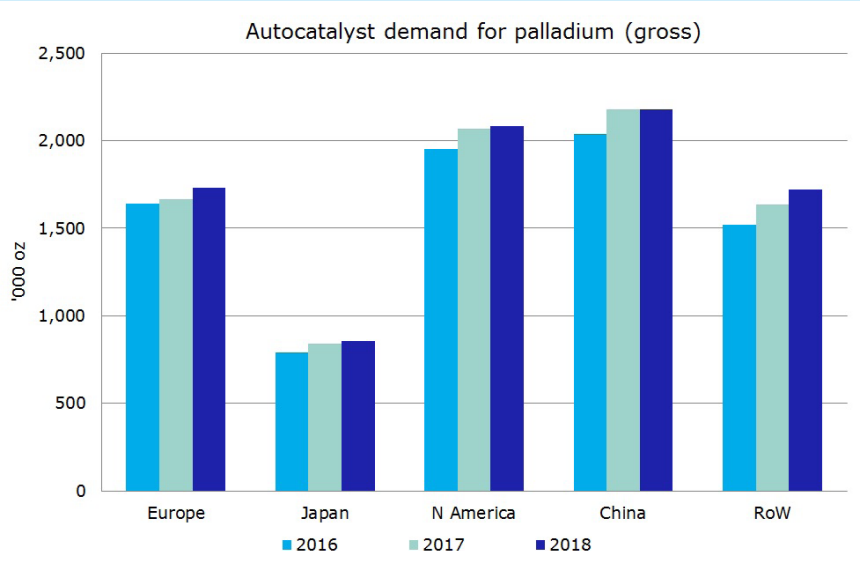
Palladium Demand: Autocatalyst '000 oz									
	Gross			Recycling			Net		
	2016	2017	2018	2016	2017	2018	2016	2017	2018
Europe	1,642	1,667	1,729	-424	-489	-500	1,218	1,178	1,229
Japan	792	842	855	-110	-123	-127	682	719	728
North America	1,950	2,069	2,082	-1,152	-1,422	-1,540	798	647	542
China	2,036	2,180	2,178	-75	-100	-130	1,961	2,080	2,048
Rest of World	1,521	1,633	1,721	-240	-270	-303	1,281	1,363	1,418
Total	**7,941**	**8,391**	**8,565**	**-2,001**	**-2,404**	**-2,600**	**5,940**	**5,987**	**5,965**

In North America, higher average loadings were associated with the implementation of US Tier 3 Federal emissions regulations, which began in 2017. Under this legislation, automakers are able to certify their vehicles to a range of different benchmarks, or 'bins', as long as they comply with fleet average emissions limits that become progressively tighter each year to 2025. An increase in the number of vehicles equipped with heavily-loaded catalyst systems capable of meeting the 2025 SULEV30 target has already had a significant impact on palladium requirements.

US emissions limits are identical for both diesel and gasoline vehicles, so the light duty diesel sector also saw growth in pgm loadings as Tier 3 standards began to take effect. This was magnified by a trend towards heavier vehicles, especially in the light truck and SUV segment in which diesel engines typically find use. This was extremely positive for palladium, because the technical specifics of US legislation have enabled US automakers to increase the palladium content of their diesel systems at the expense of platinum. In 2017 we estimate that the platinum:palladium ratio on diesel cars in this region approached 1:1, compared to over 3:1 in other light duty diesel markets.

Overall, the use of palladium on North American vehicles rose by 6% to 2.07 million oz. Nevertheless, the Chinese market retained its position as the world's largest consumer of palladium in autocatalysts, with demand up 7% to 2.18 million oz. Since light duty gasoline vehicle output rose by only 1%, this gain was primarily a result of an increase in palladium loadings, following the nationwide implementation of China 5 emissions limits for gasoline vehicles starting in January 2017.

Elsewhere, European palladium consumption rose by 2% to 1.67 million oz, reflecting stronger gasoline vehicle output and stable catalyst loadings. In the Rest of World region, demand was up by 7% to 1.6 million oz, primarily in response to



"The Chinese market retained its position as the world's largest consumer of palladium in autocatalysts, with demand up 7% in 2017."

Palladium Demand: Industrial '000 oz			
	2016	**2017**	**2018**
Chemical	414	529	497
Dental	430	398	381
Electrical	871	840	828
Other	151	134	153
Total	**1,866**	**1,901**	**1,859**

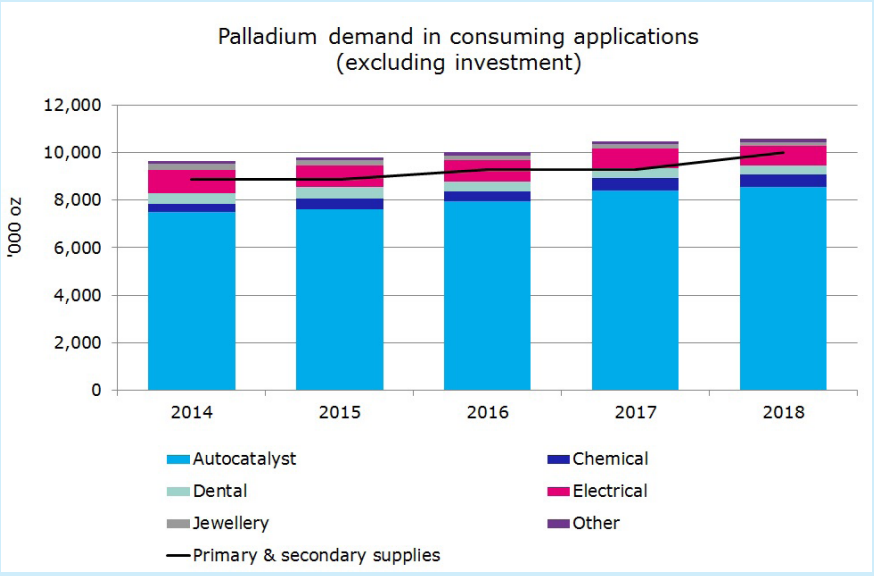
improving vehicle production in some major markets. Output of light duty gasoline vehicles in Mexico jumped by 12% to a new record of over 3.5 million units, and this was accompanied by an increase in palladium loadings on vehicles for export to the USA. South American vehicle volumes also climbed at double-digit rates, while there was a strong recovery in the Russian car market, but in both these countries output remains well below the peaks of 2011 and 2012.

Demand for palladium in industrial applications increased by 2% to just over 1.9 million oz in 2017, despite continued thrifting and substitution in the electronics and dental industries. Consumption by the electronics industry, mainly in multi-layer ceramic capacitors (MLCC), peaked in the 1990s at over 2.5 million oz a year but has been on a downward trend ever since; it dropped a further 4% to 840,000 oz last year. Base metals have replaced palladium for most end-uses, with palladium-containing MLCC now largely confined to military, medical and some specialist automotive applications. The dental sector is also seeing the gradual replacement of palladium with other materials, mainly ceramics and resins.

These declines were offset by a surge in palladium purchasing by the chemicals industry, up 28% to over 500,000 oz. Demand was robust in all regions, and at record levels in China. Like platinum, the palladium process catalyst sector is benefiting from Chinese government policy aimed at improving self-sufficiency in key chemical feedstocks.

Last year saw exceptionally strong investment in new monoethylene glycol (MEG) facilities in China, using a process known as 'coal to MEG' (CTMEG). MEG is usually produced from oil using a non-pgm catalyst; however, because China has abundant coal supplies but is a net oil importer, it has invested heavily in CTMEG plants, which require a palladium catalyst. Demand for this application was particularly strong in 2017, while palladium consumption was also boosted by the addition of new hydrogen peroxide capacity, and investment in production of caprolactam using the hydroxylamine phosphate oxime process.

The investment sector saw continued heavy liquidation of ETF holdings, even though the volume of redemptions – at 376,000 oz – was over 40% lower than in 2016. The first half of last year was dominated by activity in the European funds, as investors took advantage of rising prices to take profits: during this six-month period, over 230,000 oz of palladium was redeemed from European ETFs and there was also some minor liquidation in the US and South Africa. In contrast, the third quarter saw large net buying in South Africa, as investors

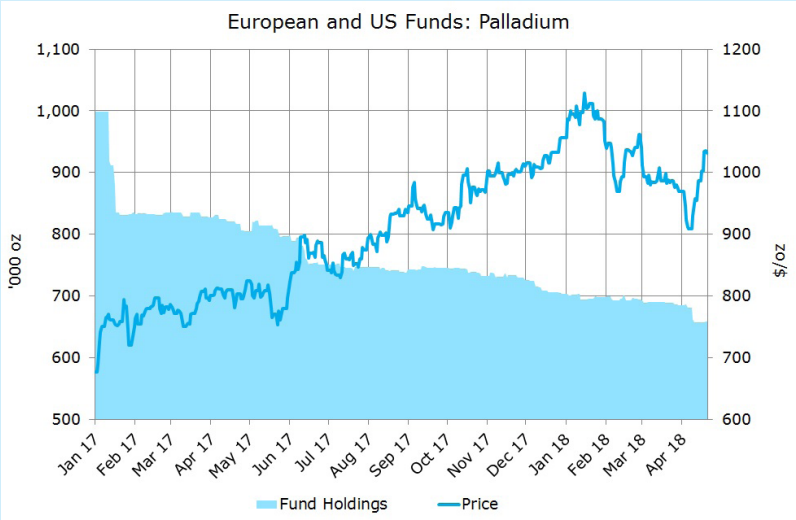


"Demand for palladium in 'consuming applications' (excluding investment) has set a series of annual records."

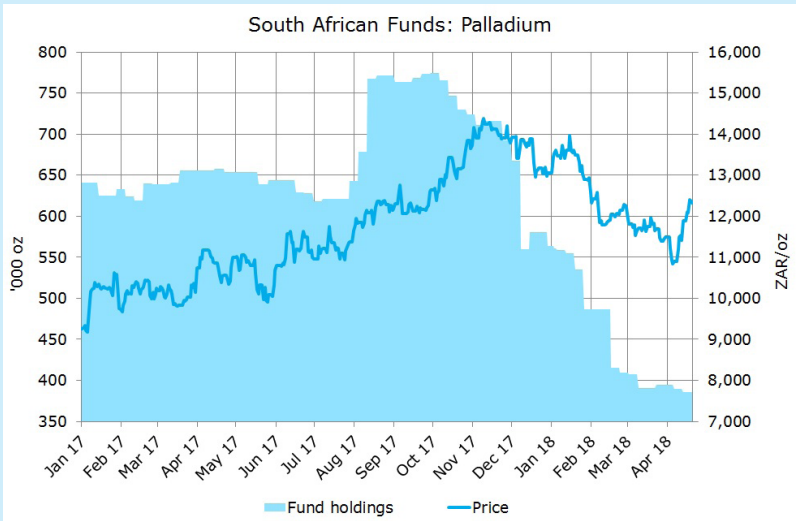
added over 150,000 oz to their holdings. As the year ended, and the rand-denominated palladium price set a series of all-time highs, this was abruptly reversed in a bout of heavy profit-taking. During the final quarter of 2017, South African holdings were reduced by over 200,000 oz, of which over 150,000 oz was sold in a two-week period in late November and early December. At the year end, worldwide palladium holdings totalled under 1.3 million oz, less than half 2014's peak of nearly 3 million oz.

Most physical palladium investment occurs in the form of ETFs, but small quantities of palladium coins are produced by national mints. Last year the US Mint issued a palladium version of its Eagle coin for the first time, but this new demand was partly offset by the return of some old palladium coins and small bars to the market by investors cashing in as palladium prices approached record levels.

Over the past three years, investors have returned nearly 1.7 million oz of palladium to the market, providing additional liquidity at a time when primary supply has been lacklustre and demand in 'consuming' applications has set successive annual records. However, in 2017 the persistent market deficits of the last six years began to have a significant impact on the market: the palladium price climbed steadily from under $700 per ounce in January, overtaking the platinum price in September, and reaching $1,050 at the year end. Its premium over platinum widened during the final quarter, approaching $150 during December. Traders reported periodic difficulties in sourcing ingot, and this tightness was reflected in lease rates, which spiked over 12% in mid-year. Although availability improved slightly in the second half of 2017, the market remained tight, with lease rates consistently above 5%.



"The first half of 2017 was dominated by activity in the European funds, as investors took advantage of rising prices to take profits."



"South African investors added over 150,000 oz to their holdings in the third quarter of 2017. However, the very end of 2017 and first two months of 2018 saw heavy liquidation."

Palladium Outlook

Supply and Demand in 2018

- This year could see a temporary move back towards balance for the palladium market, if we are correct in our forecast that some primary metal held back from sale last year will be supplied to consumers during 2018.
- We also anticipate that investment demand will remain deeply in negative territory, with liquidation at similar levels to last year.
- Recoveries of palladium from autocatalyst scrap will rise again.
- These developments will significantly outweigh a modest increase in purchasing by automakers, and will result in a narrowing of the supply shortfall to just under 240,000 oz.

After a renewed physical squeeze on the market in early 2018, which saw short-term lease rates rise above 10% and the price over $1,100, liquidity in the market improved during February and March, and palladium fell back towards $900 at the beginning of April. Investor confidence was damaged by the possibility that a US–China trade war could lead to lower global economic growth: this led to extremely heavy selling on the futures markets for much of the first quarter, with the net speculative position on NYMEX falling from 2.8 million oz in January to just under 1 million oz in early April.

There was also further selling of ETFs: during the first quarter, nearly 200,000 oz of palladium was returned to the market via ETF liquidation, mainly in South Africa. Our expectation of a much reduced market deficit in 2018 is predicated on the assumption that investors in all regions will continue to exploit profit-taking opportunities as they arise, and that the ETF sector will therefore see heavy disinvestment for a fourth consecutive year.

However, with total palladium ETF holdings totalling under 1.1 million oz at the end of March 2018, it is clear that ETF redemptions cannot continue to supplement market liquidity indefinitely. It is difficult to predict when the turning point for palladium investment might come: on the one hand, geopolitical risks to trade are negative for demand for industrial metals, and therefore for investor sentiment, but on the other hand, the geographical concentration of palladium supply makes it particularly susceptible to any possible disruption to trade in commodities. Concerns about the security of Russian supplies contributed to gains in the palladium price during mid-April.

Assuming there are no disruptions to world trade or interruptions to mining or processing, both primary and secondary supplies of palladium should rise compared to 2017. The refining of in-process inventories in South Africa will boost shipments, while we assume that Russian metal held back last year will be used to supplement sales over the 2018–2020 period. Thus, we think that Russian supplies are likely to rise in 2018, even though output from Norilsk Nickel could fall slightly, based on the company's latest production outlook. It should also be a positive year for North American producers: Stillwater's Blitz expansion will deliver significant quantities of metal for the first time, while North American Palladium plans to raise output from its Lac des Iles underground mine by 15–20% this year. Overall, primary supplies could rise by as much as 8%.

We also expect shipments of secondary metal to increase. Recoveries of palladium from automotive scrap are forecast to rise by a further 8%, in the wake of last year's 20% gain, and to reach an all-time high of nearly 2.6 million oz. This is based on our expectation that volumes of catalyst scrap will grow again, as the market bounces back from a period of weak activity during 2015–2016, while the palladium content of scrap will continue to rise in line with historic trends in palladium loadings. In total, we predict that

combined primary and secondary supplies will rise by 8% to just under 10 million oz, falling just short of gross demand, which we expect to rise 1% to 10.22 million oz.

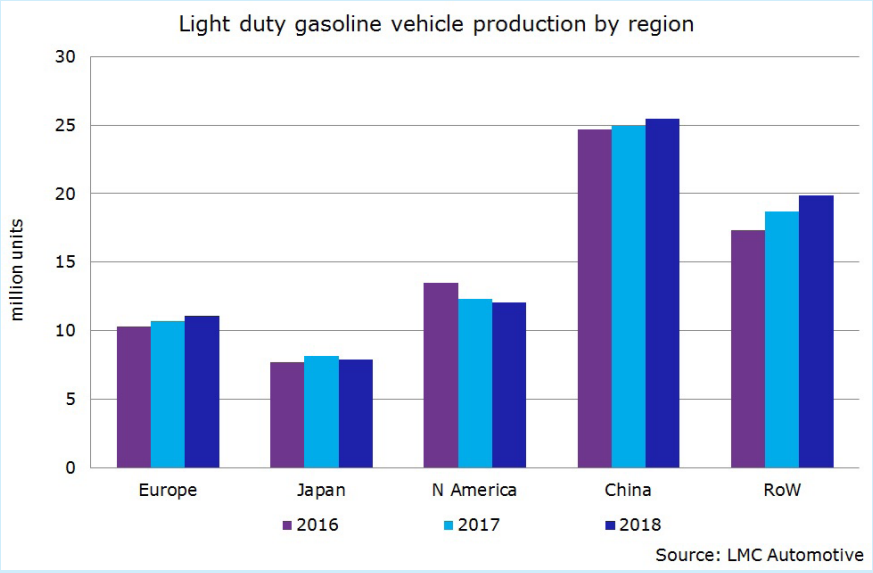
This year's narrowing in the deficit is expected to be temporary. Legislative changes are already driving autocatalyst palladium loadings higher in Europe, North America and Japan, and we now expect the implementation of new regulations in China to be brought forward, with some cities and provinces choosing to skip the China 6a stage and to enforce China 6b emissions limits as early as 2019. This will result in a step-change in global average palladium loadings between now and 2020.

Automotive demand for palladium is predicted to grow by around 2% in 2018, setting a new all-time high of 8.57 million oz. This growth is in line with forecast trends in light duty gasoline vehicle output. We expect little change in the global average palladium content of a gasoline catalyst system: slight gains in European, North American and Japanese loadings will be balanced by some minor thrifting in China.

In Europe, the implementation of tighter particle number limits under Euro 6c and the introduction of RDE testing under Euro 6d-TEMP and Euro 6d will be positive for palladium loadings on gasoline vehicles, although the impact on demand will be small in 2018. Euro 6c legislation imposes a mandatory particle number (PN) limit for gasoline direct injection (GDI) engines, in addition to existing particulate mass (PM) standards which are expressed in grams per kilometre. Starting in September 2018, Euro 6d-TEMP rules require all new cars to meet a particle number conformity factor of 1.5 during Real Driving Emissions (RDE) testing, while the NOx conformity factor of 2.1 will apply to all passenger vehicles from September 2019. By January 2021, under Euro 6d, all new cars will have to meet a conformity factor of 1.5 for both pollutants. Together, these changes will result in gasoline emissions control becoming significantly more challenging, and is expected to increase both the complexity and the pgm content of aftertreatment systems.

A change in test cycles for Japanese vehicles will also have a small positive influence on loadings this year. The WLTC testing regime, which will replace the JC08 cycle from October 2018, involves a cold start and a shorter warm-up period, meaning that catalysts will be required to convert pollutants in a colder exhaust gas stream. Higher palladium loadings can accelerate catalyst 'light off' under these conditions.

In North America, we expect increases in loadings to be slight in 2018, after last year's significant rise. The phase-in of Federal Tier 3 emissions standards will continue to exert upward pressure on loadings over the next few years, while a trend towards higher vehicle weights is also positive for palladium demand.



"Automotive demand for palladium is forecast to set a new all-time high in 2018, in line with forecast trends in light duty gasoline vehicle output."

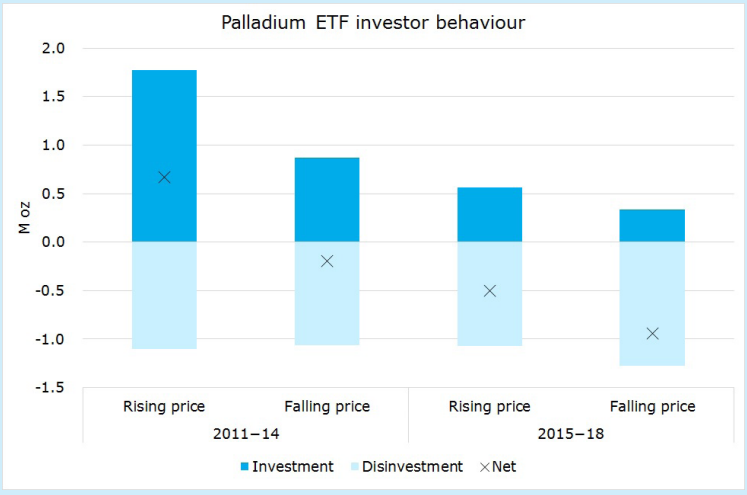
Loadings on Chinese vehicles could fall slightly this year, as automakers begin to thrift the palladium content of China 5 catalysts now that this legislation has been implemented nationwide. This will offset modest growth in vehicle output, leaving palladium demand flat.

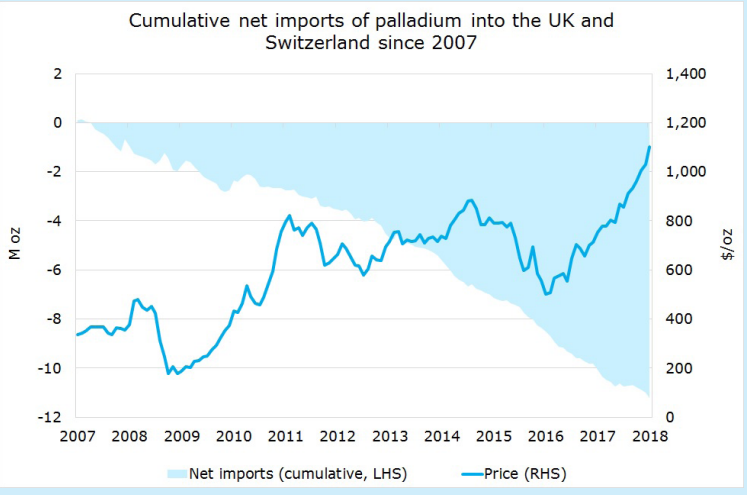
However, the prospect of significant growth in Chinese loadings has moved closer: it appears increasingly likely that some cities and provinces will skip the China 6a stage of legislation and mandate a direct move to China 6b emissions standards, in some cases from as early as 2019. If this happens, some car manufacturers may prefer to adopt China 6b for their entire fleet rather than certifying vehicles to different standards.

While pgm loadings on vehicles certified to China 6a standards will be only modestly higher than for China 5, we expect China 6b-compliant aftertreatment systems to require significantly more pgm. At present, it seems that where China 6b regulations are introduced early, the RDE component will not, initially, be enforced (the rollout of RDE requirements is currently slated for July 2023). Should early RDE compliance be imposed, this could have an even greater impact on loadings.

Demand for palladium in industrial applications is forecast to fall by 2% this year. Purchasing by the chemicals sector will remain at elevated levels, but is expected to fall slightly short of last year's total. There will also be continued thrifting and substitution in dental and electronics applications.

While our headline estimates of supply and demand in 2018 suggest that the market could move close to balance, palladium consumption continues to run significantly ahead of supply. Removing producer stock movements and ETF disinvestment from our figures would put the market in a shortage of over 700,000 oz. Analysis of trade data remains supportive of the view that the market overhang created by Russian government sales in the 1990s and early 2000s is being rapidly consumed: we estimate that in the 2012–2017 period, nearly 7.5 million oz of palladium was withdrawn from inventories in the UK and Switzerland.





"Since 2015, the steep rise in the palladium price has seen profit-taking in the largest funds almost regardless of the price environment."

"We estimate that in the 2012–2017 period, nearly 7.5 million oz of palladium was withdrawn from inventories in the UK and Switzerland."

Rhodium Summary

Supply and Demand in 2017

- The rhodium market moved into balance in 2017.
- An increase in demand outstripped growth in recycling, and primary supplies fell due to lower Russian output and some stock-building in South Africa.
- Demand for rhodium from the auto sector rose by 4%, reflecting modest growth in global output of gasoline vehicles, and some increases in catalyst loadings, especially in North America.
- Consumption in the chemical and glass sectors was also buoyant.
- However, investment demand turned negative.
- Market liquidity was reduced by speculative and strategic purchasing, and the rhodium price doubled during 2017 to a six-year high of over $1,700/oz.

Rhodium Supply and Demand '000 oz

Supply	**2016**	**2017**	**2018**
South Africa	615	612	626
Russia	85	68	70
Others	73	69	67
Total Supply	**773**	**749**	**763**
Gross Demand			
Autocatalyst	822	852	860
Other	191	209	166
Total Gross Demand	**1,013**	**1,061**	**1,026**
Recycling	-271	-309	-331
Total Net demand	**742**	**752**	**695**
Movements in Stocks	31	-3	68

Primary supplies of rhodium fell by 3% in 2017. We estimate that underlying mine output in South Africa rose slightly, but this was offset by net increases in producer stocks, both in the form of semi-processed pipeline inventories and as refined metal. As a result, overall South African supplies declined marginally. Meanwhile, Russian rhodium supplies fell sharply: we believe that output at Norilsk Nickel has declined following the depletion of stocks of stored pyrrhotite concentrate, which the company has been reprocessing over the last few years, and which were relatively rich in rhodium. While the company continues to supplement mined pgm production with the treatment of above-ground materials, notably stocks of old copper concentrate purchased from Rostec in December 2016, it appears that these contain only small amounts of rhodium.

Secondary supplies, almost entirely from autocatalyst scrap, rose by 14% last year. This was a smaller gain than we had anticipated in our February 2018 report, and was also lower than the rate of increase in palladium recycling. This may reflect the rhodium thrifting which occurred from the mid-2000s; in many cases, thrifting was achieved at the expense of increased palladium loadings.

Gross rhodium demand expanded by 5% to an all-time-record 1.06 million oz, almost exactly matching combined primary and secondary supplies, and leaving the market in balance. The auto sector remained the primary driver of demand growth, with global light duty vehicle output up 2% and increases in rhodium loadings in some major markets.

In North America, gasoline car production fell by 9%, but this was outweighed by a sharp increase in rhodium loadings as US Tier 3 emissions legislation began to take effect. This legislation is unusual in that it enables automakers to certify vehicles to a range of different standards, as long as they comply with fleet average emissions limits that tighten progressively between 2017 and 2025. There has already been a significant increase in the number of vehicles

equipped with heavily-loaded catalyst systems meeting the 2025 SULEV30 target, and this has had a marked impact on the average rhodium content of US vehicles.

Chinese rhodium loadings also increased, as China 5 emissions legislation was enforced nationwide. China remains by far the largest single rhodium-consuming auto market, and this position was reinforced last year, with a 6% increase in consumption. Elsewhere, Rest of Word demand also posted strong gains, primarily due to higher car output in Mexico, South America and Russia.

Demand for rhodium in industrial applications rose by 9% in 2017, reflecting robust consumption by the chemical industry, and exceptionally large purchasing by the glass sector, where significant quantities of rhodium were required for LCD and fibreglass capacity expansions in China and the Rest of World region. However, this was partly offset by negative investment demand (included in 'other' applications), as holders of ETFs took advantage of the steep rise in rhodium prices in order to take profits.

The market moved into balance in 2017, after two years of surpluses. Availability of rhodium tightened significantly during the year, to a much greater extent than our fundamental supply and demand numbers might suggest. We believe that this was due to an increase in speculative and strategic purchasing of rhodium, especially in Asia. We do not count this in our demand figures, as it cannot be attributed to a specific industry, and occurred outside measurable investment media. Because the rhodium market is relatively small and illiquid, this purchasing had a very significant impact on prices, which more than doubled during 2017, reaching a six-year peak of $1,715 per ounce at the year end.

Rhodium Demand: Industrial '000 oz

	2016	2017	2018
Chemical	64	74	64
Electrical	3	3	3
Glass	85	112	91
Other	39	20	8
Total	**191**	**209**	**166**

"Availability of rhodium tightened significantly during the year, and this had a significant impact on the price, which reached yet a new peak of over $2,100 in April 2018."

Rhodium Outlook

Supply and Demand in 2018

- Combined primary and secondary shipments of rhodium are forecast to rise by 3% in 2018.
- This is based on further growth in autocatalyst recycling, and assuming that South African producers sell all their production this year.
- Some refiners ended last year with pipeline stocks above normal levels, and the processing of this metal should add to output in 2018.
- In contrast, demand is predicted to contract, as modestly higher automotive consumption is offset by lower purchasing by glass and chemicals companies (who bought unusually large quantities of metal in 2017).
- Our numbers also allow for further profit-taking by holders of rhodium ETFs.
- As a result, we see the market moving back into surplus in 2018, although this will not necessarily be reflected in market liquidity if additional speculative and strategic purchasing occurs.

Demand for rhodium in autocatalysts is forecast to rise by 1% in 2018. Modest increases in the average rhodium content of gasoline cars sold in Europe, Japan and North America will be offset by slight thrifting in China; overall, we expect the use of rhodium in the light duty gasoline sector to rise in line with a predicted 2% gain in global car output. However, demand from the light duty diesel sector is predicted to fall by nearly a third, reflecting lower diesel production in Europe, along with a significant shift away from the use of lean NOx traps for NOx control.

Beyond 2018, we expect to see an upward trend in global rhodium loadings, as legislation tightens in most major automotive markets. European automakers are predicted to increase rhodium loadings to comply with real driving emissions (RDE) testing under Euro 6d-TEMP and Euro 6d legislation, which will be phased in between now and January 2022. Under Tier 3 Federal regulations, US fleet emissions limits will fall steadily over the period to 2025, while China is entering a period of major legislative change, with China 6a and 6b emission standards scheduled to be phased in over the 2020–2023 period. Some cities and provinces are expected to move directly to the stricter 6b limits (although initially without the RDE component), and this will have a significant impact on average rhodium loadings in the coming years.

Consumption of rhodium in other applications will fall steeply in 2018, after heavy buying by chemical and glass manufacturers last year. This reduction is not reflective of weaker underlying conditions in either industry, but is primarily related to the timing of purchases for capacity expansions. We also expect further profit-taking by ETF investors; this is included in our forecast for demand in 'other' applications.

While total demand for rhodium is expected to retreat by 3% this year, the prospect of future increases in automotive demand may stimulate further speculative and strategic buying. If this should occur, rhodium availability could remain tight, even though our supply–demand estimates suggest that the market is likely to move back into surplus in 2018.

Ruthenium and Iridium

Summary of 2017 and Outlook for 2018

- Ruthenium and iridium prices rose strongly during 2017, in response to firm demand and strategic purchasing in Asia.
- Consumption of ruthenium in chemicals applications was exceptionally strong last year, and will rise again in 2018, reflecting significant investment in caprolactam and adipic acid capacity.
- Iridium saw good demand in 2016–2017 for crucibles from the electrical sector, and for the coating of anodes in the electrochemical sector; however, we expect consumption to fall this year.

Ruthenium Demand: Industrial '000 oz			
	2016	**2017**	**2018**
Chemical	384	468	537
Electrical	433	408	425
Electrochemical	188	210	202
Other	155	168	186
Total	**1,160**	**1,254**	**1,350**

Iridium Demand: Industrial '000 oz			
	2016	**2017**	**2018**
Chemical	23	23	23
Electrical	112	88	69
Electrochemical	58	88	57
Other	81	75	82
Total	**274**	**274**	**231**

Rhodium was not the only minor pgm to see dramatic price movements in 2017: the ruthenium price more than quadrupled, from $40 per ounce at the beginning of the year to $190 in December, while iridium gained more than 40% to reach $970/oz.

We estimate that ruthenium consumption rose by 8% to 1.26 million oz in 2017, with very strong demand from the Chinese chemicals industry, mainly for the manufacture of caprolactam and adipic acid (feedstocks for nylon 6 and nylon 66). In other regions, some of the process steps used to make these chemicals may involve a nickel or palladium catalyst, but ruthenium is not usually required. However, the Chinese caprolactam and adipic acid industry has adopted a different process route involving a ruthenium catalyst. Rising domestic demand has stimulated massive investment in nylon feedstock capacity in China, with the result that ruthenium demand in this segment grew by two thirds in 2017.

Ruthenium use in electrochemical applications was also strong, despite an increase in the recycling of electrodes used in chlor-alkali production. In recent years, the ruthenium price has been too low to permit the recovery of metal from spent electrodes, but price gains during 2017 have made recycling more cost-effective. However, much of the ruthenium is lost from the electrodes during use, so only a small proportion of the original metal can be recovered.

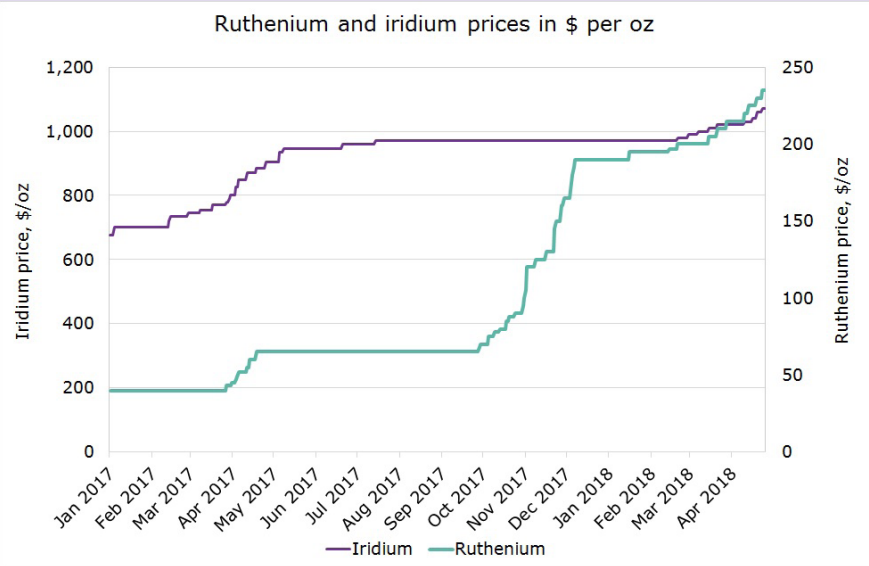
Iridium consumption was flat in 2017: there was significant purchasing for the re-coating of anodes used in electrowinning by some base metal producers, but this was offset by lower demand for iridium in crucibles, used in the electronics industry to manufacture single crystals.

In the last two years, demand for both iridium and ruthenium has exceeded mine output, but sales from producer stocks

have helped to keep the markets supplied. We believe that unusually large amounts of iridium were shipped in 2016 and of ruthenium in 2017, but some of this metal has been absorbed by significant strategic purchasing in Asia, which is not included in our demand numbers.

Ruthenium is expected to see another year of strong demand growth in 2018, with purchasing by the Chinese caprolactam and adipic acid expected to rise by a further 25% in 2018. This year has also seen unusually strong demand for ruthenium in highly specialised alloys used in aerospace and machining applications. However, iridium consumption is expected to fall, due to reduced purchasing by the electrochemical sector following an unusually strong year in 2017, and lower investment by the electrical industry in crucibles used in the manufacture of single crystals.

Mine production of iridium should be sufficient to satisfy demand this year, assuming that producers do not experience any disruption to processing activities, and they sell all their output. However, iridium is a very small and illiquid market where modest increases in demand, or fluctuations in supply, can have a significant impact on availability. In contrast, mine output of ruthenium will again fall significantly short of consumption. Despite recent selling from stocks, we believe that producers have some remaining ruthenium inventory, which we assume will be mobilised to help meet demand.



"The ruthenium price more than quadrupled last year, and reached a seven-year peak of $235 per ounce in April 2018. Iridium also made strong gains, to a six-year high of $1,070."

Platinum Supply & Demand

Troy ounces

PLATINUM '000 oz - Supply and Demand							
							2018 numbers are a forecast
		2013	2014	2015	2016	2017	2018
Supply[1]	South Africa	4,208	3,546	4,572	4,392	4,459	4,410
	Russia[2]	736	700	670	717	692	662
	North America	318	339	314	337	336	337
	Zimbabwe[3]	410	401	400	489	466	480
	Others[3]	174	167	151	162	159	165
	Total Supply	**5,846**	**5,153**	**6,107**	**6,097**	**6,112**	**6,054**
Demand[4]	Autocatalyst[4]	2,937	3,060	3,232	3,330	3,292	3,184
	Chemical	522	576	502	475	504	551
	Electrical[4]	219	225	228	230	234	262
	Glass	102	143	227	246	364	346
	Investment	871	277	451	620	356	245
	Jewellery[4]	2,984	2,839	2,746	2,412	2,296	2,258
	Medical and Biomedical[5]	217	214	215	218	220	223
	Petroleum	146	172	140	176	220	202
	Other	419	434	441	458	476	496
	Total Gross Demand	**8,417**	**7,940**	**8,182**	**8,165**	**7,962**	**7,767**
Recycling[6]	Autocatalyst	-1,199	-1,280	-1,112	-1,159	-1,279	-1,384
	Electrical	-24	-27	-29	-32	-34	-36
	Jewellery	-790	-762	-574	-738	-638	-609
	Total Recycling	**-2,013**	**-2,069**	**-1,715**	**-1,929**	**-1,951**	**-2,029**
Total Net Demand[7]		**6,404**	**5,871**	**6,467**	**6,236**	**6,011**	**5,738**
Movement in Stocks[8]		**-558**	**-718**	**-360**	**-139**	**101**	**316**

Platinum Gross Demand by Region

Troy ounces

PLATINUM '000 oz - Gross Demand by Region

2018 numbers are a forecast

		2013	2014	2015	2016	2017	2018
Europe	Autocatalyst	1,280	1,475	1,671	1,825	1,776	1,649
	Chemical	98	111	120	122	121	123
	Electrical	15	12	13	13	14	14
	Glass	7	11	11	11	11	11
	Investment	-40	-73	-88	109	36	90
	Jewellery	217	204	203	177	176	177
	Medical and Biomedical	74	72	71	71	70	70
	Petroleum	-12	22	-4	4	14	25
	Other	106	108	105	107	110	113
	Total	**1,745**	**1,942**	**2,102**	**2,439**	**2,328**	**2,272**
Japan	Autocatalyst	503	448	395	391	387	370
	Chemical	42	41	43	41	40	42
	Electrical	27	31	33	32	31	35
	Glass	-20	-96	4	2	25	6
	Investment	-40	19	700	543	171	140
	Jewellery	310	313	314	310	309	306
	Medical and Biomedical	19	16	16	16	16	16
	Petroleum	-1	3	3	3	2	2
	Other	70	71	79	74	74	76
	Total	**910**	**846**	**1,587**	**1,412**	**1,055**	**993**
N. America	Autocatalyst	339	356	368	344	320	350
	Chemical	102	113	114	103	113	113
	Electrical	19	18	22	26	32	39
	Glass	7	10	10	29	45	17
	Investment	57	7	-32	109	127	-5
	Jewellery	213	218	227	220	238	239
	Medical and Biomedical	85	85	85	86	87	88
	Petroleum	23	21	40	37	18	18
	Other	122	125	116	121	122	123
	Total	**967**	**953**	**950**	**1,075**	**1,102**	**982**
China	Autocatalyst	130	130	136	145	161	156
	Chemical	133	155	131	121	125	140
	Electrical	36	39	38	39	41	48
	Glass	93	144	178	134	161	237
	Investment	0	0	0	0	0	0
	Jewellery	2,100	1,935	1,796	1,510	1,358	1,290
	Medical and Biomedical	17	18	19	19	20	21
	Petroleum	56	30	32	61	105	93
	Other	48	53	58	71	79	87
	Total	**2,613**	**2,504**	**2,388**	**2,100**	**2,050**	**2,072**
RoW	Autocatalyst	685	651	662	625	648	659
	Chemical	147	156	94	88	105	133
	Electrical	122	125	122	120	116	126
	Glass	15	74	24	70	122	75
	Investment	894	324	-129	-141	22	20
	Jewellery	144	169	206	195	215	246
	Medical and Biomedical	22	23	24	26	27	28
	Petroleum	80	96	69	71	81	64
	Other	73	77	83	85	91	97
	Total	**2,182**	**1,695**	**1,155**	**1,139**	**1,427**	**1,448**
	Grand total	**8,417**	**7,940**	**8,182**	**8,165**	**7,962**	**7,767**

Platinum Supply & Demand

Tonnes

PLATINUM Tonnes - Supply and Demand							
							2018 numbers are a forecast
		2013	2014	2015	2016	2017	2018
Supply[1]	South Africa	130.9	110.3	142.2	136.6	138.7	137.2
	Russia[2]	22.9	21.8	20.8	22.3	21.5	20.6
	North America	9.9	10.5	9.8	10.5	10.5	10.5
	Zimbabwe[3]	12.7	12.5	12.4	15.2	14.5	14.9
	Others[3]	5.4	5.2	4.7	5.0	4.9	5.1
	Total Supply	**181.8**	**160.3**	**189.9**	**189.6**	**190.1**	**188.3**
Demand[4]	Autocatalyst[4]	91.2	95.1	100.6	103.6	102.4	99.1
	Chemical	16.3	18.0	15.5	14.8	15.7	17.1
	Electrical[4]	6.8	7.1	7.1	7.1	7.3	8.1
	Glass	3.2	4.4	6.9	7.7	11.3	10.7
	Investment	27.2	8.6	14.1	19.3	11.1	7.6
	Jewellery[4]	92.8	88.3	85.5	75.0	71.4	70.2
	Medical and Biomedical[5]	6.7	6.6	6.6	6.8	6.8	7.0
	Petroleum	4.5	5.4	4.4	5.5	6.9	6.4
	Other	13.1	13.5	13.8	14.2	14.8	15.4
	Total Gross Demand	**261.8**	**247.0**	**254.5**	**254.0**	**247.7**	**241.6**
Recycling[6]	Autocatalyst	-37.3	-39.9	-34.5	-36.1	-39.9	-43.0
	Electrical	-0.7	-0.8	-0.9	-1.0	-1.0	-1.2
	Jewellery	-24.6	-23.7	-17.9	-23.0	-19.8	-18.9
	Total Recycling	**-62.6**	**-64.4**	**-53.3**	**-60.1**	**-60.7**	**-63.1**
Total Net Demand[7]		**199.2**	**182.6**	**201.2**	**193.9**	**187.0**	**178.5**
Movement in Stocks[8]		**-17.4**	**-22.3**	**-11.3**	**-4.3**	**3.1**	**9.8**

Platinum Gross Demand by Region

Tonnes

PLATINUM Tonnes - Gross Demand by Region

2018 numbers are a forecast

		2013	2014	2015	2016	2017	2018
Europe	Autocatalyst	39.8	45.9	52.0	56.8	55.2	51.3
	Chemical	3.0	3.5	3.7	3.8	3.8	3.8
	Electrical	0.5	0.4	0.4	0.4	0.4	0.4
	Glass	0.2	0.3	0.3	0.3	0.3	0.3
	Investment	-1.2	-2.3	-2.7	3.4	1.1	2.8
	Jewellery	6.8	6.3	6.3	5.5	5.5	5.5
	Medical and Biomedical	2.3	2.2	2.2	2.2	2.2	2.2
	Petroleum	-0.4	0.7	-0.1	0.1	0.4	0.8
	Other	3.3	3.4	3.3	3.3	3.4	3.5
	Total	**54.3**	**60.4**	**65.4**	**75.8**	**72.3**	**70.6**
Japan	Autocatalyst	15.6	13.9	12.3	12.2	12.0	11.5
	Chemical	1.3	1.3	1.3	1.3	1.2	1.3
	Electrical	0.8	1.0	1.0	1.0	1.0	1.1
	Glass	-0.6	-3.0	0.1	0.1	0.8	0.2
	Investment	-1.2	0.6	21.8	16.9	5.3	4.4
	Jewellery	9.6	9.7	9.8	9.6	9.6	9.5
	Medical and Biomedical	0.6	0.5	0.5	0.5	0.5	0.5
	Petroleum	0.0	0.1	0.1	0.1	0.1	0.1
	Other	2.2	2.2	2.5	2.3	2.3	2.4
	Total	**28.3**	**26.3**	**49.4**	**44.0**	**32.8**	**31.0**
N. America	Autocatalyst	10.5	11.1	11.5	10.7	10.0	10.9
	Chemical	3.2	3.5	3.5	3.2	3.5	3.5
	Electrical	0.6	0.6	0.7	0.8	1.0	1.2
	Glass	0.2	0.3	0.3	0.9	1.4	0.5
	Investment	1.8	0.2	-1.0	3.4	4.0	-0.2
	Jewellery	6.6	6.8	7.1	6.8	7.4	7.4
	Medical and Biomedical	2.6	2.6	2.6	2.7	2.7	2.7
	Petroleum	0.7	0.7	1.2	1.2	0.6	0.6
	Other	3.8	3.9	3.6	3.8	3.8	3.8
	Total	**30.0**	**29.7**	**29.5**	**33.5**	**34.4**	**30.4**
China	Autocatalyst	4.0	4.0	4.2	4.5	5.0	4.9
	Chemical	4.2	4.8	4.1	3.8	3.9	4.4
	Electrical	1.1	1.2	1.2	1.2	1.3	1.5
	Glass	2.9	4.5	5.5	4.2	5.0	7.4
	Investment	0.0	0.0	0.0	0.0	0.0	0.0
	Jewellery	65.3	60.2	55.9	47.0	42.2	40.1
	Medical and Biomedical	0.5	0.6	0.6	0.6	0.6	0.7
	Petroleum	1.7	0.9	1.0	1.9	3.3	2.9
	Other	1.5	1.6	1.8	2.2	2.5	2.7
	Total	**81.2**	**77.8**	**74.3**	**65.4**	**63.8**	**64.6**
RoW	Autocatalyst	21.3	20.2	20.6	19.4	20.2	20.5
	Chemical	4.6	4.9	2.9	2.7	3.3	4.1
	Electrical	3.8	3.9	3.8	3.7	3.6	3.9
	Glass	0.5	2.3	0.7	2.2	3.8	2.3
	Investment	27.8	10.1	-4.0	-4.4	0.7	0.6
	Jewellery	4.5	5.3	6.4	6.1	6.7	7.7
	Medical and Biomedical	0.7	0.7	0.7	0.8	0.8	0.9
	Petroleum	2.5	3.0	2.2	2.2	2.5	2.0
	Other	2.3	2.4	2.6	2.6	2.8	3.0
	Total	**68.0**	**52.8**	**35.9**	**35.3**	**44.4**	**45.0**
	Grand total	**261.8**	**247.0**	**254.5**	**254.0**	**247.7**	**241.6**

Palladium Supply & Demand

Troy ounces

PALLADIUM '000 oz - Supply and Demand							
							2018 numbers are a forecast
		2013	2014	2015	2016	2017	2018
Supply[1]	South Africa	2,464	2,126	2,683	2,570	2,554	2,651
	Russia[2]	2,628	2,589	2,434	2,773	2,407	2,787
	North America	831	912	874	892	891	930
	Zimbabwe[3]	322	327	320	396	386	379
	Others[3]	152	160	144	129	133	133
	Total Supply	**6,397**	**6,114**	**6,455**	**6,760**	**6,371**	**6,880**
Demand[4]	Autocatalyst[4]	7,069	7,515	7,622	7,941	8,391	8,565
	Chemical	378	315	451	414	529	497
	Dental	457	464	468	430	398	381
	Electrical[4]	1,017	970	903	871	840	828
	Investment	-8	943	-659	-646	-386	-373
	Jewellery[4]	354	272	222	191	173	167
	Other	109	111	134	151	134	153
	Total Gross Demand	**9,376**	**10,590**	**9,141**	**9,352**	**10,079**	**10,218**
Recycling[6]	Autocatalyst	-1,899	-2,185	-1,897	-2,001	-2,404	-2,600
	Electrical	-463	-474	-475	-481	-482	-482
	Jewellery	-157	-89	-46	-21	-21	-17
	Total Recycling	**-2,519**	**-2,748**	**-2,418**	**-2,503**	**-2,907**	**-3,099**
Total Net Demand[7]		**6,857**	**7,842**	**6,723**	**6,849**	**7,172**	**7,119**
Movement in Stocks[8]		**-460**	**-1,728**	**-268**	**-89**	**-801**	**-239**

Palladium Gross Demand by Region

Troy ounces

PALLADIUM '000 oz - Gross Demand by Region

						2018 numbers are	forecast
		2013	2014	2015	2016	2017	2018
Europe	Autocatalyst	1,502	1,583	1,613	1,642	1,667	1,729
	Chemical	71	-23	77	80	82	84
	Dental	80	77	70	66	60	53
	Electrical	112	113	101	99	95	93
	Investment	-14	-74	-200	-269	-287	-105
	Jewellery	61	60	59	58	55	55
	Other	24	25	27	22	22	32
	Total	**1,836**	**1,761**	**1,747**	**1,698**	**1,694**	**1,941**
Japan	Autocatalyst	782	794	760	792	842	855
	Chemical	18	16	15	15	15	15
	Dental	184	205	227	200	182	179
	Electrical	220	212	231	227	221	217
	Investment	-4	-2	4	-3	-3	-3
	Jewellery	70	67	66	64	57	55
	Other	9	9	9	9	9	9
	Total	**1,279**	**1,301**	**1,312**	**1,304**	**1,323**	**1,327**
N. America	Autocatalyst	1,770	1,963	2,032	1,950	2,069	2,082
	Chemical	68	71	76	76	78	81
	Dental	168	156	145	138	130	123
	Electrical	159	140	131	128	124	121
	Investment	10	-205	-181	-71	-19	-15
	Jewellery	43	44	41	38	33	33
	Other	43	43	60	46	44	44
	Total	**2,261**	**2,212**	**2,304**	**2,305**	**2,459**	**2,469**
China	Autocatalyst	1,499	1,608	1,654	2,036	2,180	2,178
	Chemical	144	160	208	164	260	216
	Dental	8	8	8	7	7	7
	Electrical	168	170	158	156	155	155
	Investment	0	0	0	0	0	0
	Jewellery	155	78	34	10	9	5
	Other	15	16	17	41	44	48
	Total	**1,989**	**2,040**	**2,079**	**2,414**	**2,655**	**2,609**
RoW	Autocatalyst	1,516	1,567	1,563	1,521	1,633	1,721
	Chemical	77	91	75	79	94	101
	Dental	17	18	18	19	19	19
	Electrical	358	335	282	261	245	242
	Investment	0	1,224	-282	-303	-77	-250
	Jewellery	25	23	22	21	19	19
	Other	18	18	21	33	15	20
	Total	**2,011**	**3,276**	**1,699**	**1,631**	**1,948**	**1,872**
	Grand total	**9,376**	**10,590**	**9,141**	**9,352**	**10,079**	**10,218**

Palladium Supply & Demand

Tonnes

PALLADIUM Tonnes - Supply and Demand							
						2018 numbers are	forecast
		2013	2014	2015	2016	2017	2018
Supply[1]	South Africa	76.6	66.1	83.4	79.9	79.4	82.5
	Russia[2]	81.7	80.5	75.7	86.3	74.9	86.7
	North America	25.9	28.4	27.2	27.7	27.7	28.9
	Zimbabwe[3]	10.0	10.2	10.0	12.3	12.0	11.8
	Others[3]	4.7	5.0	4.5	4.0	4.1	4.1
	Total Supply	**198.9**	**190.2**	**200.8**	**210.2**	**198.1**	**214.0**
Demand[4]	Autocatalyst[4]	219.9	233.7	237.0	247.0	261.0	266.4
	Chemical	11.8	9.8	14.1	12.9	16.4	15.4
	Dental	14.1	14.5	14.6	13.4	12.4	11.9
	Electrical[4]	31.5	30.2	28.1	27.1	26.0	25.7
	Investment	-0.2	29.3	-20.5	-20.1	-12.0	-11.6
	Jewellery[4]	11.0	8.5	6.9	6.0	5.4	5.2
	Other	3.4	3.5	4.2	4.7	4.3	4.8
	Total Gross Demand	**291.5**	**329.5**	**284.4**	**291.0**	**313.5**	**317.8**
Recycling[6]	Autocatalyst	-59.1	-68.0	-59.0	-62.2	-74.7	-80.9
	Electrical	-14.4	-14.8	-14.8	-15.0	-15.1	-15.0
	Jewellery	-4.9	-2.7	-1.4	-0.7	-0.6	-0.5
	Total Recycling	**-78.4**	**-85.5**	**-75.2**	**-77.9**	**-90.4**	**-96.4**
Total Net Demand[7]		**213.1**	**244.0**	**209.2**	**213.1**	**223.1**	**221.4**
Movement in Stocks[8]		**-14.2**	**-53.8**	**-8.4**	**-2.9**	**-25.0**	**-7.4**

Palladium Gross Demand by Region

Tonnes

PALLADIUM Tonnes - Gross Demand by Region

						2018 numbers are	forecast
		2013	2014	2015	2016	2017	2018
Europe	Autocatalyst	46.7	49.2	50.2	51.1	51.8	53.8
	Chemical	2.2	-0.7	2.4	2.5	2.5	2.6
	Dental	2.5	2.4	2.2	2.1	1.9	1.7
	Electrical	3.5	3.5	3.1	3.0	2.9	2.9
	Investment	-0.4	-2.3	-6.2	-8.4	-8.9	-3.3
	Jewellery	1.9	1.9	1.8	1.8	1.7	1.7
	Other	0.7	0.8	0.8	0.7	0.7	1.0
	Total	**57.1**	**54.8**	**54.3**	**52.8**	**52.6**	**60.4**
Japan	Autocatalyst	24.3	24.7	23.6	24.6	26.2	26.6
	Chemical	0.6	0.5	0.5	0.5	0.5	0.5
	Dental	5.7	6.4	7.1	6.2	5.7	5.6
	Electrical	6.8	6.6	7.2	7.1	6.9	6.7
	Investment	-0.1	-0.1	0.1	-0.1	-0.1	-0.1
	Jewellery	2.2	2.1	2.0	2.0	1.8	1.7
	Other	0.3	0.3	0.3	0.3	0.3	0.3
	Total	**39.8**	**40.5**	**40.8**	**40.6**	**41.3**	**41.3**
N. America	Autocatalyst	55.1	61.1	63.2	60.7	64.4	64.8
	Chemical	2.1	2.2	2.4	2.4	2.4	2.5
	Dental	5.2	4.9	4.5	4.3	4.0	3.8
	Electrical	4.9	4.4	4.1	4.0	3.8	3.8
	Investment	0.3	-6.4	-5.6	-2.2	-0.6	-0.5
	Jewellery	1.3	1.4	1.3	1.2	1.0	1.0
	Other	1.3	1.3	1.9	1.4	1.4	1.4
	Total	**70.2**	**68.9**	**71.8**	**71.8**	**76.4**	**76.8**
China	Autocatalyst	46.6	50.0	51.4	63.3	67.8	67.7
	Chemical	4.5	5.0	6.5	5.1	8.1	6.7
	Dental	0.2	0.2	0.2	0.2	0.2	0.2
	Electrical	5.2	5.3	4.9	4.9	4.8	4.8
	Investment	0.0	0.0	0.0	0.0	0.0	0.0
	Jewellery	4.8	2.4	1.1	0.3	0.3	0.2
	Other	0.5	0.5	0.5	1.3	1.4	1.5
	Total	**61.8**	**63.4**	**64.6**	**75.1**	**82.6**	**81.1**
RoW	Autocatalyst	47.2	48.7	48.6	47.3	50.8	53.5
	Chemical	2.4	2.8	2.3	2.4	2.9	3.1
	Dental	0.5	0.6	0.6	0.6	0.6	0.6
	Electrical	11.1	10.4	8.8	8.1	7.6	7.5
	Investment	0.0	38.1	-8.8	-9.4	-2.4	-7.7
	Jewellery	0.8	0.7	0.7	0.7	0.6	0.6
	Other	0.6	0.6	0.7	1.0	0.5	0.6
	Total	**62.6**	**101.9**	**52.9**	**50.7**	**60.6**	**58.2**
	Grand total	**291.5**	**329.5**	**284.4**	**291.0**	**313.5**	**317.8**

Rhodium Supply & Demand

Troy ounces

RHODIUM '000 oz - Supply and Demand							
							2018 numbers are a forecast
		2013	2014	2015	2016	2017	2018
Supply[1]	South Africa	554	470	611	615	612	626
	Russia[2]	80	80	80	85	68	70
	North America	23	24	22	24	22	22
	Zimbabwe[3]	36	36	36	44	42	40
	Others[3]	8	7	5	5	5	5
	Total Supply	**701**	**617**	**754**	**773**	**749**	**763**
Demand[4]	Autocatalyst[4]	753	769	762	822	852	860
	Chemical	79	90	73	64	74	64
	Electrical	5	3	3	3	3	3
	Glass	47	49	52	85	112	91
	Other	87	38	30	39	20	8
	Total Gross Demand	**971**	**949**	**920**	**1,013**	**1,061**	**1,026**
Recycling[6]	Autocatalyst	-281	-306	-262	-271	-309	-331
	Total Recycling	**-281**	**-306**	**-262**	**-271**	**-309**	**-331**
Total Net Demand[7]		**690**	**643**	**658**	**742**	**752**	**695**
Movement in Stocks[8]		**11**	**-26**	**96**	**31**	**-3**	**68**

Rhodium Supply & Demand

Tonnes

RHODIUM Tonnes - Supply and Demand							
							2018 numbers are a forecast
		2013	2014	2015	2016	2017	2018
Supply[1]	South Africa	17.2	14.6	19.0	19.1	19.0	19.5
	Russia[2]	2.5	2.5	2.5	2.6	2.1	2.2
	North America	0.7	0.7	0.7	0.7	0.7	0.7
	Zimbabwe[3]	1.1	1.1	1.1	1.4	1.3	1.2
	Others[3]	0.2	0.2	0.2	0.2	0.2	0.2
	Total Supply	**21.7**	**19.1**	**23.5**	**24.0**	**23.3**	**23.8**
Demand[4]	Autocatalyst[4]	23.4	23.8	23.7	25.5	26.5	26.8
	Chemical	2.5	2.9	2.3	2.0	2.3	2.0
	Electrical	0.0	0.0	0.0	0.0	0.0	0.0
	Glass	1.4	1.5	1.7	2.6	3.5	2.8
	Other	2.8	1.2	1.0	1.3	0.7	0.4
	Total Gross Demand	**30.1**	**29.4**	**28.7**	**31.4**	**33.0**	**32.0**
Recycling[6]	Autocatalyst	-8.7	-9.5	-8.2	-8.4	-9.6	-10.3
	Total Recycling	**-8.7**	**-9.5**	**-8.2**	**-8.4**	**-9.6**	**-10.3**
Total Net Demand[7]		**21.4**	**19.9**	**20.5**	**23.0**	**23.4**	**21.7**
Movement in Stocks[8]		**0.3**	**-0.8**	**3.0**	**1.0**	**-0.1**	**2.1**

Ruthenium Demand

Troy ounces and tonnes

RUTHENIUM '000 oz - Demand							
							2018 numbers are a forecast
		2013	2014	2015	2016	2017	2018
Demand	Chemical	321	332	444	384	468	537
	Electrical	336	360	457	433	408	425
	Electrochemical	145	136	151	188	210	202
	Other	105	108	149	155	168	186
	Total Demand	**907**	**936**	**1,201**	**1,160**	**1,254**	**1,350**

RUTHENIUM Tonnes - Demand							
							2018 numbers are a forecast
		2013	2014	2015	2016	2017	2018
Demand	Chemical	10.0	10.3	13.8	11.9	14.6	16.7
	Electrical	10.5	11.2	14.2	13.5	12.7	13.2
	Electrochemical	4.5	4.2	4.7	5.8	6.5	6.3
	Other	3.3	3.4	4.6	4.8	5.2	5.8
	Total Demand	**28.3**	**29.1**	**37.3**	**36.0**	**39.0**	**42.0**

Iridium Demand

Troy ounces and tonnes

IRIDIUM '000 oz - Demand							
							2018 numbers are a forecast
		2013	2014	2015	2016	2017	2018
Demand	Chemical	21	22	22	23	23	23
	Electrical	35	49	89	112	88	69
	Electrochemical	41	39	41	58	88	57
	Other	68	71	76	81	75	82
	Total Demand	**165**	**181**	**228**	**274**	**274**	**231**

IRIDIUM Tonnes - Demand							
							2018 numbers are a forecast
		2013	2014	2015	2016	2017	2018
Demand	Chemical	0.7	0.7	0.7	0.7	0.7	0.7
	Electrical	1.1	1.5	2.8	3.5	2.7	2.1
	Electrochemical	1.3	1.2	1.3	1.8	2.8	1.8
	Other	2.1	2.2	2.4	2.5	2.3	2.5
	Total Demand	**5.2**	**5.6**	**7.2**	**8.5**	**8.5**	**7.1**

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 sold in all regions, including Russia and the CIS. Demand in Russia and the CIS 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.

[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, allocated to where the car was first registered, rather than where the metal is finally recovered. 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.

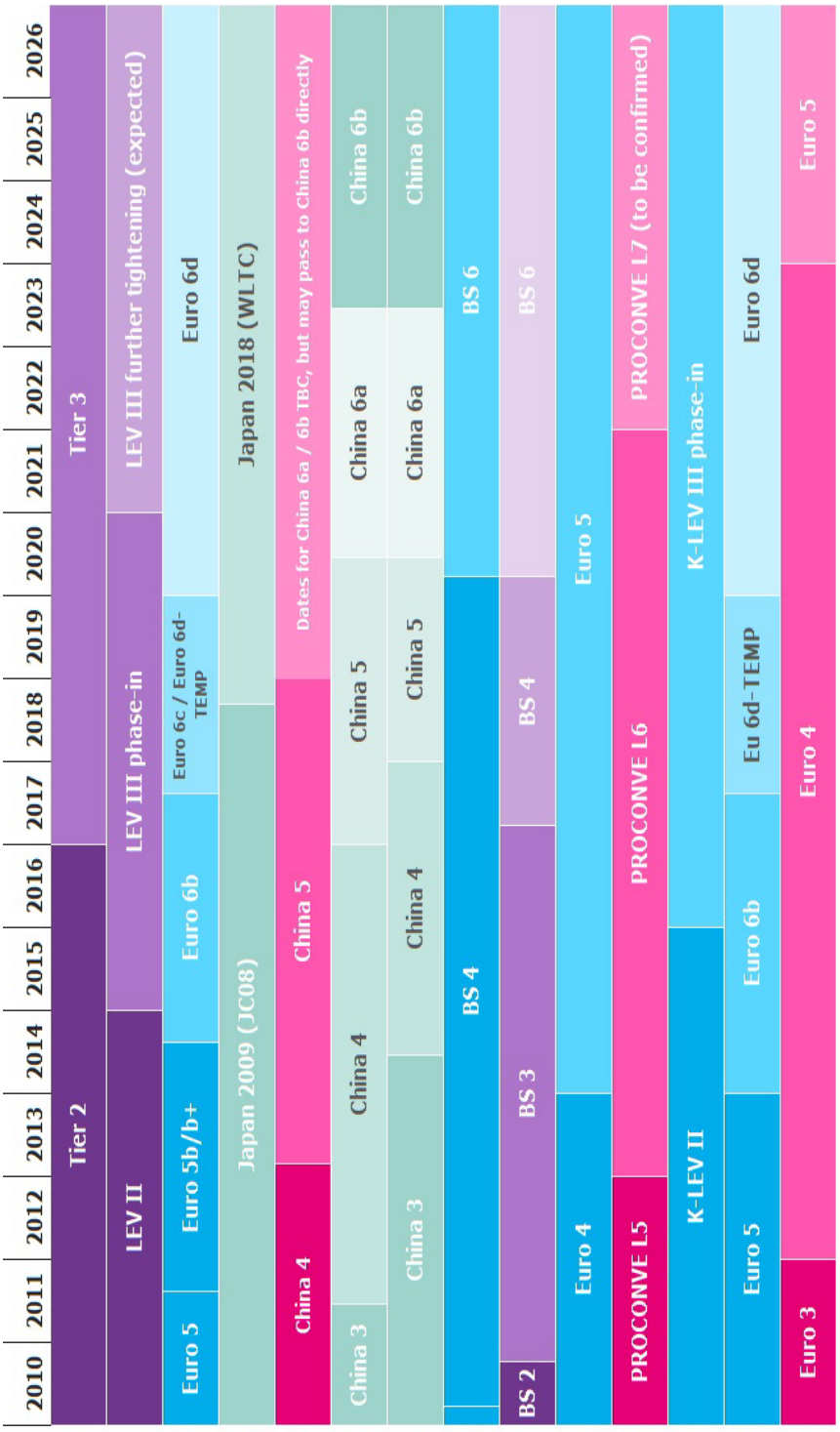
[8]Movements in stocks in any given year reflect changes in stocks held by fabricators, dealers, banks and depositories but excluding stocks held by primary refiners and final consumers. A positive figure (sometimes referred to as a 'surplus') reflects an increase in market stocks. A negative value (or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

Glossary

ASC	Ammonia slip catalyst
CF	Conformity factor
CO	Carbon monoxide
CO_2	Carbon dioxide
DOC	Diesel oxidation catalyst
DPF	Diesel particulate filter
EEC	European Economic Community
ELV	End-of-life vehicle
ETF	Exchange traded fund
FCEV	Fuel cell electric vehicle
GPF	Gasoline particulate filter
HC	Hydrocarbon
HDD	Heavy duty diesel
LAB	Linear alkyl benzene
LDG	Light duty gasoline
LDD	Light duty diesel
LEV	Low emission vehicle
LNT	Lean NOx trap
NOx	Oxides of nitrogen
NO	Nitrogen monoxide
NO_2	Nitrogen dioxide
NRMM	Non-road mobile machinery
NYMEX	New York Mercantile Exchange
PM	Particulate matter or soot
PN	Particle number
PNA	Passive NOx adsorber
ppm	Parts per million
PTA	Purified terephthalic acid
PX	Paraxylene
RDE	Real driving emissions
RoW	Rest of world region
SCR	Selective catalytic reduction
SGE	Shanghai Gold Exchange
SUV	Sports utility vehicle

Emissions Legislation

Light Duty

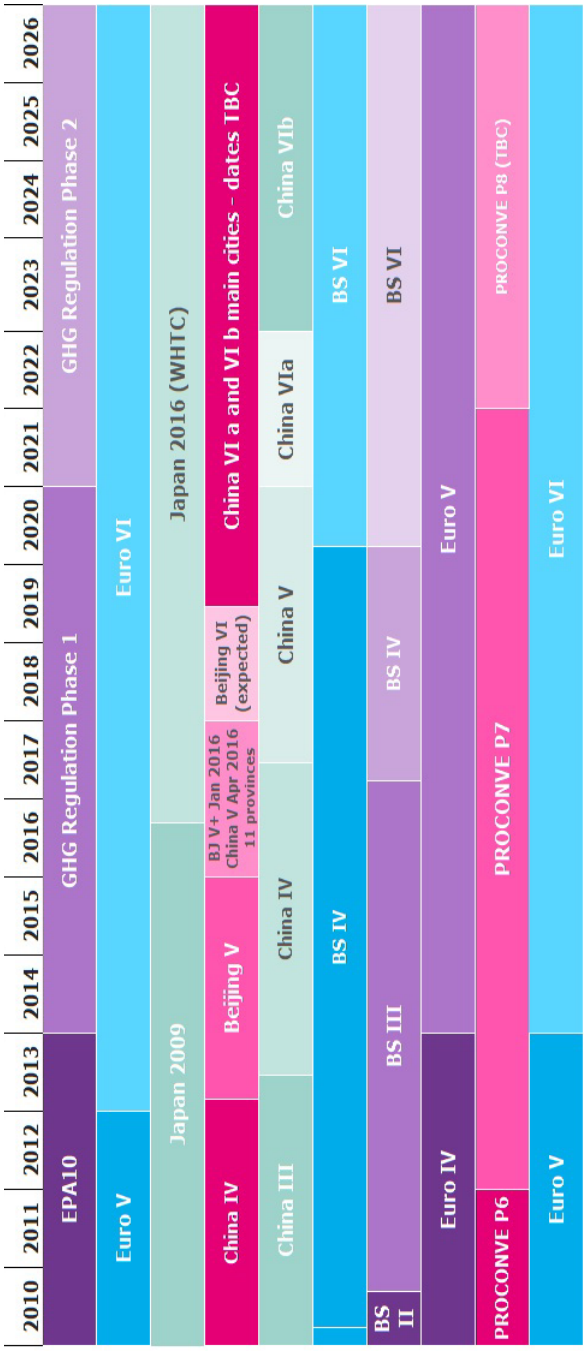


Dates shown are for New Vehicle Type Approvals for passenger cars.

China dates subject to frequent change; dates shown represent best available current view.

Emissions Legislation

Heavy Duty Diesel



China dates subject to frequent change; dates shown represent best available current view.

JM

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