PGM MARKET REPORT NOVEMBER 2016

Forecast of Platinum SUPPLY & DEMAND IN 2016

FORECAST: PLATINUM

- Lower mine supply and strong investment demand will keep the market in significant deficit in 2016.
- Weak steel prices continue to depress growth in recoveries from automotive scrap.
- Higher auto and industrial consumption will offset a fall in sales to jewellery makers.
- Chinese jewellery demand will be hit by store closures and competition from carat gold.
- Japanese demand for platinum bars remains unusually high, outweighing further ETF redemptions.

The platinum market will remain in deficit in 2016, despite a significant deterioration in platinum purchasing by Chinese jewellery fabricators. We expect world jewellery demand to fall by 9% this year, but this will be offset by growth in consumption on European diesel vehicles and in Asian chemicals and glass plants, and strong purchasing of platinum bars by Japanese investors. On the supply side, a modest improvement in recoveries of platinum from automotive and jewellery scrap will be balanced by a 2% fall in mine shipments.

The last two years have seen a large Eastward transfer of market stocks of platinum. Between January 2015 and mid-October 2016, we estimate that over 1 million oz of platinum was acquired by Japanese private investors, who purchase metal in the form of bars typically weighing between 50 and 500 grams. During this period, falls in the dollar platinum price were magnified by yen appreciation, resulting in a very significant decline in the Japanese retail price of platinum: from over ¥5,000 per gram in early 2015 to lows of around ¥3,500 per gram in January and October 2016. At the same time, platinum also moved to a substantial discount to gold, reinforcing perceptions of value-for-money among Japanese investors.

This large physical buying has had little impact on availability or prices of platinum on the global market, partly because it has occurred during a period when Western investors have been liquidating their physical platinum holdings: between January 2015 and mid-October 2016, ETF investors in Europe, North America and South Africa sold over 400,000 oz of platinum. Prices have been more influenced by activity on the futures markets, with a rising trend over the first eight months of 2016 corresponding with a near tripling of the net long position on NYMEX to over 3 million oz in August, while a subsequent fall in platinum prices was associated with a collapse in the NYMEX net long position to just 1.5 million oz by mid-October.

It is worth noting that investors in Japan are not the only Asian buyers taking advantage of low platinum prices: there have also been reports of stock-building in China. However, this Chinese buying cannot be attributed with certainty to any single demand sector, so we do not include it in our estimates of investment or industrial demand, but treat it instead as a movement in market stocks. It is likely that this buying is strategic in nature, and is driven by fundamental considerations, including the weak outlook for supply.

Primary supplies of platinum are expected to fall this year, due to a predicted 5% drop in shipments from South Africa, where some of the large western Bushveld operations are likely to report a sharp drop in underlying mine output. In addition, we expect destocking by producers to decline.

As we noted in our previous report, South African producers drew heavily upon refined and pipeline inventories in 2014–2015, during which period

Platinum Supply and Demand '000 oz			
Supply	**2014**	**2015**	**2016**
South Africa	3,547	4,571	4,347
Russia	700	670	652
Others	896	868	1,008
Total Supply	**5,143**	**6,109**	**6,007**
Gross Demand			
Autocatalyst	3,120	3,267	3,318
Jewellery	2,897	2,829	2,572
Industrial	1,776	1,749	1,954
Investment	277	451	487
Total Gross Demand	**8,070**	**8,296**	**8,331**
Recycling	-2,071	-1,730	-1,902
Total Net Demand	**5,999**	**6,566**	**6,429**
Movements in Stocks	-856	-457	-422

Johnson Matthey
Precious Metals Management

"Underlying mine production in South Africa will show a moderate decline this year."

we estimate that around 650,000 oz of platinum were supplied from stocks. Available inventories are now largely depleted and, going forward, the industry will have less flexibility to compensate for any fluctuations in underlying output. We do still expect some modest destocking during 2016, but at a much reduced rate compared with the past two years.

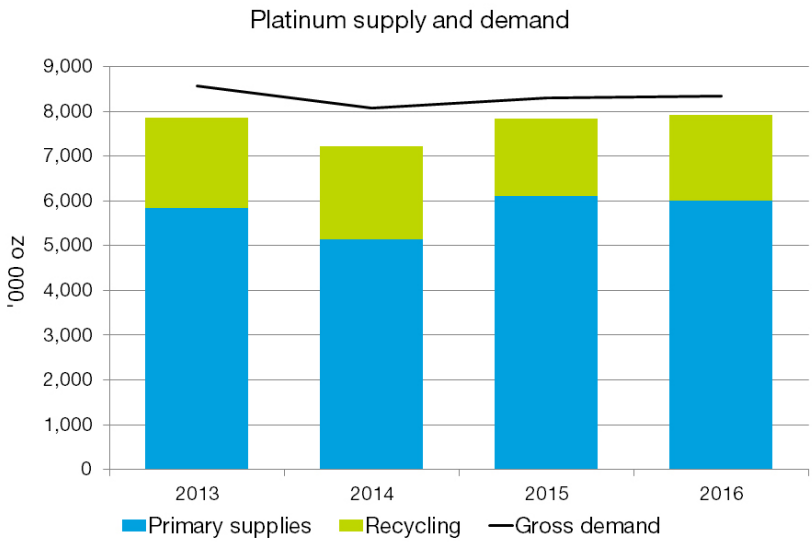
The first half of 2016 saw some significant stock fluctuations, primarily at Anglo Platinum, which reported an increase in inventories of unprocessed pgm following a twelve-day safety stoppage at its Precious Metals Refinery. Output from the refinery, which handles all of Anglo's annual platinum production, was affected for about seven weeks in total, and this led to the accumulation of significant quantities of pgm in the processing pipeline. To compensate for the shortfall in refined output, the company liquidated significant quantities of metal from its refined stockpiles. It also sourced some of its first-half pgm sales from 'market operations', but we do not include this metal in our supply numbers.

The company had expected to clear the refining backlog before the year end, but in September 2016, it was forced to shut down the number one furnace at its Waterval smelter, following a leak of molten matte. The planned rebuild will take around three to four months, and will lead to the accumulation of some unrefined concentrate stocks during the final quarter. The company estimates that 70,000–100,000 oz of platinum production may be deferred into 2017.

"Several large western Bushveld mining complexes experienced a difficult start to 2016."

Other South African refiners began 2016 with above-normal in-process inventories, and released modest quantities of platinum from the processing pipeline in the first half, partially compensating for a relatively lacklustre production outlook.

Excluding stock movements, underlying mine production in South Africa is expected to show a moderate decline this year. Several of the large western Bushveld mining complexes experienced a difficult start to 2016, a result of further shaft closures, safety stoppages, and accidental damage to infrastructure. First-half production of platinum in concentrate was down by 10% at Anglo's Rustenburg group of mines, and by 7% at Lonmin's Marikana operations; in the same period, the Impala lease area reported a 7% decline in refined output.



Impala Platinum's Rustenburg operations have endured a particularly difficult start to 2016, with major incidents affecting output from two major shafts. In January 2016, an underground fire at 14 Shaft caused extensive damage to the lower section of the mine, cutting platinum output by around 80,000 oz this year. Four months later, in May 2016, a serious fall-of-ground incident at 1 Shaft resulted in production being suspended for a prolonged period. In addition, output has been reduced by the closure of the 8 and 12 Shaft mechanised sections in December 2015, although this has been offset by progress with commissioning and ramp-up at two new mining complexes, 16 Shaft and 20 Shaft. Overall, there was a 15% fall in mill throughput at the Impala lease area in the first half of 2016.

"South African producers have less scope to maintain sales via inventory withdrawals."

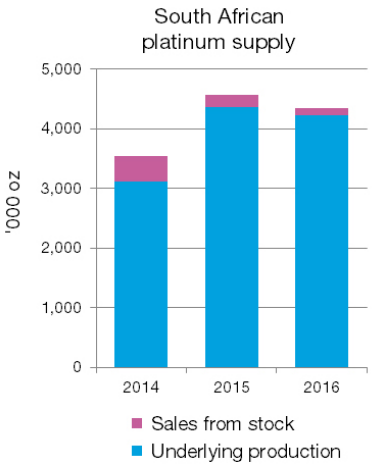
Lonmin's Marikana operation also saw a 15% drop in the quantity of ore treated by its concentrator plants during the January to June period. The company has shut a number of less efficient mining areas and shafts, and further closures are planned: the Newman shaft will cease production by the end of 2016 and the Hossy shaft will shut during 2017. These closures will be partly offset by the ramp-up of production at newer shafts.

At Anglo's Rustenburg operation, production was affected by a combination of safety stoppages and difficult ground conditions: mill throughput at the underground mines dropped by 11%. The Rustenburg group of mines has been sold to Sibanye Gold, with the transaction completed on 1st November 2016.

These declines were partly offset by an improved first-half performance at some other operations. Northam's Booysendal North mine has now reached steady-state production levels on the UG2 reef, and has commenced development of a Merensky operation; production of platinum in concentrate rose by more than 50% in the January to June period. Elsewhere, Bafokeng Platinum reported a 16% increase in platinum output, with improved mining volumes at the established BRPM operation, and additional tonnage from on-reef development activities at the new Styldrift mine. At Anglo's Amandelbult mines, production of platinum in concentrate rose by 15%, reflecting efficiency improvements at the underground operations, and the start-up of a new UG2 open-cast section. The Kroondal mine recorded its highest ever platinum output in a half-year period, up 6% to 137,000 oz; it is now owned jointly by Anglo Platinum and Sibanye, following the completion of the latter's acquisition of Aquarius Platinum.

"Russian supplies are now expected to decline marginally in 2016 with lower output from alluvial operations."

One new mine entered production in the first half of 2016: Platinum Group Metals Limited's Maseve mine, adjacent to BRPM on the western Bushveld. The mine produced its first concentrate in February 2016, with the mill being fed initially from a stockpile of low-grade development ore and subsequently from underground production. However, output in the first half was very modest, with the company reporting that it had produced around 5,000 oz of pgm in concentrate in the January to May period. In September 2016, it was announced that underground development and mining rates had fallen behind schedule: production is now expected to total 91,500 oz of combined pgm and gold (4E) between commissioning and April 2017, down from previous guidance of 110,000 oz.



Overall, we expect production losses due to shaft closures, safety stoppages and technical incidents to outweigh gains from improved efficiencies and the ramp-up at new mines and shafts, leaving underlying South African platinum output down marginally compared to 2015. With producers having less scope to maintain sales via withdrawals from inventories, we expect supplies from this region to fall by 5% to 4.35 million oz.

Russian supplies are now expected to decline marginally in 2016: while shipments by Norilsk Nickel are expected to be flat, output from alluvial operations in the Far East of Russia is expected to decline. These alluvial operations have now been in production for around two decades, and grades have fallen significantly as the deposits become worked out.

First-half platinum production from Norilsk Nickel's Russian operations was little changed compared to 2015, but sales increased by 15% to 370,000 oz as the company drew down stocks of refined metal that were accumulated last year. Full-year output may fall: the planned transfer of some processing operations from the Norilsk mine site to the Kola

"North American platinum supplies will rise by 16% with higher output of primary and by-product platinum."

peninsula is expected to result in a one-time, permanent pipeline build in the final months of 2016 (see page 27 for further details). However, sales from inventory should enable Norilsk Nickel to maintain annual pgm shipments at around last year's level.

North American platinum supplies are forecast to rise by 16% to 369,000 oz in 2016, in line with increased sales of primary pgm from Stillwater and higher output of by-product platinum from the Canadian nickel miners.

At Stillwater, the USA's only primary pgm miner, combined platinum and palladium production is expected to increase by 3–4% this year. However, sales could rise by as much as 10%, because some metal that was put to stock last year will be sold in 2016.

Elsewhere in the USA, small amounts of by-product pgm are produced from nickel and copper mining, for example at Lundin Mining's Eagle mine in Michigan. This operation reached full production in 2015, but output will decline going forward because the mine plan allows for the highest grade ore to be extracted early in the operation's life.

Almost all Canadian platinum production is derived from nickel mining operations in Sudbury, Ontario, and in northern Quebec. Vale reported first-half platinum output up 9% at 96,000 oz; it should be noted that some of the company's refined output comes from concentrates produced by other miners. At Glencore, platinum output from the company's own ores processed at the Integrated Nickel Operations amounted to 50,000 oz in the January to June period, an increase of 14%.

"Platinum supplies from Zimbabwe are forecast to rise to an all-time high this year."

Supplies from Zimbabwe are forecast to rise by more than 20% this year to 486,000 oz, an all-time high for this country. The bulk of this increase will come from Zimbabwe's largest pgm producer, Zimplats, but we also expect modest improvements from Unki and Mimosa, both of which reported incremental gains in mill throughput and platinum output in the first half of 2016.

Zimplats is on course to achieve record production levels this year. The company has undertaken a number of measures to compensate for output lost during the redevelopment of the Bimha mine, which was closed in August 2014 following a shaft collapse. It has redeployed mining teams to other shafts, reopened open-cast operations, and ramped up production from the new Mupfuti Mine; as a result, mill throughput increased by 22% to nearly 3.3 million tonnes in the first half of 2016. Output of platinum in matte rose by 82% in the same period, to nearly 160,000 oz, with the processing of stockpiled material, accumulated during a smelter outage last year, adding around 20,000 oz. For the full year, we expect Zimplats' platinum production to approach 300,000 oz, up by more than a third compared to 2015.

We have increased our estimate of platinum supplies from other regions in line with new information on output in China, where production of pgm-containing ores has increased since 2014.

Government statistics suggest that production of alluvial platinum in Colombia in 2015 amounted to only 20,000 oz, lower than previously reported. We allow for a modest recovery in output in 2016; over the last few years, production has typically been in the 30,000–50,000 oz range.

"We now expect platinum recoveries from scrap autocatalyst to rise by only 3% this year."

In Europe, the largest producer of by-product pgm (outside European Russia) is the Kevitsa nickel mine in Finland, which since June 2016 has been owned and operated by Boliden. This operation produced 32,000 oz of platinum in 2015, and output should be similar this year.

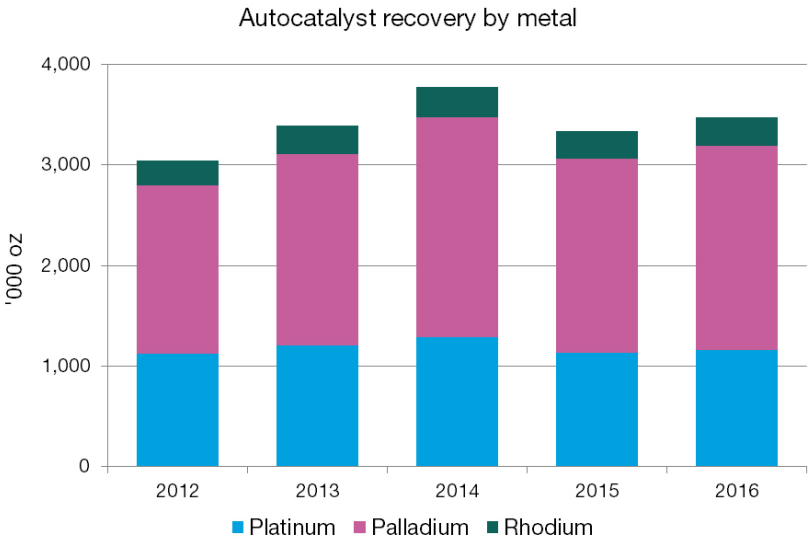
Recoveries of platinum from autocatalyst recycling fell by over 12% in 2015, mainly due to lower vehicle scrappage rates in most major markets, plus some hoarding of catalyst scrap along the recycling chain. In our May 2016 report, we forecast that recoveries would rise by 9% this year, in line with predicted growth in the pgm content of autocatalyst scrap and the anticipation that stock-building would begin to be reversed. However, in the January to September period, our data on refinery intakes of scrap autocatalyst material shows only a modest increase in overall pgm content.

We now expect platinum recoveries to rise by only 3% this year, to 1.16 million oz; this will be the third consecutive year in which autocatalyst recycling has fallen significantly short of expectations. This shortfall has been caused by a combination of weakness in world steel markets and relatively lacklustre pgm prices, which remain well below 2013–2014 levels.

"Declines in the exchange value of end-of-life vehicles are encouraging consumers to keep them longer."

In the past, shortfalls in recycling were caused primarily by short-term hoarding by collectors, and were quickly reversed once prices improved. This time, stockpiling appears to be only a small part of the story. In the last three years, there have been some underlying shifts in the auto recycling market, with declines in the exchange value of end-of-life vehicles (ELVs) encouraging consumers to keep vehicles longer. This is leading to an increase in average vehicle lifetimes in the mature markets of Europe, North America and Japan. At the same time, lower ELV values have shifted the economics in favour of exporting vehicles to less developed markets rather than dismantling them. The outcome has been a significant slowdown in the volume of catalytic converters being collected, processed and refined.

This increase in the average age of ELVs entering the scrap collection circuit has had an impact on the pgm content of scrapped catalysts. Based on historic trends in catalyst fitment, we would expect short-term growth in platinum recycling to outperform that of palladium and rhodium, reflecting the trajectory of platinum demand on European diesels between 2000 and 2005. However, as a result of the rising average age of ELVs, platinum loadings on catalyst scrap have risen more slowly than we had previously anticipated. In Western Europe, vehicle lifetimes in the past were typically around twelve to thirteen years, but the most recently available data suggests that the peak period for deregistrations may now extend from thirteen to eighteen years.



Nevertheless, there has been some modest improvement in platinum grades on catalyst scrap collected from ELVs in Europe this year, and we forecast that European platinum recovery will rise by 5% in 2016. In contrast, Japanese recoveries will be flat, while platinum recycling in North America is likely to fall slightly; the peak in US autocatalyst platinum demand occurred much earlier than in Europe, so there is less potential for growth in platinum recycling in this region.

Platinum Demand: Autocatalyst '000 oz									
	Gross			Recycling			Net		
	2014	2015	2016	2014	2015	2016	2014	2015	2016
Europe	1,487	1,658	1,767	-530	-476	-501	957	1,182	1,266
Japan	475	413	391	-62	-62	-63	413	351	328
North America	356	402	382	-571	-460	-456	-215	-58	-74
China	130	135	165	-25	-29	-36	105	106	129
Rest of World	672	659	613	-94	-100	-105	578	559	508
Total	**3,120**	**3,267**	**3,318**	**-1,282**	**-1,127**	**-1,161**	**1,838**	**2,140**	**2,157**

We expect the quantity of platinum recovered from old jewellery to rise by nearly a quarter this year, as increased recycling in China offsets a small decline elsewhere.

In Japan, low platinum prices have had a negative impact on recycling rates, although this has been partly offset by a relatively stable gold price: jewellery recycling activity in Japan is strongly linked with gold prices. Most platinum jewellery recycling in Japan takes place via a large network of scrap metal collectors, many of whom entered the business in 2009–2010 during a period of rising gold prices. The industry is now highly competitive and, in order to differentiate themselves, some jewellery collectors have begun to focus on gemstones, including very small diamonds weighing 0.18 carats or less, known as 'melee', usually exported to overseas markets such as Hong Kong. Without this, it is likely that many collectors would have gone out of business.

"There was a large increase in platinum jewellery recycling in China during the first half."

In contrast, we believe that there was a large increase in the recycling of platinum jewellery in China during the first half of 2016. This market differs from Japan in that almost all jewellery is returned via the retail and wholesale network, either when consumers trade in old jewellery for newer items, or when old retail stock is returned for reworking. Recycling was unusually low during the second half of 2015, but climbed to unprecedented levels during the first six months of this year, when it accounted for over a third of gross demand.

We believe that much of this increase is explained by a contraction of retail activity, which has resulted in some destocking in the jewellery distribution chain. The health of the Chinese jewellery sector is intrinsically linked to developments in the large gold market, which has been negatively affected by factors including a slowdown in economic growth and government anti-corruption measures which have hit sales of gold bars and ornaments. This in turn has led to the closure of some retail stores, with unsold platinum stock being returned to manufacturers to be reworked into new items.

"Demand for platinum in autocatalysts will rise by 2%, aided by record world diesel vehicle output."

In addition, there is some evidence that, last year, manufacturers were reluctant to take scrapped items because of concerns about alloy content. This led to a surplus of metal available from scrap, and resulted in recycled jewellery metal trading at a discount to spot during the first half of 2016; this in turn has provided an incentive for manufacturers to use scrap metal to meet their production requirements.

Higher recycling should offset lower mine shipments, leaving combined primary and secondary supplies slightly up this year. Meanwhile, global demand is also forecast to rise marginally, with growth in the auto, industrial and investment sectors offsetting a steep fall in sales of platinum to jewellery makers.

World demand for platinum in autocatalysts is forecast to rise by 2% to 3.32 million oz. Record world output of diesel vehicles combined with tightening emissions legislation in Europe and China will more than offset continued thrifting and substitution on gasoline catalysts.

"European light duty diesel output will rise for the third consecutive year."

It should be noted that we have revised our figures for auto platinum demand in 2014 and 2015 to reflect new information on thrifting and substitution by some Japanese carmakers, both at their domestic plants and in their US and Asian transplants. Japanese manufacturers have been more cautious about removing platinum from their gasoline catalysts than their US and European counterparts. However, in the last two to three years, substitution has gathered pace, and it appears that platinum usage has fallen more swiftly than we previously believed.

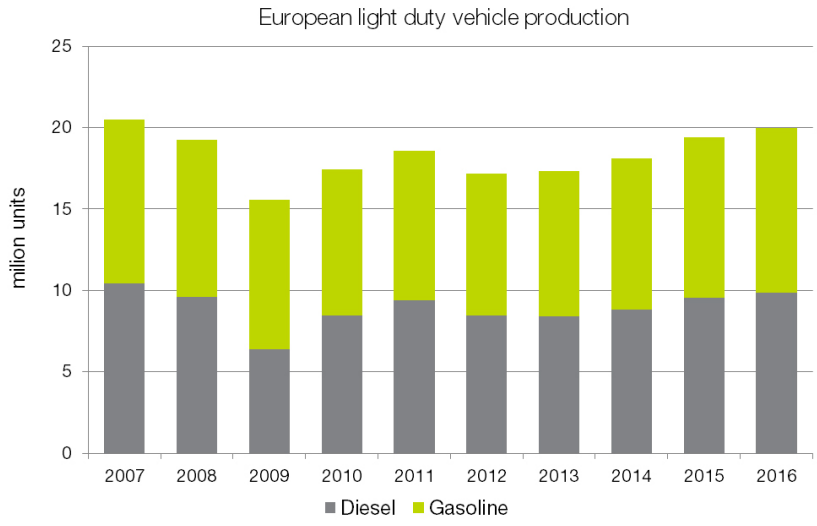
Europe remains by far the largest market for platinum in autocatalysts, mainly because of its large diesel sector and strict emissions legislation: this year, total demand for platinum from the European auto sector is forecast to rise by 7% to 1.77 million oz, the highest level since 2008. In this region, diesel catalysts, mainly for cars but also for heavy duty trucks and off-road applications, will account for over 95% of platinum usage.

"This is likely the peak year for platinum loadings on European diesel vehicles in this round of EU legislation."

Light duty diesel (LDD) vehicle production in Europe is forecast to rise by 3% this year, the third consecutive year of growth; this gain reflects improving consumer demand for vehicles in all major European Union car markets. To date, there is no evidence that the VW emissions scandal has caused an accelerated decline in diesel sales. Diesel market share of European production drifted down from just under 51% in 2011 to 49% last year, and is expected to remain around this level in 2016.

This loss of market share does not appear to reflect a fundamental shift in consumer preferences; rather, it is a consequence of the increased availability of new, down-sized gasoline engines offered by many automakers in smaller car segments. These small gasoline vehicles have taken a disproportionate share of recent market growth; they are less expensive than equivalent diesel-engined models and, at current fuel prices, diesel's advantage in terms of lower running costs has been eroded, particularly for smaller vehicles.

This year's rise in diesel car output will be accompanied by a further increase in the average platinum content of a diesel catalyst system, as Euro 6b regulations are applied to all LDD vehicles sold in Europe, including light commercial vehicles. This is likely to be the peak year for platinum loadings in this round of EU emissions legislation.



The primary reason for higher platinum loadings in 2016 is an increase in the use of lean NOx traps (LNTs), usually in conjunction with a diesel particulate filter (DPF). This catalyst configuration is typically chosen for smaller vehicles; larger cars are generally equipped with selective catalytic reduction (SCR) technology for NOx control, in addition to an oxidation catalyst (DOC) and a DPF. (Sometimes the functions of the DPF and SCR are combined into a single brick; at Johnson Matthey, this is referred to as SCRF™). A more detailed discussion of European diesel catalyst technology is provided in a special feature on page 20.

Euro VI legislation for heavy duty diesel (HDD) vehicles has been fully implemented since January

"Tightening diesel emissions limits in China are leading to a sharp rise in platinum loadings."

2014. Some truck makers are now releasing second-generation Euro VI vehicles, which tend to have catalyst systems with lower total pgm loadings and increased palladium content. As a result, total platinum utilisation on HDDs will be just 2% higher in 2016, despite an anticipated 6% increase in truck production.

Platinum's only significant application in the European light duty gasoline segment is in highly-loaded NOx traps for a small number of cars powered by stratified lean-burn gasoline engines. Demand in this application is expected to be stable this year.

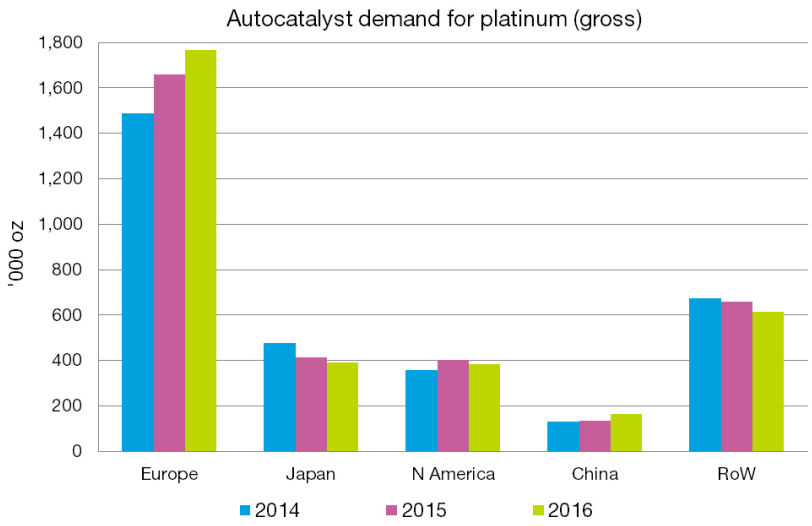
The only other region which will see growth in platinum automotive demand in 2016 is China. In this region, most platinum usage has historically been on gasoline vehicles; until recently, diesel legislation was lenient, and loadings on diesel catalysts were light. This is now changing: diesel emissions limits have begun to tighten, leading to a sharp rise in platinum loadings.

"Platinum demand in automotive markets outside of Europe and China will decline this year."

In April 2016, eleven Chinese provinces and cities, including the Beijing and Shanghai areas, implemented China 5 limits for diesel cars. This legislation, which is equivalent to Euro 5 and will result in the widespread use of platinum-rich DPFs, will apply nationally from January 2018. Diesel vehicles account for only around 3% of Chinese light duty output (around 680,000 units in 2016), but this segment is growing in line with the expansion of the overall market.

The use of platinum on heavy duty diesel (HDD) vehicles in China will also grow this year, although from a very small base. The application of China V regulations to public vehicles in Beijing, Shanghai and nine other provinces began in April 2016; the new rules will be enforced nationally on all heavy vehicles starting in July 2017. Most heavy trucks will meet the new limits using SCR only, but a minority of vehicles will also be fitted with a DOC.

Platinum demand in other regional automotive markets is expected to decline this year, due to further substitution of platinum with palladium in gasoline catalysts, a reduction in heavy duty truck output in North America, and a steep fall in diesel car output in the world's second largest diesel market, India.



In Japan, carmakers have historically taken a cautious approach to removing platinum from their gasoline catalysts. However, in the last three years, palladium adoption has been in full swing, and Japanese demand for platinum in autocatalysts recorded double-digit declines in 2014 and 2015. The rate of substitution should slow this year: platinum usage by automakers in Japan is set to fall by 5%.

North American consumption of platinum will also decline, due to a sharp reduction in class 8 truck production. Demand for platinum in light duty diesel applications will be little changed: having seen strong growth in recent years, diesel share has stabilised in 2016.

"Consumer sentiment towards diesel cars has become less positive in India."

In the Rest of World region, platinum demand will be hit by lower diesel car output in some Asian countries, and a reduction in heavy duty trucks manufactured in Mexico for sale in the US market. The fall in light duty diesel production is likely to be particularly pronounced in India: consumer sentiment towards diesel cars has become less positive over the last two years, due to a doubling of duty on diesel fuel (compared with a 20% increase for gasoline), and measures to limit sales of diesel vehicles in the Delhi area. A ban on sales of larger diesel cars and SUVs with engines over 2 litres was initially imposed in December 2015 for a three-month period, but was extended until July, and has since been replaced by a higher rate of sales tax. The government has also banned the registration of new diesel taxis in Delhi. The result has been a sharp fall in sales of diesel cars, which in turn has caused local manufacturers to scale back production. Indian automakers are expected to produce 1.42 million LDD vehicles in 2016, down 17% on last year.

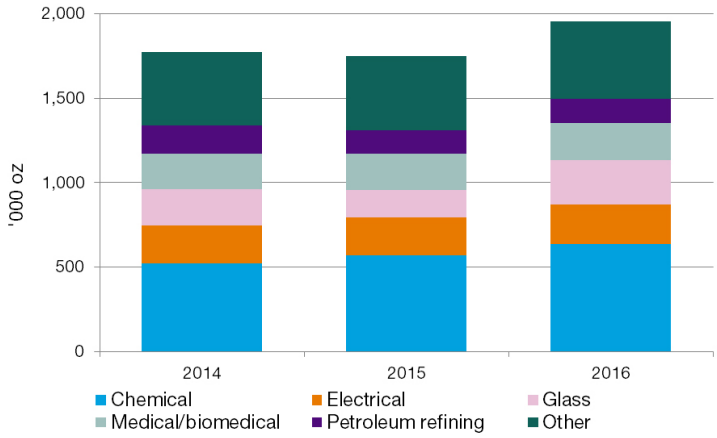
"Heavy purchasing by the chemicals industry will see China and the Rest of the World region achieve record demand."

Overall, autocatalyst demand will be at eight-year highs, while we also expect industrial consumption to reach a five-year peak. The latter will be underpinned by exceptionally heavy purchasing by the chemicals industry, with both China and the Rest of World region set to achieve record demand levels. Chinese government policy is for the country to become increasingly self-sufficient in bulk chemicals such as paraxylene (PX) and linear alkyl benzene (LAB), the production of which uses platinum catalysts. Consequently, domestic producers have benefited from government incentives to invest in new plants and expansions, even in market sectors where there is no shortage of capacity on a global basis.

The outlook for glass demand in 2016 is positive. We expect heavy investment in new fibreglass production capacity in China, and also at Chinese-owned plants in North America and the Rest of World region. This reflects growing demand for lightweight but strong fibre-reinforced plastics, used for example in the auto industry in place of heavier steel parts. Strong fibreglass demand will offset weaker platinum sales to the display glass sector, with one Chinese manufacturer delaying a major expansion planned for 2016 until next year.

Net demand for platinum from the petroleum refining industry has recovered this year following sales of platinum back to the market last year, in the wake of earlier refinery closures. Investment in refining capacity in the Rest of World region remains strong, but the Chinese industry is currently suffering from some overcapacity. However, China has seen new investment in base oils production, where pgm catalysts are used to produce higher quality oils for engine lubrication.

Gross industrial demand for platinum



This year has seen strong growth in sales of platinum to fuel cell manufacturers, albeit off a small base. (Note: fuel cell demand is included in our electrical numbers). While the bulk of demand is for stationary applications, there has been significant progress in the commercialisation of fuel cell electric vehicles, with three major manufacturers now offering FCEVs to consumers. However, volumes will remain small in the near term, with combined production of Hyundai's ix35 Fuel Cell, Honda's Clarity and Toyota's Mirai expected to be below 3,000 units this year (the Mirai accounting for most of these).

"Gross platinum jewellery demand will contract by 9% to its lowest total since 2011."

Except in the fuel cell segment, demand from the electrical sector has been rather lacklustre in 2016. Personal computer sales are forecast to fall by around 7% this year, and this will hit demand for hard disk drive units. However, in terms of platinum demand, this will be largely offset by an increase in the number of disks per drive, as manufacturers increase the storage capacity of their products.

Combined autocatalyst and industrial consumption of platinum is expected to rise by around 5%, or 256,000 oz, this year. However, this gain will be directly offset by a predicted fall in gross jewellery demand, which is now forecast to contract by 257,000 oz (9%) to 2.57 million oz, the lowest total since 2011.

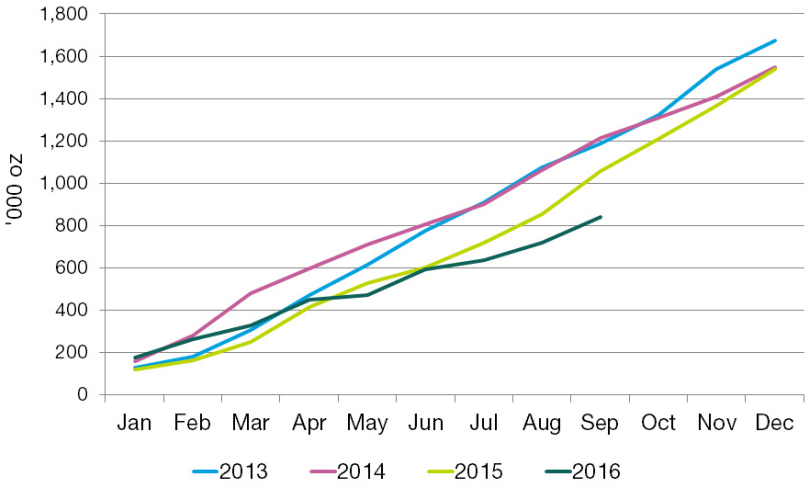
Following an unexpectedly strong performance in the second half of last year, sales of platinum to Chinese jewellery manufacturers recorded a solid start to 2016. Purchasing of platinum, estimated from a range of sources including Shanghai Gold Exchange (SGE) data and trade statistics, was up by around a third in the first quarter of 2016 compared with the same period of last year. Thus, in our May report, we had forecast some modest growth in platinum jewellery demand this year.

"The Chinese jewellery industry is going through a difficult period at both the retail and manufacturing level."

However, as the year has progressed, purchasing levels have gradually eased and, by the end of August, we estimate that cumulative demand was 16% behind that seen in the same period of 2015. It appears that strong platinum demand between mid-2015 and early 2016 was partly driven by manufacturer and retail stocking; however, disappointing sales over the Chinese New Year period left a large inventory overhang which has reduced new orders to manufacturers.

This weakness has been corroborated by Johnson Matthey's latest survey of Chinese jewellery makers, which suggested that fabrication of platinum jewellery declined in the first half, while manufacturers sourced a much higher than usual proportion of their metal needs from recycled jewellery items (this is reflected in our increased estimate of Chinese jewellery recycling).

Estimated cumulative annual purchasing by the platinum jewellery industry in China (net)



It should be noted that the decline in jewellery manufacturing in the first half of 2016 is not representative of underlying retail conditions, because last year's restocking had the effect of pulling forward some fabrication demand into 2015. Nevertheless, it is clear that the Chinese jewellery industry is going through a difficult period, both at the retail and at the manufacturing level, with yellow gold affected to an even greater degree than platinum. Nearly all jewellery makers have laid off workers and some small factories have closed, manufacturing margins have been slashed as fabricators seek to gain market share, showroom opening hours have been cut, and some retail outlets have closed.

Overall, most jewellery market participants describe business as unusually challenging, and some ascribe this to a change in consumer behaviour

Platinum Demand: Jewellery '000 oz									
	Gross			Recycling			Net		
	2014	2015	2016	2014	2015	2016	2014	2015	2016
Europe	204	203	183	-5	-5	-5	199	198	178
Japan	313	314	305	-275	-256	-242	38	58	63
North America	220	240	233	-23	-11	-3	197	229	230
China	1,935	1,796	1,515	-455	-298	-455	1,480	1,498	1,060
Rest of World	225	276	336	-4	-4	-4	221	272	332
Total	**2,897**	**2,829**	**2,572**	**-762**	**-574**	**-709**	**2,135**	**2,255**	**1,863**

away from the purchase of visible signs of wealth. There has also been increased competition from white and carat gold jewellery, which is priced per piece rather than on the basis of metal weight, allowing both manufacturers and retailers to realise higher margins. Finally, platinum faces an additional challenge from weak metal prices, which in China are broadly negative for total demand, as they detract from platinum's reputation as the most precious jewellery metal.

"There has been a steep drop in the hallmarking of platinum watch cases in Switzerland."

These factors have led us to cut our forecast of gross platinum jewellery demand in China to 1.52 million oz in 2016. This is 16%, or 281,000 oz, lower than last year. Moreover, increased recycling levels seen during 2016 will result in a dramatic fall in net platinum consumption in Chinese jewellery, which at 1.06 million oz will set an eight-year low.

Japanese and European jewellery fabrication will also decline this year. In the past two years, some Japanese manufacturers and retailers – especially those offering pearl-set pieces – have benefited from growth in luxury goods purchases by tourists, particularly from China. However, while 2016 has seen record numbers of foreign visitors arriving in Japan, it seems that they have, on average, been spending less. This may be linked to the introduction by the Chinese government of new tariffs on luxury goods imports, along with a stricter customs inspection regime. In addition, jewellery fabrication in Japan has been affected by the relocation of some production to offshore factories elsewhere in Asia. Overall, we expect sales of platinum to Japanese jewellery makers to fall by 3% this year.

The European platinum jewellery industry is dominated by Switzerland and the UK, which together account for about two thirds of platinum usage in this region. UK hallmarking statistics were up strongly in the first half of 2016, but fell sharply in the third quarter, while there has been a steep drop in the hallmarking of platinum watch cases in Switzerland.

"In North America, consumer demand for platinum jewellery will rise at a slower pace than in 2015."

In North America, consumer demand for platinum jewellery is expected to rise again this year, albeit at a slower pace than in 2015: the US presidential campaign has had a negative effect on consumer confidence and retail activity. Platinum's move to a large discount to gold has reduced the retail price differential between the two metals, and this has favoured demand for platinum in the bridal sector, where the choice between white gold and platinum is often made on grounds of affordability. At the same time, the availability of platinum jewellery has expanded, with improved stocking in jewellery stores as well as a significant increase in online selling activity.

However, our figure for North American jewellery fabrication demand has been adjusted downwards to reflect an increase in imports, with this demand reallocated to our Rest of World region.

The Indian market (also included in our Rest of Word figures) will continue to expand rapidly in 2016, despite some disruption to the market in the early part of the year. Catastrophic

"The Indian market for platinum jewellery will continue to expand rapidly, despite some disruption in early 2016."

flooding in the Chennai area in November and December 2015 led to the postponement of some weddings that were planned for the first quarter of this year, with a consequent impact on sales of platinum jewellery and, in turn, restocking by retailers. The Chennai region alone accounts for over 20% of Indian platinum jewellery sales.

Jewellery fabrication was also disrupted by nationwide industrial action in the first half of 2016. Jewellers went on strike during March and April in response to a proposed 1% increase in excise duty on non-silver jewellery. This government has since reversed its decision.

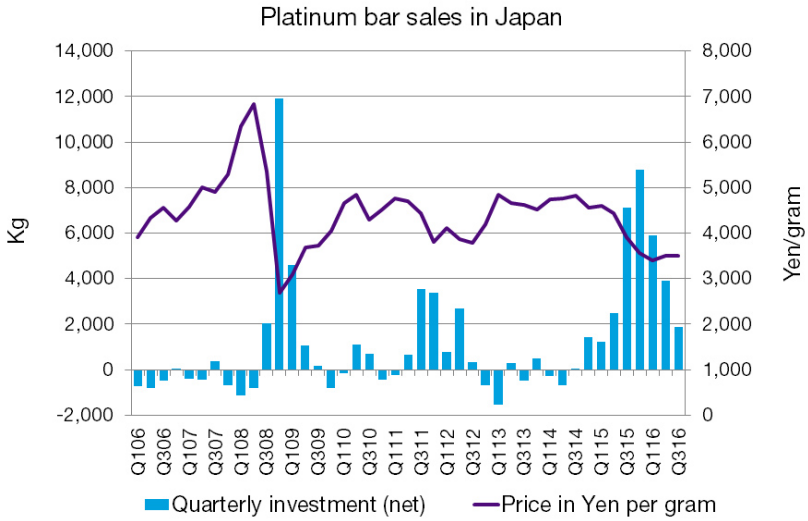
We expect fabrication levels to improve significantly during the second half of 2016, as the effects of the flooding and the strike recede, and the platinum industry continues to benefit from a historically large discount to gold. For the full year, we expect demand from the Indian jewellery industry to rise by around 20%.

"This will be another strong year for platinum investment bars in Japan."

This will be another strong year for platinum investment, with buoyant demand for investment bars in Japan greatly outweighing liquidation of ETFs in other regions. This is forecast to lift total net investment by 8% to 487,000 oz. We estimate that Japanese investors purchased over 380,000 oz of platinum in the first nine months of 2016, and that annual demand for investment bars in Japan could approach half a million ounces, although it is unlikely to match the exceptional total seen in 2015.

This unusually prolonged period of heavy buying in Japan appears to reflect a conjunction of several positive influences, including low yen-denominated pgm prices, a wide discount to gold, and changing investment patterns among younger people.

The primary stimulus for Japanese investment is price. The retail platinum price in Japan was below the important psychological price point of ¥4,000 per gram for much of the first ten months of 2016, only moving decisively above this level between mid-July and mid-August, when some profit-taking by investors was seen. In addition, investors have been attracted by an unusually wide discount to gold, which exceeded ¥1,000 per gram for much of the first quarter, and has remained above ¥800 for most of the year to date. This has tended to reinforce investors' perceptions that platinum offers unusually good value for money, both relative to historic prices and in comparison to gold.



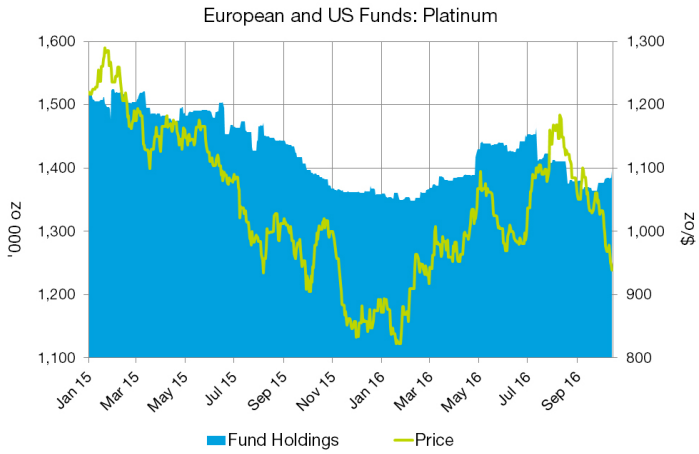
It appears that platinum has begun to appeal to a wider investment market in Japan, with younger investors now showing interest in precious metals, including platinum. This shift has been accompanied by a fall in the size of a typical Japanese investment bar; in the past, this market was dominated by large bars weighing 500 grams, but the most popular bar size is now 100 grams.

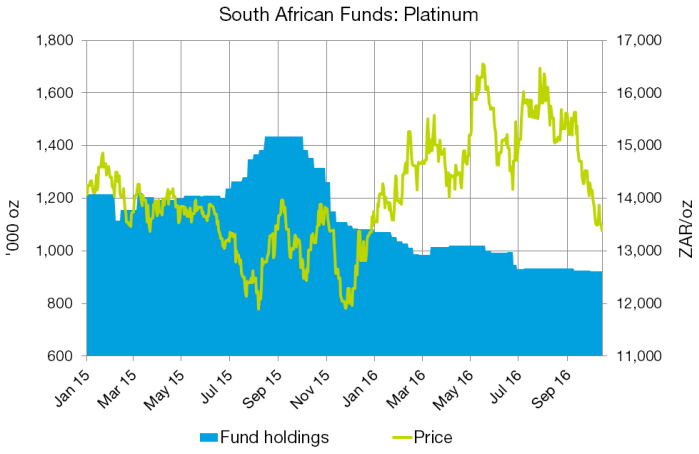
It is possible that some investors have been attracted to precious metals as a means of storing wealth in a portable form, as a result of recent changes to inheritance tax and social security regulations; the

value of smaller bars in the 50 to 200 gram range falls well below that which would trigger a reporting requirement. However, we believe that price remains by far the most important influence on Japanese demand.

In contrast, demand for platinum ETFs is expected to remain in negative territory for a second consecutive year. There has been heavy selling activity in South Africa, where ETF investors liquidated some 150,000 oz of platinum during the first nine months of 2016. This has occurred during a period of very strong gains in South African mining equities: the value of platinum mining stocks quoted on the Johannesburg Stock Exchange more than doubled between January and early October. It is clear that sentiment towards mining stocks has improved sharply, encouraging institutional investors to rotate out of ETFs and into equities. Because rand-denominated platinum prices have risen sharply over the last year, many investors will have been in a position to realise profits on their ETF holdings.

Elsewhere, activity in ETF funds has been relatively subdued. There has been a modest upturn in investor interest in the USA, primarily as a result of improving prices, but there has been little overall movement in the European funds. In Japan, investors have made further modest additions to their ETF holdings, with these purchases occurring during periods of sustained weakness in yen-denominated prices in January and October.





Outlook for Platinum
SUPPLY & DEMAND IN 2017

OUTLOOK: PLATINUM

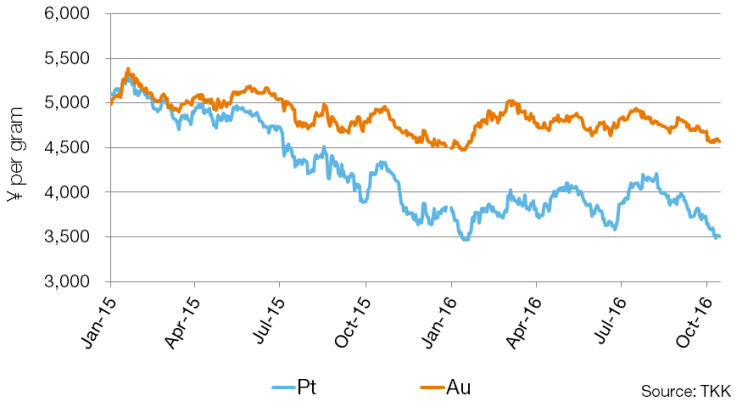
- A predicted fall in auto and jewellery demand could leave the platinum market in surplus in 2017.
- Primary supplies will be flat, but there is potential for auto recycling to rebound after two weak years.
- European diesel loadings will decline as carmakers adopt new catalyst strategies to meet RDE standards.
- Investment will be influenced by trends in platinum prices and the yen, but is more likely to fall than to rise.

After five years of deficit, the platinum market may move into surplus in 2017 for the first time since 2011. While primary supplies are likely to be flat at best, there is potential for recycling to rebound following two years of weak volumes. Demand is expected to decline: industrial consumption should remain firm, but we expect gross sales to European automakers and Chinese jewellery manufacturers to contract. The extent of the fall in demand will depend in large part upon investment activity and, in particular, whether we see a slowdown in Japanese bar sales.

In the last five years, deficits in the platinum market have primarily been a function of investment demand: had it not been for physical purchasing via ETFs and by Japanese retail investors, there would have been surpluses in all years except 2014 (when supplies were hit by a prolonged strike at major mines in South Africa).

However, in 2017, it may be more difficult for investment buying to tip the market into deficit. Gross demand in 'consuming applications' (automotive, industrial and jewellery) could fall by around 3%, while growth in recycling should compensate for any weakness in primary supplies. At the same time, we believe that investment demand is more likely to decline than to rise. There is little sign that ETF holders have recovered their appetite for platinum (although US investors have added modestly to their holdings in recent months); should US interest rates rise as expected, this would tend to reduce the attractiveness of non-yielding assets such as precious metals. Meanwhile, Japanese demand will depend largely upon movements in platinum and gold prices, and in the dollar:yen exchange rate. Continued weakness in yen platinum prices would be positive for demand, especially if the discount to gold remains high, but any significant moves above ¥4,000 per gram could result in some profit-taking.

Retail prices of Pt and Au in yen per gram
Includes 8% sales tax



Source: TKK

Price weakness could also stimulate further stock-building in China, although we believe that purchasing to date has been motivated more by strategic considerations including platinum's critical importance in many industrial processes, and by the weak supply outlook.

Prospects for short to medium term growth in pgm mining in South Africa are muted. The country's platinum output peaked at over 5 million oz in the mid-2000s, but has been on a generally declining trend since 2007: in 2016 and 2017, we expect underlying mine production to stabilise at 4.2–4.3 million oz. (It should be noted that some limited stock sales are expected to keep supplies slightly ahead of production in both years).

"Prospects for short to medium term growth in pgm mining in South Africa are muted."

This decline in output was mainly due to ore reserve depletion, rationalisation and shaft closures at the large underground mines on the western Bushveld owned and operated by Anglo American Platinum, Impala Platinum and Lonmin. These operations, traditionally the mainstay of the South African platinum industry, produced nearly 3.4 million oz of platinum in 2007 but output has since fallen by around a third, to little more than 2.2 million oz. Looking forward, two large replacement shafts at Impala's lease area are currently in the ramp-up phase, but these gains will be offset by rationalisation elsewhere on the western Bushveld.

There is some growth to come from expansions and debottlenecking at existing mines at other locations on the Bushveld, and the ramp-up of a small number of new operations. In the immediate future, there should be some additional ounces from Royal Bafokeng Platinum's Styldrift and Platinum Group Metals Ltd's Maseve projects. Further ahead, there is the prospect of higher production from Anglo American's Mogalakwena mine, an expansion at Northam's Booysendal operations, and the start-up of Wesizwe's Bakubung project. Nevertheless, we expect output to remain below the level seen in the 2007 to 2011 period.

Zimbabwe supplies are expected to peak in 2016, due to the processing of some inventory. Looking forward, we may see a small decline in platinum output in the short term, as production at Zimplats stabilises at 260,000 oz per annum, and Mimosa and Unki maintain output at current levels.

"Supplies of platinum from Norilsk Nickel are expected to be stable over the next two years."

Further ahead, Zimplats is finalising plans to develop a new shaft ('Portal 6'), with a bankable feasibility study due to be presented to the Impala Platinum board in November 2016. Development of this new mine is expected to cost around $148 million over five years, with first production due in 2021. It will replace output from Zimplats' oldest mines, which will be approaching depletion.

The Zimbabwe mines generally enjoy lower operational risks than their South African counterparts, thanks to a stable and skilled workforce, and a wide, shallow reef that can be mined using mechanised methods. However, political risk remains high. The mines face government demands to beneficiate pgm concentrate locally, to increase Zimbabwean participation in company ownership structures, and to demonstrate that they are actively exploiting their mineral resources. The stakes are considerable: for example, in June 2016, the Zimbabwe government initiated legal action to compulsorily acquire part of Zimplats' mining lease area.

Supplies of platinum from Norilsk Nickel are expected to be stable over the next two years, although there may be some short-term disruption during the reconfiguration of the company's processing flow sheet. However, output of platinum from alluvial sources in the Far East of Russia has been on a steeply declining trend over the past three years, and this is expected to continue.

In North America, platinum supplies are forecast to be flat in 2017. Stillwater Mining is developing a new mining section, Blitz, which will add around 60,000–75,000 oz of platinum per annum once at full production; however, no significant pgm output from this project is expected before 2018.

"The direction of total platinum supplies next year will be determined by trends in recycling markets."

Overall, we see little prospect of any near-term improvement in primary platinum output, with global shipments in 2017 likely to be very similar to levels seen this year. This means that the direction of total primary plus secondary supplies next year will be determined by trends in recycling markets, and particularly in the autocatalyst recovery sector.

As we suggested on page 5, the quantity of platinum recovered from scrapped autocatalysts during the 2014 to 2016 period has been significantly less than the amount that we calculate should theoretically have become available. This shortfall appears to have been caused by a fall in steel prices, which began in the final months of 2013, reducing the incentive to scrap ageing vehicles and leading to rising lifetimes. At the same time, weak pgm prices have encouraged periodic hoarding of catalyst material by scrap yards betting on higher pgm prices in future.

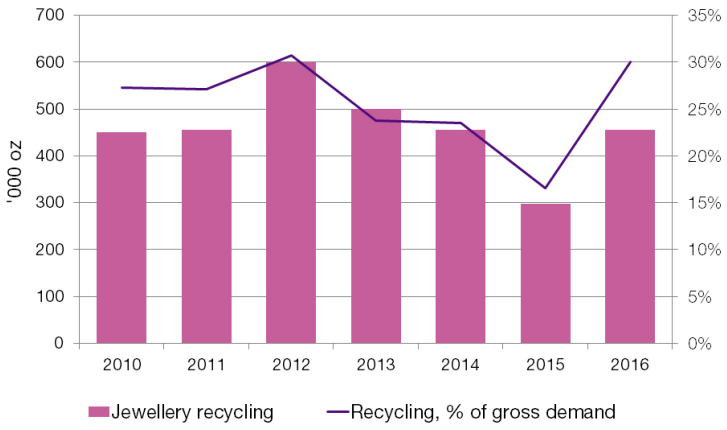
This means that there may be some potential for short-term fluctuations in autocatalyst recovery, if pgm price trends encourage any movement in inventories. However, it is more difficult to establish when, or whether, end-of-life vehicles (ELVs) which have failed to reach scrap yards over the last several years will be returned for recycling.

"The recovery of platinum from jewellery scrap is likely to decline in 2017."

ELVs entering the scrap collection circuit over the next few years will mostly have been built between the late 1990s and the early 2000s. This causes an additional challenge in forecasting, because of the dramatic changes in catalyst fitment that took place in the late 1990s and early 2000s: during this period, platinum's share of the mainly gasoline US market faltered and then collapsed, while platinum usage on European diesels saw unprecedented expansion. As a result of these changes in catalyst loadings, small variations in vehicle life can have important implications for pgm loadings on catalyst scrap.

In Europe, the underlying platinum content of catalyst scrap is rising, but more slowly than we had previously anticipated, because of increases in vehicle life. In contrast, in North America, platinum accounts for a declining proportion of the pgm recovered from catalyst scrap. Looking forward, we expect these two trends to broadly offset each other and, in the medium term, we expect the recycling of platinum from autocatalysts to flatten off and, eventually, begin to decline. However, in the short term, this trend could be temporarily obscured if steel and pgm prices improve and recycling volumes return to previous levels.

Chinese platinum jewellery recycling



The recovery of platinum from jewellery scrap is likely to decline in 2017. This year has seen elevated levels of scrap recovery in China, but excess retail stocks of old jewellery have now been drawn down, and we expect the market to return to more normal levels of activity. In Japan, where jewellery scrap largely originates from the public rather than from the retail distribution chain, the volume of jewellery recycling is linked to price: recoveries tend to rise during periods of rising or volatile gold and platinum prices. In the absence of large price movements, Japanese jewellery recycling is more likely to fall than to rise.

Automotive demand for platinum is expected to decline slightly in 2017. In Europe, platinum loadings on light duty diesel vehicles are thought to have peaked this year, now that

"Diesel catalyst systems are already complex and varied and will become more so over the next five years."

Euro 6b standards are universally enforced; going forward, the introduction of real driving emission (RDE) testing, starting in September 2017, will have important implications for catalyst technology and pgm loadings. Diesel catalyst systems are already complex and varied – often comprising several catalyst bricks, some or all of which contain pgm – and will become more so over the next five years.

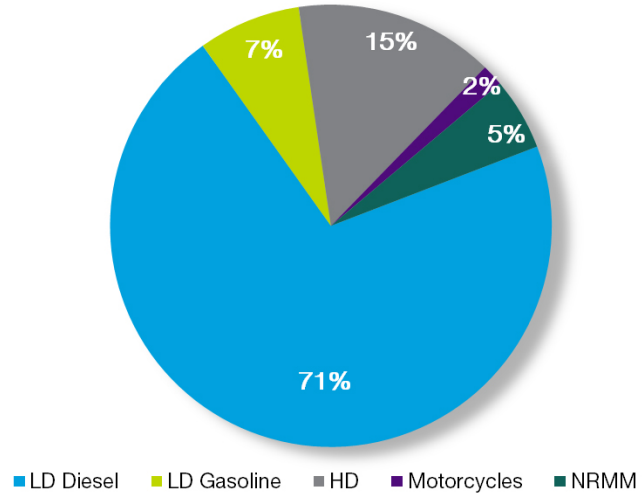
During the initial stage of RDE legislation (known as Euro 6d-TEMP – see pages 24 and 25 for details), we expect to see greater use of non-pgm selective catalytic reduction (SCR) technology, and a decline in the fitment of platinum-rich lean NOx traps (LNTs). In some cases, the functions of the particulate filter and SCR will be combined, which will also tend to reduce platinum loadings due to the loss of the pgm-coated filter, although this may be partly offset by higher pgm loadings elsewhere in the system. As a result, we expect platinum loadings on European diesel cars to decline by around 5% next year.

From 2020, RDE requirements will become more rigorous, under Euro 6d regulations (see pages 24 and 25). At this stage, we anticipate that there will be an increase in the number of vehicles carrying both NOx traps and SCRs; this should partly compensate for reductions in platinum usage elsewhere in the system. More information on the evolution of European diesel catalyst technology can be found in a special feature on page 20.

"The European heavy duty diesel market is expected to see some near-term changes to pgm use."

The European heavy duty diesel market is also expected to see some near-term changes to pgm use. All heavy trucks sold in Europe use pgm catalysts to control carbon monoxide, hydrocarbons and particulate matter, and SCR for NOx treatment. Although SCR relies on a base metal catalyst, the choice of SCR type – iron (Fe), copper (Cu) or vanadium (V) – has an impact on the pgm content of the upstream pgm-containing bricks. First generation Euro VI systems (from 2013 onwards) favoured the use of Fe-SCR. However, V-SCR is becoming increasingly common on second generation Euro VI vehicles. V-SCR performs well at low temperatures and is less sensitive to the NO to NO_2 ratio in the exhaust gas stream, allowing a lower platinum loading to be used on the DOC.

Platinum demand by auto sector 2016



It should be noted that while V-SCR is gaining share in European heavy duty vehicles, it is not used in light duty applications, nor is it currently approved for use in North America (except in some non-road applications). However, the US market is undergoing some other developments in catalyst technology. In particular, the light duty diesel sector is expected to move towards higher palladium loadings on catalyst bricks upstream of the SCR unit, in order to help the aftertreatment system pass the low temperature portion of the testing cycle. This additional palladium is displacing platinum to a certain extent.

The world's two largest heavy duty markets, India and China, currently use relatively little pgm in diesel emissions treatment – about 200,000 oz combined, or 6% of total world platinum demand in diesel catalysts. However, both countries are entering a period of rapid legislative change that will lead to much greater platinum use.

"China V heavy duty legislation will be enforced nationwide from July 2017."

In China, only around half of all heavy vehicles are fitted with pgm-containing catalysts, and where pgm is used, loadings are usually very light. This is set to change over the next few years: China V will be enforced nationwide from July 2017, and we expect China VI regulations to be introduced starting in 2020. The latter is broadly similar to Euro VI and will result in the vast majority of Chinese trucks being fitted with pgm catalysts.

In India, where the current Bharat IV legislation is equivalent to Euro IV, fewer than 50% of trucks are currently fitted with pgm catalysts, as it is usually possible to comply with the regulations via engine calibration and SCR. However, the government intends to move directly to Bharat VI (equivalent to Euro VI) limits in 2020. This will result in Indian trucks being fitted with aftertreatment systems similar to those used in Europe.

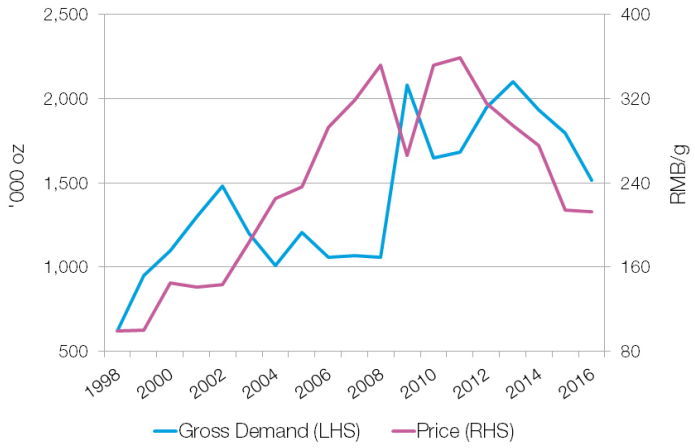
Industrial demand could weaken slightly next year, as the pace of expansion in China's chemicals, fibreglass and petroleum refining industries eases. These sectors have seen significant new investment in the last two to three years, in some cases in spite of existing global overcapacity, in line with Chinese government policy to reduce dependence on imports. However, we do expect to see some improvement in demand from the electrical sector, where anticipated growth in shipments of 'enterprise drives' should lead to some increase in platinum purchasing by hard disk producers in Asia.

"Industrial demand could weaken slightly next year as the pace of expansion in China eases."

Usage of platinum in fuel cells, also included in our estimates of electrical industry demand, should continue to rise at double-digit rates in 2017, and could exceed 50,000 oz for the first time. Stationary fuel cell applications should continue to perform well; on the automotive side, Toyota plans to produce at least 3,000 Mirai FCEV next year, while Mercedes Benz will launch a hybrid fuel cell vehicle with a supplementary lithium-ion battery which can be plugged in and charged externally.

Fuel cells are being retrofitted as range extenders on some battery electric vans, primarily in France, where generous government subsidies are available for zero emission vehicles. During 2016, several hundred vehicles have been fitted with a range extender, and there is potential for this figure to reach the thousands in 2017. The cells involved are small – typically 5 to 20 kW, compared with 100 kW for a FCEV – and platinum consumption per vehicle is proportionately lower.

China: gross platinum jewellery demand and price



The outlook for jewellery demand in China in 2017 is weak. The industry is facing some general economic headwinds: lack of confidence in future growth is leading to changes in spending patterns, with consumers increasingly likely to put their surplus cash into interest-bearing investments or real estate rather than into luxury goods purchases. Gold jewellery sales have been particularly hard hit, with the impact of changing consumer spending patterns amplified by ongoing anti-corruption initiatives.

While these gold-specific factors do not directly affect platinum jewellery, weak gold demand has led to a contraction in the retail jewellery network. In recent years, some of the growth in platinum demand has been related to new store openings, which necessitated increases in retail inventory: a typical

"In China, weak prices have been damaging for perceptions of platinum as the most precious jewellery metal."

outlet might hold 2 to 6 kg of platinum jewellery, depending on size and location, in addition to much larger quantities of gold. Conversely, rationalisation at the retail level has led to reduced stock requirements across the industry.

The industry also faces some other negative trends that are specific to platinum. Between 1998 and 2013, Chinese fabrication demand rose strongly despite a general upward trend in the platinum price; during this period, any short-term price correction incited heavy buying by jewellery makers. However, since 2013, lower prices have failed to stimulate demand. Indeed, it appears that persistently weak prices have been damaging for perceptions of platinum as the most precious jewellery metal; this change in consumer perception has probably been exacerbated by a lack of promotional activity in recent years. There is also increased competition from carat gold products, which typically provide higher margins for both manufacturers and retailers. As stores have closed and counter space has shrunk, retail chains are increasingly pushing carat gold in order to recoup lost revenues from declining sales of platinum and pure gold jewellery. This move to carat gold has been reinforced by a shift in consumer preferences away from single, high-value items in favour of multiple purchases of lower-value pieces that can be coordinated with different outfits. Carat gold pieces are typically lighter than equivalent platinum items, and are available in a wider range of design and colour options.

The upshot is that platinum sales to Chinese jewellery makers are expected to fall again next year, although at a slower rate than in 2016, on the basis that inventory adjustments are likely to play a smaller role in determining demand. While we continue to expect strong growth in India, this will not be sufficient to prevent a second consecutive year of overall decline in gross jewellery demand.

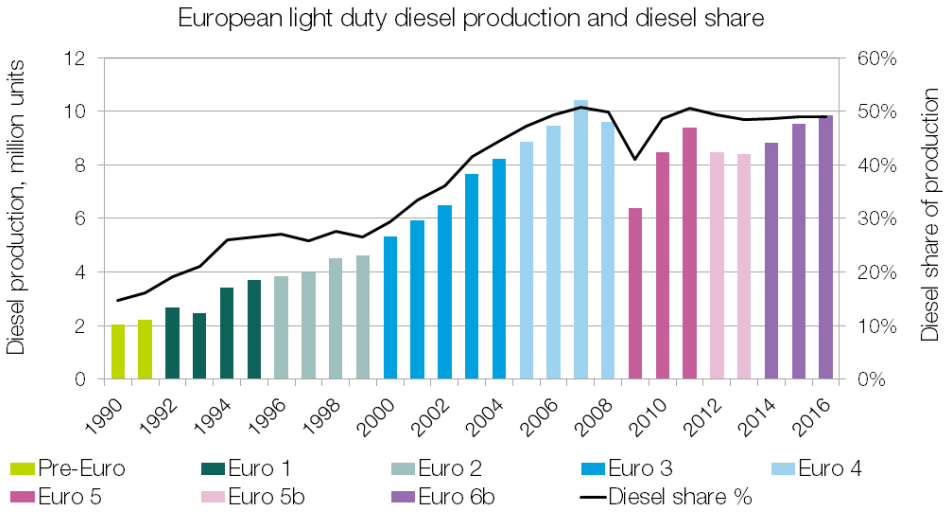
Special Feature
EUROPEAN DIESEL

European diesel emissions legislation and catalyst technology

Europe is by far the world's largest light duty diesel market, accounting for around 60% of all diesel cars manufactured globally. As European Union emissions legislation has tightened over the past quarter-century, the use of platinum-rich catalysts on light duty diesels has become universal, and in recent years pgm loadings have increased and catalyst systems have become more complex. Looking forward, recent developments in diesel emissions technology, especially in the field of NOx control, will enable automakers to meet the new Real Driving Emissions (RDE) standards.

The early years: Euro 1 and 2

Although the European authorities began to regulate vehicle emissions via a series of EEC directives starting in the 1970s, widespread use of catalysts on passenger cars did not begin until the early 1990s. Initially, catalyst use was mainly confined to gasoline vehicles: most diesel cars could meet Euro 1 (1992) limits via engine calibration alone, without the need for any exhaust gas aftertreatment. However, from Euro 2 (1996) the vast majority of European diesel vehicles were fitted with oxidation catalysts (DOCs) to meet carbon monoxide (CO) and hydrocarbon (HC) limits.



Note to chart: EU emissions legislation is usually phased in over a period of two or three years; columns are coloured according to the date of first implementation of each legislation stage. Colours do not necessarily correspond directly to catalyst fitment, due to these phase-in periods, and because historically some automakers sold vehicles complying with new limits ahead of their formal enforcement. Production also includes vehicles exported to non-EU countries.

Special Feature
EUROPEAN DIESEL

A DOC functions by oxidising CO and any unburnt HC over a pgm catalyst (the reduction of NOx is hard to achieve in the oxygen-rich environment of a diesel exhaust stream, and DOCs have little NOx activity). Although by the early 1990s, palladium was starting to be used in gasoline autocatalysts, early diesel catalysts were platinum-only. In the oxidising environment of a diesel exhaust stream, palladium is more readily deactivated than platinum by conversion into palladium oxide, while it is also more vulnerable to sulphur poisoning than platinum.

Peak diesel: 2000–2007

Euro 3 standards were implemented from 2000, further reducing permitted CO, HC and particulate matter (PM) emissions, and introducing a separate NOx limit for the first time. This led to a steady climb in the platinum loadings on light duty diesels.

Euro 4 legislation (from 2005, but met ahead of this date by many vehicles) mandated even more stringent standards, particularly for NOx and particulate matter. These tougher NOx regulations could be achieved without specific NOx aftertreatment; one strategy was to reduce diesel engine combustion temperatures, thereby decreasing NOx but increasing particulate matter and CO emissions, requiring higher platinum loadings on the DOC. At this stage, most diesels could comply with EU standards without specific aftertreatment strategies for particulate matter.

This period coincided with a dramatic expansion in the production of diesel vehicles in Europe. Output more than doubled over an eight-year period, from under 5 million in 1999 to a peak of over 10 million in 2007, with platinum consumption rising from under 400,000 oz per annum to over 1.8 million oz over this period. The spectacular growth in platinum usage was reinforced by the decision by some automakers to offer vehicles which exceeded regulatory standards: for example, starting in 2003–2004, some car companies offered optional fitment of an additional catalyst brick, known as a diesel particulate filter (DPF), to reduce emissions of small particulates that are harmful to human health.

Nevertheless, after 2005, growth in loadings began to flatten: as diesel vehicle output and platinum usage grew, there were progressive improvements in diesel engine and catalyst technology. This limited the need to increase pgm loadings as emissions legislation tightened, and eventually permitted some thrifting to occur.

Euro 5: particulate filters and palladium substitution

The next stage of EU emissions legislation, Euro 5, was phased in starting in September 2009, although many vehicles met the standards ahead of this date. The new regulations mandated an 80% reduction in particulate matter emissions compared to Euro 4, and led to the fitment of DPFs on all European diesel cars, in addition to DOCs.

Special Feature
EUROPEAN DIESEL

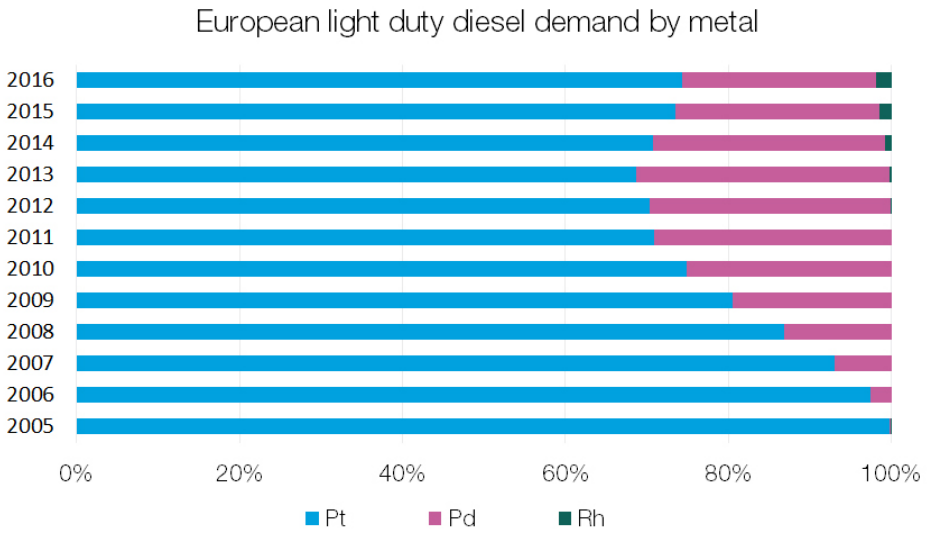
A DPF works by trapping particulate matter (soot) in the filter walls. However, in order to prevent the filter becoming blocked, it is necessary to burn off the accumulated soot at regular intervals. This can be achieved by increasing the exhaust gas temperature during periodic 'regeneration events', allowing the soot to be oxidised over a pgm catalyst into CO_2 and water.

Meanwhile, another revolution in diesel pgm demand was gathering momentum through the late 2000s: the availability of fuel with a very low sulphur content (under 10 ppm) enabled automakers to introduce palladium into their diesel catalyst systems, starting in around 2006 but rapidly gaining pace thereafter. The addition of palladium to the pgm mix improves high-temperature stability, extending catalyst lifetime and enabling loadings to be reduced. Adding palladium is particularly beneficial for vehicles fitted with catalysed DPFs, because it enables high-temperature regeneration events to take place without damaging the catalyst.

The result was that, after 2008, pgm loadings on diesel catalysts stabilised and then began to fall, while automakers were able to replace some platinum with palladium. This substitution had a beneficial impact on total catalyst system costs, at a time when most car companies were experiencing significant financial pressures in the wake of the global financial crisis of 2007. By 2013, total diesel pgm loadings were 8% below their 2008 level, while palladium had increased to over 30% of the total.

Euro 6b: new strategies for NOx control

From 2014, the introduction of Euro 6b emissions legislation reversed the trend towards lower loadings. Although there were no further changes to PM limits, a 56% reduction in

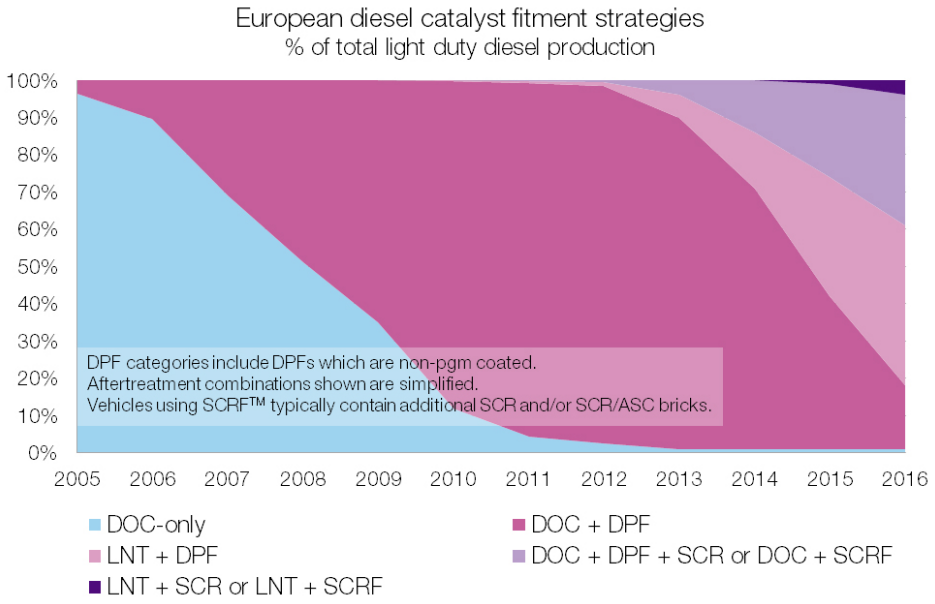


Special Feature
EUROPEAN DIESEL

permissible NOx emissions compelled automakers to add NOx aftertreatment technology to the vast majority of their diesel cars: the result has been a dramatic increase in the complexity and variety of diesel catalyst systems.

At present, there are two broad categories of aftertreatment systems used on Euro 6b-compliant diesel vehicles, although multiple variants exist. Typically, in smaller vehicles where space is at a premium, manufacturers have tended to adopt lean NOx trap (LNT) technology, in conjunction with a particulate filter. An LNT is a pgm catalyst that adsorbs NOx during normal, lean engine conditions, then releases and converts it during short periods of fuel-rich operation (see below for further details).

In larger vehicles, where physical space is less of a constraint, many automakers have chosen non-pgm selective catalytic reduction (SCR) technology for NOx control. An SCR unit reduces NOx to gaseous nitrogen and water over a base metal catalyst in the presence of ammonia (usually in the form of a urea solution commonly known as AdBlue™); it therefore requires the addition of a urea tank and injection equipment. A typical catalyst configuration would see the vehicle fitted with a DOC, DPF and SCR bricks, in sequence. However, some automakers are now combining the function of the SCR and the filter on a single, non-pgm brick, for which various proprietary names exist; at Johnson Matthey, this technology is known as SCRF™. The use of SCRF™ makes for a more compact aftertreatment system, and also allows the SCR brick to be placed closer to the engine in a hotter position, enabling it to reach operating temperature more quickly.



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Overall, Euro 6b has resulted in a steady increase in average pgm loadings, particularly of platinum, which plays a critical role in the oxidation of NO to NO_2, a key step in the treatment of NOx using LNTs or SCR.

The next challenge: Real Driving Emissions

In May 2015, EU Member States approved European Commission proposals to introduce real-world driving emissions test procedures for gasoline and diesel vehicles. These Real Driving Emissions (RDE) standards will be phased in between 2017 and 2022 and will drive the next wave of change in diesel catalyst strategies employed by European automakers.

The introduction of RDE standards for NOx will occur in two phases. Under Euro 6d-TEMP, which will be phased in between September 2017 and September 2020, NOx emissions measured during RDE testing must be less than 2.1 times those permitted during the laboratory test cycle used for type approval emissions testing. In the second stage, Euro 6d, this 'conformity factor' (CF) will be reduced to 1.5, applying to new models from January 2020 and to all vehicles from January 2022.

The implications for catalyst technology and pgm loadings are complex. For Euro 6d-TEMP, we expect the European LDD market to see a shift away from LNTs and towards increased use of SCR (usually in conjunction with a DOC and particulate filter), because the latter technology offers more reliable NOx conversion at higher speeds. Thus, we expect some short-term decline in pgm loadings on European diesels.

However, for Euro 6d, with the tighter NOx conformity factor, some automakers may choose to replace the DOC upstream of the SCR with a NOx trap. The combination of NOx trap and SCR technologies improves NOx control at very low engine temperatures, such as those experienced immediately after engine start-up and during prolonged stop–start city driving, and provides an effective aftertreatment solution over the full range of driving conditions. Additional use of NOx traps should be positive for pgm loadings, although this will be offset by increasing uptake of SCRF™ technology and the corresponding loss of the pgm-coated DPF brick.

The future of NOx trap technology

NOx traps are currently undergoing a phase of technical development aimed at optimising their performance when used in conjunction with SCR or SCRF™ to ensure that NOx limits can be met over a wide range of different driving conditions. The catalysts being developed fall into two broad families: lean NOx traps and passive NOx adsorbers. In either case, these bricks also provide the functionality of the DOC.

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In an LNT, NOx is adsorbed onto the surface of the catalyst while the engine operates in its normal 'lean' (fuel-poor, oxygen-rich) mode. Periodically, the engine switches to 'rich' (fuel-rich, oxygen-poor) conditions for a few seconds at a time, via the injection of additional fuel: this regenerates the NOx trap, reducing the NOx to nitrogen gas and water. The LNTs being developed for Euro 6d are designed for use in conjunction with SCR or SCRF™ and will be used mainly to control NOx at lower engine temperatures: as the engine heats up, the SCR takes over most of the work of converting the NOx. These NOx traps will be platinum-rich and relatively highly loaded compared to other catalyst bricks but, unlike their Euro 6b predecessors, they will not necessarily contain rhodium.

A second family of NOx traps can be referred to as passive NOx adsorbers (PNAs); the diesel Cold Start Concept (dCSC™) catalyst currently being developed by Johnson Matthey broadly falls into this category. This type of NOx trap adsorbs NOx at very low temperatures such as those during engine start-up, and then releases it once the engine has warmed up, but unlike a conventional LNT does not convert the NOx to nitrogen gas and water – instead, this reaction occurs downstream, over the SCR or SCRF™ brick. Use of this technology removes the need for rich purges, thus reducing the fuel penalty of NOx trap regeneration, and provides excellent 'cold start' performance . These NOx traps contain platinum (for HC and CO conversion) and palladium (to trap the NOx), but rhodium is not required.

European emissions limits, compression ignition (diesel) vehicles

	Euro 1	Euro 2	Euro 3	Euro 4	Euro 5	Euro 5b	Euro 6b	Euro 6c / 6d-TEMP	Euro 6d
	Jul 1992	Jan 1996	Jan 2000	Jan 2005	Sep 2009	Sep 2011	Sep 2014	Sep 2017	Jan 2020
Fuel sulphur limit (ppm)	(2000)	500	350	50	≤10	≤10	≤10	≤10	≤10
CO (mg/km)	2720	1000	640	500	500	500	500	500	500
HC + NOx (mg/km)	970	700	560	300	230	230	170	170	170
NOx (mg/km)			500	250	180	180	80	80	80
PM (mg/km)	140	80	50	25	5	4.5	4.5	4.5	4.5
PN # (Nb/km)						6*E11	6*E11	6*E11	6*E11
Durability ('000 km)	80	80	80 or 5 yrs	100 or 5 yrs	160	160	160	160	160
RDE conformity factor NOx								2.1	1.5
RDE conformity factor PN#								TBC	TBC

Dates and limits given are for Category M and N1 Class I vehicles, dates for N1 Class II & III vehicles are typically applied one year later in each case.

Dates given refer to new vehicle type approvals, all vehicle models must meet the limits generally one year later.

Forecast of Palladium SUPPLY & DEMAND IN 2016

FORECAST: PALLADIUM

- The palladium market will remain in significant deficit, with higher auto demand and little change in supplies.
- Auto scrap volumes have been hit by weak steel prices, dampening growth in palladium recoveries.
- Autocatalyst demand will set a new record, with Chinese car sales boosted by tax incentives.
- Liquidation of palladium ETFs has slowed, but investment will remain in negative territory in 2016.

Palladium demand is forecast to rise by 5% to 9.69 million oz in 2016, as growth in autocatalyst demand outweighs a slight decline in industrial consumption. Palladium investment, mainly via ETFs, is likely to remain in negative territory, but the rate of selling has decreased this year compared with 2015. Meanwhile, mine shipments will rise only marginally, while growth in the autocatalyst recycling sector will again fall short of expectations, leaving combined primary and secondary supplies up by 1%, and the market in a deficit of over 650,000 oz.

This very strong fundamental position has not been fully reflected in price movements, partly because the existence of market stocks continues to weigh on investor and speculator sentiment. Physical investment demand remains depressed, with continued redemptions of ETF holdings, which fell by nearly 300,000 oz in the first nine months of 2016. On the futures markets, speculator sentiment has been muted, with net long positions well below their 2014 peak of 3 million oz. Net longs on NYMEX were below 1 million oz for most of the first seven months of 2016, recovering to a high of 1.65 million oz in mid-August as palladium moved above $700, but subsequently retreating to 1.3 million oz in mid-October as the price retraced to below $650.

For the time being, market stocks remain adequate to supply consumer needs, and there is little sign of stress in the physical market: while premiums for sponge over ingot moved higher in mid-year, perhaps reflecting some shortage of South African metal in the wake of some refinery disruption at Anglo Platinum in the first half, they have since returned to more normal levels.

Supplies of palladium from South Africa are forecast to drop by 4% to 2.57 million oz in 2016, with sales from producer stocks set to fall sharply compared with the previous two years. Underlying mine output will be stable or marginally higher, in contrast to platinum production, which is predicted to decline slightly. Palladium will benefit from increased production at a number of mines exploiting relatively palladium-rich ores, including Mogalakwena on the northern limb of the Bushveld, and some eastern limb UG2 operations.

Palladium Supply and Demand '000 oz			
Supply	**2014**	**2015**	**2016**
South Africa	2,125	2,684	2,571
Russia	2,589	2,434	2,487
Others	1,389	1,326	1,427
Total Supply	**6,103**	**6,444**	**6,485**
Gross Demand			
Autocatalyst	7,500	7,655	7,840
Jewellery	272	225	215
Industrial	2,001	2,039	1,987
Investment	943	-659	-357
Total Gross Demand	**10,716**	**9,260**	**9,685**
Recycling	-2,752	-2,460	-2,549
Total Net Demand	**7,964**	**6,800**	**7,136**
Movements in Stocks	-1,861	-356	-651

At Mogalakwena, Anglo American Platinum's large open-pit mine on the northern limb, mill throughput rose by 6% in the first half, although a slight fall in grade limited the gain in pgm production to around 2%. Full-year production of pgm in concentrate is likely to reach record levels, around 400,000 oz of platinum and perhaps as much as 450,000 oz of palladium.

On the eastern Bushveld, several mines reported a strong operational performance in the January to June period. Northam's Booysendal mine completed the ramp-up of its UG2 mining operations and also began to extract

"Palladium sales from South African producer stocks are set to fall sharply."

small quantities of Merensky Reef, lifting first-half palladium output by over 50% compared with last year. At the Two Rivers mine, a joint venture between Impala Platinum and African Rainbow Minerals (ARM), additional ore tonnes have been treated through another facility, lifting mill throughput by 8% and palladium output by 12% in the first six months of 2016. Meanwhile, two Anglo joint ventures on the eastern Bushveld – Modikwa (with ARM) and Mototolo (with Glencore) – also reported strong first-half production, with palladium output boosted by a combination of higher tonnage and improved grades.

Output of pgm from Norilsk Nickel's Russian operations was little changed in the first half of 2016. However, the company continues to forecast a decline in full-year production: palladium output is expected to be 2.30–2.39 million oz, and platinum 542,000–586,000 oz. This compares with full-year 2015 output of around 2.58 million oz of palladium and 610,000 oz of platinum.

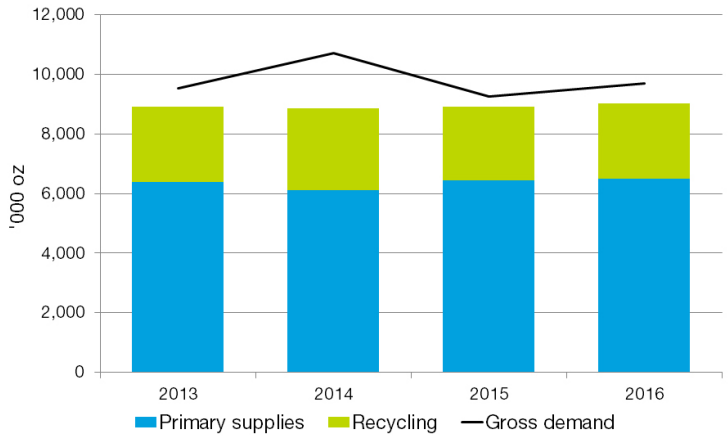
"Norilsk Nickel should maintain pgm shipments by drawing upon inventories."

It is likely that expectations of lower output in the second half relate to ongoing changes to the process flowsheet at the Norilsk and Kola processing plants. The old nickel smelter at the Norilsk mine site has now been closed (although the newer Nadezhda smelter continues to operate), and some nickel- and pgm-processing activities are being transferred to the company's Kola Division and to Norilsk Nickel Harjavalta in Finland. This is predicted to result in a one-off, permanent pipeline build that is currently expected to occur between the fourth quarter of 2016 and the first quarter of 2017.

However, the company should be able to maintain pgm shipments at or even slightly above last year's level, by drawing upon inventories of refined platinum and palladium that it accumulated during 2015. In the first half of 2016, sales of palladium from refined inventories totalled 123,000 oz.

In May 2016, it was reported that Norilsk Nickel had begun pilot purchases for its Global Palladium Fund, in which it may invest up to $200 million. Norilsk's intention is to reduce market volatility by acquiring market stocks held by the Russian central bank and by hedge funds. Such transactions involve a change in the ownership of existing market stocks, but do not affect our supply or demand numbers.

Palladium supply and demand



Palladium supplies from North America are predicted to rise by 7% to 922,000 oz in 2016, with increased pgm output from primary pgm mining and from nickel operations.

In the first half of this year, Stillwater Mining reported a modest increase in both mill throughput and mined pgm output, due to improved efficiencies and productivity at its Stillwater and East Boulder mines in Montana, USA. For the full year, it expects combined platinum and palladium production to reach 535,000–545,000 oz, up from 521,000 oz in 2015.

Canada's only primary palladium miner, North American Palladium, reported a 14% increase in palladium output in the first half of 2016, to 78,000 oz. This gain was due to a mill shutdown in the comparable period of 2015. However,

"Mine shipments of palladium are forecast to grow by only 1% in 2016."

the outlook for the remainder of this year is muted: the underground mine is transitioning to a new mining method, and production has been affected by seismic events and related ground problems.

Over a third of total North American palladium output is derived from nickel mining, mainly from Vale's and Glencore's Canadian operations, although small quantities of pgm are produced in the USA, notably from Lundin's Eagle mine in Michigan. In the first half, Vale reported a significant increase in nickel and copper output from its Sudbury operations, which we expect to be reflected in higher full-year pgm totals. Refined palladium output in the first half was down slightly at 195,000 oz; it should be noted that this figure includes concentrate produced by other miners.

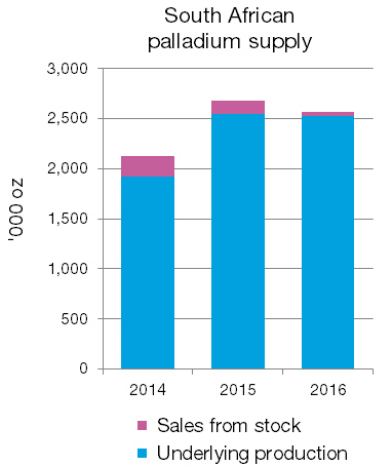
In the first half of 2016, Glencore reported production of 101,000 oz of palladium via its Integrated Nickel Operations, a 10% increase on the same period of last year. We believe that this gain is related to higher copper grades at the company's Nickel Rim South mine in Sudbury, and higher throughput of Raglan material, which is relatively palladium rich. Raglan ores are reported to average around 1.8 grams of palladium per tonne, compared with 1.25 grams per tonne at the company's Sudbury operations.

"Catalyst scrap volumes in the US and Europe showed little improvement in the first nine months of 2016."

We have revised our estimates of supplies from other regions based on new information from China, where output of pgm has increased in recent years in line with higher ore production and improved recoveries.

Overall, mine shipments of palladium are forecast to grow by only 1% in 2016, while the recovery of palladium from secondary materials is expected to be sluggish for a second consecutive year. The recycling of palladium from spent autocatalysts is predicted to rise by 5% this year, a lower rate of growth than we anticipated in our May 2016 report: the volume of catalyst scrap reaching US and European refineries was unusually weak in 2015, and showed little signs of improvement during the first nine months of 2016. This depressed performance appears to be related to weak steel and pgm prices, and is discussed in more detail on page 5.

Most of the growth in palladium recycling this year will come from catalyst scrap collected from end-of-life vehicles in China and some Rest of World countries. The first significant use of palladium catalysts on gasoline cars in China occurred around ten years ago, and these vehicles are now reaching scrap yards in greater numbers. There has also been a notable increase in scrap collection in markets such as India, South America and Korea, all of which have had catalyst-enforcing emissions legislation for gasoline cars for at least the last decade.



North America is by far the largest source of palladium recovered from catalyst scrap, due to the early adoption of palladium catalysts by US automakers, and the very high loadings that were sometimes employed in the late 1990s and early 2000s, when engine and catalyst technology was less advanced and fuels less clean. We had expected to see some growth in the palladium content of US scrap this year. However, during the first nine months of 2016, the pgm split in refinery intakes was largely unchanged. We expect palladium recovery from catalyst scrap in North America to rise by only 1% this year.

The relentless expansion of palladium autocatalyst demand is set to continue in 2016, with worldwide usage on vehicles expected to rise by 185,000 oz to set a new record

Palladium Demand: Autocatalyst '000 oz									
	Gross			Recycling			Net		
	2014	2015	2016	2014	2015	2016	2014	2015	2016
Europe	1,583	1,624	1,639	-469	-396	-398	1,114	1,228	1,241
Japan	785	773	782	-119	-106	-110	666	667	672
North America	1,961	2,026	1,944	-1,335	-1,110	-1,124	626	916	820
China	1,623	1,662	1,944	-82	-116	-161	1,541	1,546	1,783
Rest of World	1,548	1,570	1,531	-184	-211	-239	1,364	1,359	1,292
Total	**7,500**	**7,655**	**7,840**	**-2,189**	**-1,939**	**-2,032**	**5,311**	**5,716**	**5,808**

of 7.84 million oz. In the last seven years, annual consumption of palladium in autocatalysts has risen by nearly 4 million oz; gross demand in this application alone now exceeds world primary supplies by over 20%, underscoring the critical importance of recycling for the palladium market.

Gasoline applications, including motorcycles and a small number of gasoline heavy duty vehicles in China, account for over 85% of auto demand, with the remainder occurring in diesel catalysts.

There has been little change in global average palladium loadings on gasoline catalysts over the last year. While there has been some modest thrifting in Europe and the USA, this has been offset by higher loadings in China, where the implementation of China 5 regulations began this year.

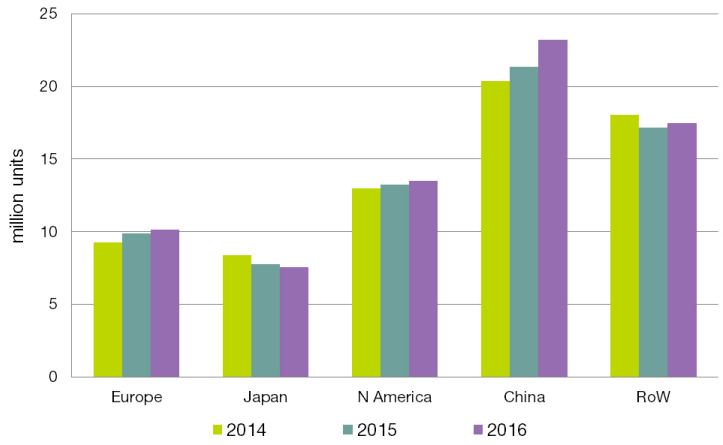
"This year's growth in automotive palladium demand will be driven by increases in light duty vehicle output."

Likewise, palladium loadings on diesel catalysts have shown no overall growth. Although the palladium content of catalyst systems will increase moderately in many developing markets, this will be offset by lower palladium content on catalysts fitted to Euro 6b vehicles, where a higher ratio of platinum in the aftertreatment system is beneficial for optimal NOx conversion.

This year's growth in automotive palladium demand will therefore be driven almost entirely by increases in light duty vehicle output. Of the world's major automotive markets, only Japan is expected to contract in 2016; in Europe and North America, output is set to expand by around 3%, while China will see production rise by 9% to exceed 24 million units.

In China, car sales were up 15% at 16.7 million units in the first nine months of 2016, as consumers took advantage of a temporary tax break on smaller vehicles. In October 2015, the government halved the purchase tax on vehicles with engines smaller than 1.6 litres, in response to a steep fall in vehicle sales triggered by a collapse in the Chinese stock market which eroded household wealth.

Light duty gasoline vehicle production by region



This government policy had a number of objectives, beyond simply encouraging people to buy cars. It was intended to support Chinese-owned carmakers, whose product ranges tend to focus on smaller vehicles, as well as to encourage consumers to opt for models with smaller, more fuel-efficient engines and lower exhaust emissions. As a result of the tax break, Chinese car companies have seen their market share rise significantly this year. They have been particularly successful in the compact sports utility vehicle (SUV) segment, where Chinese brands offer a wider range of models than their international competitors.

With this tax concession due to expire at the end of the year, it is likely that the final months of 2016 will see consumers rush to buy new vehicles before it is too late. Dealers are

"China 5 emissions limits have been enforced in eleven provinces and cities since April 2016."

engaging in a variety of promotional activities to encourage consumers to bring forward their purchases, including discounts as well as countdown timers on websites and in stores. While this is likely to be positive for sales in the final months of 2016, it risks having a negative effect on demand in the early part of next year. As a result, the China Association of Automobile Manufacturers is lobbying the government to make the tax cut on small cars permanent, on the basis that this will encourage the development of fuel-efficient vehicles.

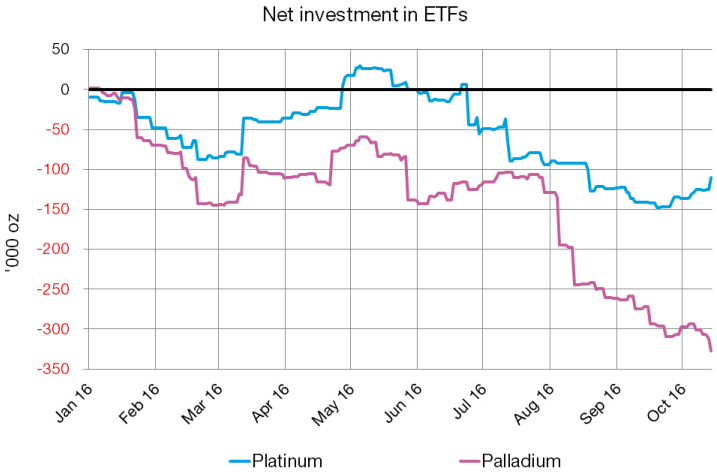
This boom in car sales and production has coincided with rising palladium loadings on many Chinese vehicles. China 5 emissions limits have been enforced in eleven provinces and cities since April 2016, and many of the cars produced and sold in 2016 will comply with these stricter standards. This should help lift Chinese autocatalyst demand for palladium by 17%, to 1.94 million oz.

"The use of palladium in its core electrical and chemical applications will weaken slightly in 2016."

Demand for palladium in jewellery is forecast to decline. In the USA, palladium has established a small niche as a jewellery metal in its own right: it is primarily sold as an affordable alternative to platinum for men's bridal rings. However, lower platinum prices have reduced palladium's economic advantage, and we think that demand is likely to be flat this year. In China, where demand for palladium jewellery peaked at 1.5 million oz in 2005, fabrication of palladium jewellery is now almost non-existent (and net demand, after accounting for recycling, is negative).

Palladium is also used as an alloying agent in both platinum and white gold jewellery. In Japan, where platinum jewellery alloys typically contain between 5% and 15% palladium, palladium usage has been hit by a combination of lower jewellery fabrication and a move to higher platinum-content alloys. In Europe, white gold has been the most popular precious jewellery metal for the last several years, and this provides a solid base for palladium demand (very little nickel is used in white gold in Europe due to allergy concerns). However, the market share of white gold is being eroded by an increase in the popularity of rose and yellow gold.

The use of palladium in its core industrial applications in the chemical and electrical sectors will also weaken slightly in 2016, as will purchasing of palladium alloys by dental laboratories. Demand for palladium catalysts in the Chinese bulk chemical industry is expected to ease, following record offtake in 2015, with some plant expansions being delayed. It should be noted that we have downgraded our estimates of chemical demand in the last two years, reflecting new information on thrifting of catalyst loadings and the extension of catalyst lifetimes in the purified terephthalic acid (PTA) industry.



Elsewhere, trends in the electronics industry remain unchanged, with gradual thrifting of palladium from multi-layer ceramic capacitors being partly offset by robust demand for palladium in the plating of connector and lead frames. In the dental sector, the largest market, Japan, is shrinking as resins and ceramic materials take market share from palladium-containing 'Kinpala' alloy. As a result, some alloy suppliers have begun to withdraw from the market.

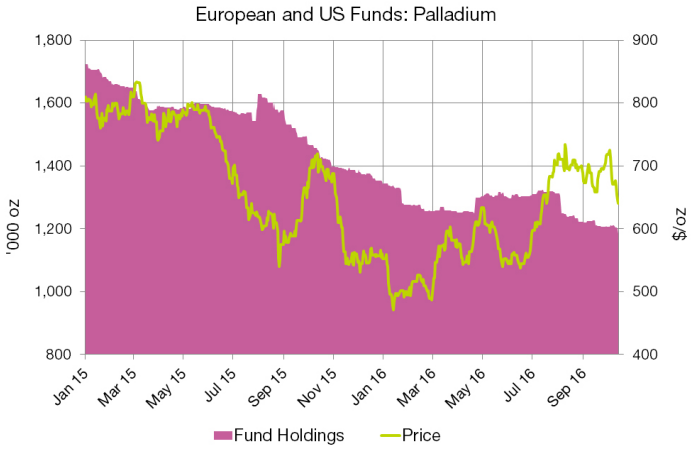
"ETF redemptions will fall sharply this year, pushing the palladium market further into deficit."

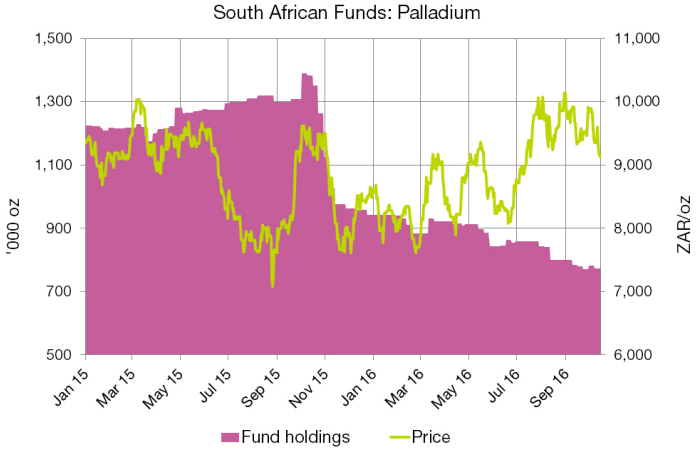
In the last seven years, demand for palladium in its 'consuming applications' (i.e. total palladium use in automotive, industrial and jewellery applications) has shown consistent growth, from a post-financial-crisis low of 7.2 million oz in 2009 to a forecast 10 million oz in 2016. However, over this period, very large annual swings in investment demand have obscured this underlying trend. Thus, our headline number for total demand in 2016, at 9.7 million oz, remains below the 2014 peak, and only modestly above the 2010 level of 9.5 million oz.

Over this period, annual changes in ETF demand have determined the direction of change in the supply–demand balance – although, since Russian government stock sales ceased from 2013, the market has been consistently in deficit to a greater or lesser degree. This will remain the case in 2016: ETF redemptions will fall sharply, leading to a positive swing in investment demand of 302,000 oz, which will push the market further into deficit by a similar amount.

This year's ETF liquidation has been concentrated in South Africa: activity in the longer-established funds in North America and Europe has been rather subdued during 2016, although the overall picture remains one of profit-taking. There was some opportunistic buying in some of the European funds during the second quarter, but this was reversed as the palladium price moved temporarily above $700 in August. Overall, combined US and European ETF holdings fell by around 135,000 oz in the first nine months of 2016.

In South Africa, demand for pgm ETFs has been affected by a change in sentiment towards mining company stocks, with investors rotating out of their metal holdings and into equities. Palladium price and exchange rate movements have probably intensified this process: in rand terms, palladium rose by more than 25% between mid-2015 and September 2016, putting many South African investors in a position to take profits. In the first nine months, South African investors reduced their ETF holdings by over 160,000 oz.





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Outlook for Palladium
SUPPLY & DEMAND IN 2017

OUTLOOK: PALLADIUM

- Mine supplies of palladium will be flat, but recycling could bounce back if steel prices rise.
- Palladium demand is forecast to grow, leaving the market in significant deficit for a sixth consecutive year.
- Tighter legislation should boost auto consumption, even if Chinese car sales slow.
- With palladium ETFs vulnerable to profit-taking, investment may remain in negative territory.

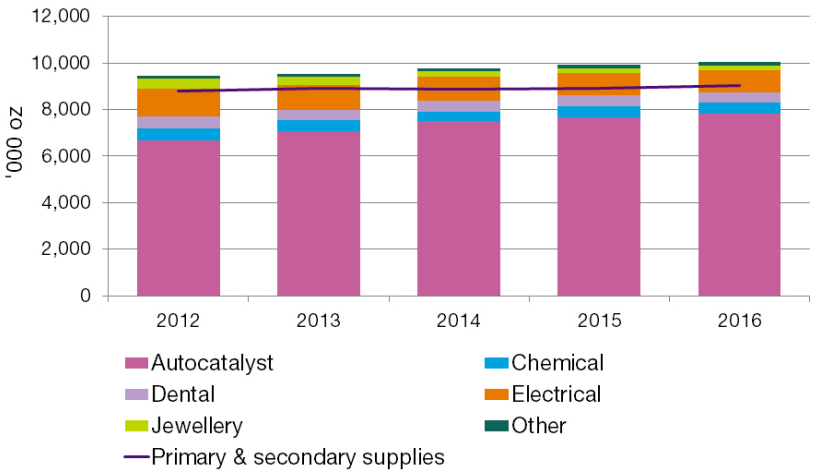
Mine shipments of palladium are predicted to remain flat in 2017, while gross demand in 'consuming applications' – autocatalyst, industrial and jewellery – is set to continue its upward march. The market is likely to remain in fundamental deficit even if there is a rebound in recycling volumes and ETF holders continue to liquidate their investments.

Since sales of Russian state stocks ceased from 2013, global supplies of palladium have been broadly flat at around 6.4–6.5 million oz per annum, with the exception of 2014 when pgm output in South Africa was disrupted by strike action. We expect primary shipments to remain stable at around this level for at least another two years.

South Africa and Russia each supply similar amounts of palladium: between 2.5 and 2.6 million oz in 2016. There has been some growth in South African output in recent years, mainly due to expansion at Anglo American Platinum's Mogalakwena mine which exploits the palladium-rich Platreef ore body, and to a lesser extent as a consequence of increased extraction of eastern Bushveld platinum ores. However, palladium output from Russia's Norilsk Nickel has been in gradual decline, from over 3 million oz in 2007 to below 2.6 million oz in each of the last three years.

Next year should see shipments from both countries continue at similar levels to those seen in 2016. In South Africa, there is some minor growth to come from expansions and debottlenecking, but the likelihood of periodic production losses due to safety stoppages, labour unrest and technical incidents remains high. The underlying trend in Russian production is flat, but there is some risk of short-term disruption during the transfer of some base metal and pgm refining activities from the Polar site to the Kola Peninsula.

Palladium demand in consuming applications (excluding investment)



In both regions, there is some prospect of growth in palladium supplies in the long term. For example, in South Africa, Ivanplats and Platinum Group Metals Limited continue to work on their projects on the northern limb of the Bushveld, which could ultimately produce substantial quantities of palladium. However, significant technical and financial hurdles remain to be overcome before either of these projects can contribute to supplies. Likewise, in Russia, there may be some potential for increases in output from Norilsk Nickel's 'South Cluster' operations and from the neighbouring Chernogorskoye project being

> **It will require significant increases in both steel and pgm prices for recycling volumes to recover.**

developed by Russian Platinum. However, the timing and ultimate size of these projects remain very uncertain and they are unlikely to add to supply this decade.

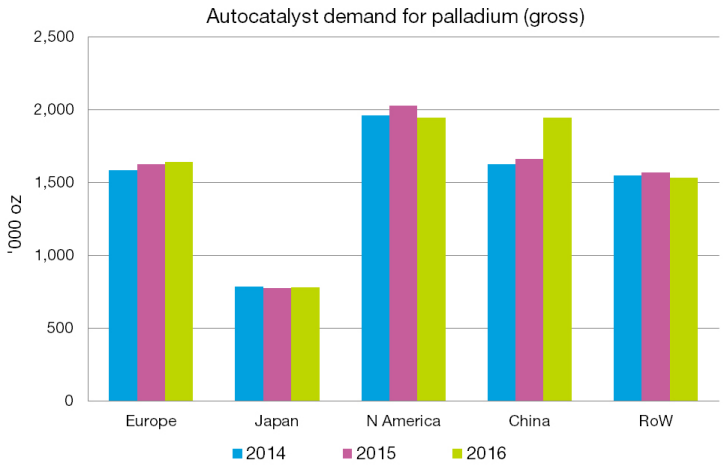
Elsewhere, the only firm, near-term prospect of higher palladium supply outside southern Africa is at Stillwater Mining's operations in the USA. The company is developing a new mining section, known as Blitz, adjacent to its Stillwater mine. This project is scheduled to enter production towards the end of next year, but is unlikely to make a significant contribution to pgm supplies before 2018.

The J-M reef mined by Stillwater contains exceptionally high pgm grades compared to most other deposits worldwide: the ore extracted by the company's current mining operations at Stillwater and East Boulder typically contains around 15 grams of combined platinum and palladium per tonne, while Blitz will mine even richer ores, expected to grade over 20 grams per tonne (including at least 15 grams of palladium). These will be the richest palladium ores mined anywhere in the world. At completion, the company expects the project to add around 270,000–330,000 oz of pgm output per annum, of which around three-quarters will be palladium.

> **It seems probable that increases in demand for palladium will continue to outstrip growth in supplies.**

With little prospect of any significant increase in primary supplies, the market will remain heavily reliant on recycling, which in the last two years has contributed about 2.5 million oz of palladium per annum, equivalent to 28% of all palladium shipments from combined primary and secondary sources. Most of this metal is sourced from the recycling of autocatalysts removed from end-of-life vehicles (ELVs), with smaller amounts coming from the processing of electronic and jewellery scrap.

Expectations of rising recoveries of palladium from spent autocatalyst have been disappointed in the last two years. A fall in steel prices has resulted in fewer vehicles entering the scrap collection circuit, depressing recoveries of all the autocatalyst pgm; in addition, it appears that there has been some periodic hoarding of scrap in the hope of benefiting from higher pgm prices in future. As a result, pgm recoveries have fallen from their 2014 peak, rather than rising steadily as market commentators had anticipated.



Refinery intakes remain depressed at the time of writing in October 2016. In our view, it will require significant increases in both steel and pgm prices for recycling volumes to recover to pre-2015 levels of activity. Should this happen, it could result in substantial quantities of unprocessed scrap entering the recycling circuit, and in turn could lead to sizeable short-term growth in palladium recoveries. However, at present, there is no sign of any imminent rebound, and it is possible that refinery intakes could remain depressed for another year.

This means that there is a wide range of uncertainty with regards to the trajectory of combined primary plus secondary supplies in 2017. However, regardless of the rate of growth in secondary palladium shipments, it seems probable that increases in demand will continue to outstrip growth in supplies.

"China could be the world's largest market for palladium in autocatalysts in 2017."

Our projections for next year suggest that gains in automotive demand for palladium will exceed underlying growth rates in vehicle output, due to tightening legislation in China and the USA, while industrial demand will be boosted by a strong performance from the chemicals sector. Thus, even if investors continue to liquidate their ETF holdings for a third consecutive year, we should see some overall growth in total palladium demand.

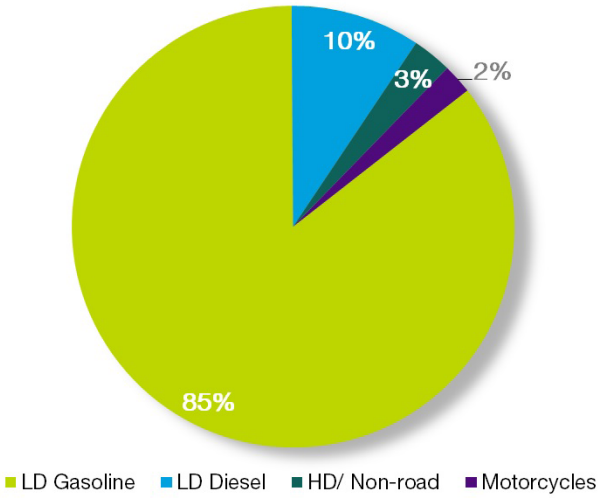
In China, a tax break on the purchase of smaller vehicles is due to come to an end on 31st December 2016. It is likely that the removal of this incentive will lead to a cooling-off in car sales, which have been growing at a double-digit pace for much of 2016. However, underlying demographic factors remain positive: increasing numbers of young people in less developed cities (tiers 3 to 6) are purchasing vehicles, which are seen as relatively affordable compared with the high and rising cost of real estate. Overall, we expect car sales to be flat to slightly up next year, while domestic output of gasoline cars is likely to stabilise at around 23 million units.

We continue to forecast growth in sales of palladium to Chinese automakers, which could exceed 2 million oz in 2017, making China the world's largest market for palladium in autocatalysts. The average palladium loading on a Chinese gasoline car is set to grow again next year, as China 5 standards for light duty gasoline vehicles are implemented nationally starting in January 2017. In addition, palladium is gradually increasing its share of diesel catalyst demand, although this remains a minor component of the total market: diesel's share of light duty vehicle output in China is less than 3%.

The average pgm content of Chinese vehicles is lower than in Europe, despite vehicles in the two regions having a similar average engine displacement. Automakers in China have benefited from experience gained in meeting Euro 5 and 6 emissions standards in the European market, enabling them to optimise pgm loadings on their vehicles. However, it is likely that this gap will begin to close in coming years, as China implements emissions legislation which will, at the time of proposed implementation, be the strictest in the world.

China 6a limits will be enforced nationwide starting in July 2020, bringing Chinese legislation into line with European standards, although permitted carbon monoxide emissions will be half those mandated under Euro 6c. This will be followed by a second stage of legislation, China 6b, currently expected to be applied nationwide in 2023, which will further tighten standards for total hydrocarbon, non-methane hydrocarbon, particulate matter and NOx, and will also enforce RDE testing. While there is still considerable uncertainty over catalyst fitment strategies for the new legislation, there is no doubt that Chinese automakers will need to use higher pgm loadings on three way catalysts, and in some cases will also need to equip vehicles with palladium-rich gasoline particulate filters (GPFs).

Palladium demand by auto sector 2016



India is another growing car market with potential for significant increases in both gasoline vehicle output and pgm loadings. At present, Indian emissions legislation is moving to the equivalent of Euro 4, and loadings remain comparatively low, but the implementation of Bharat 6 (equivalent to Euro 6) legislation from around 2020 should see the palladium content of catalysts

"India is seeing strong growth in output of gasoline cars, forecast to rise by a double-digit percentage again next year."

starting to rise. India is currently seeing strong growth in output of gasoline cars, expected to rise by a double-digit percentage again next year, reflecting overall expansion of light vehicle production combined with gains in gasoline market share at the expense of diesel.

Elsewhere in the Rest of World region, important markets such as Indonesia, Iran, Russia and Brazil are predicted to see some recovery in car output in 2017 following a period of weak demand for vehicles. All of these countries have catalyst-enforcing emissions legislation for gasoline vehicles, but there have been no major changes in emissions legislation, and loadings across the Rest of World region are broadly stable. The exception is Mexico, where the average palladium content on Mexican-built cars exported to the USA is rising, to comply with tightening fleet standards imposed by Californian LEV III and Federal Tier 3 legislation.

Europe is likely to see another modest rise in gasoline car output in 2017, but slight thrifting on gasoline catalysts will leave overall palladium demand little changed. The implementation of Euro 6b legislation has had little impact on catalyst fitment on gasoline vehicles. However, the application of a tighter particle number limit on gasoline vehicles under Euro 6c (from September 2017), combined with the implementation of real driving emissions (RDE) testing under Euro 6d-TEMP and Euro 6d, is expected to lead to some upward pressure on loadings in future. In particular, we expect some additional use of GPFs, especially once conformity factors tighten starting in 2020.

"In North America, tougher emissions limits will lead to increases in gasoline and diesel palladium loadings."

In North America, the last seven years have seen a strong recovery in output of light duty vehicles, from a post-financial-crisis low of just over 7 million units to a predicted 13.9 million in 2016 (of which 94% will have gasoline engines). Growth has now begun to flatten off and car production may fall next year. Nevertheless, there should still be room for an increase in the use of palladium on autocatalysts, due to the phased implementation of tougher Californian and Federal emissions standards. This will lead to some modest increases in palladium loadings on gasoline cars, and a sharp rise in palladium usage on diesel vehicles, some of which are being fitted with an additional palladium-rich brick in order to improve NOx control at low engine temperatures (for further details, refer to our special feature on page 20).

Demand for palladium in industrial applications should be firm in 2017, with demand from the Chinese chemicals sector set to bounce back, partly due to delays in plant construction which have pushed some catalyst purchases into next year. We also expect to see strong sales of palladium to hydrogen peroxide producers, who are expanding their capacity in response to growing downstream demand for caprolactam and propylene oxide (for which hydrogen peroxide is a precursor).

"Industrial demand for palladium should be firm in 2017, with Chinese chemicals sector purchases set to bounce back."

The largest uncertainty on the demand side is, as ever, in the investment sector. During the first nine months of 2016, South African investors benefited from relative strength in the rand-denominated palladium price to rotate out of ETFs and into equities. While the rand-denominated palladium price has been on a downward trend since September, some investors may still be in a position to take profits. Likewise, a significant proportion of the metal held in North American and European funds was acquired before 2011 at prices below $600, leaving many investors 'in the money' even after recent price declines. Thus, palladium is probably still more vulnerable to ETF profit-taking than platinum, and investment demand could remain in negative territory for another year.

Forecast of Rhodium SUPPLY & DEMAND IN 2016

FORECAST: RHODIUM

- The rhodium market will remain in surplus in 2016, despite flat supplies and higher autocatalyst demand.
- South African shipments will fall, due to weak output from some large western Bushveld mines.
- Low steel prices are hampering the auto recovery market, but scrap volumes are rising in China and the Rest of World.
- Although world auto production will rise, rhodium thrifting by Japanese car companies will limit demand growth.

The rhodium market will remain in surplus in 2016, despite a modest increase in demand from the autocatalyst and glass sectors. While primary supplies edge lower, this will be offset by a modest increase in recycling. The market's move into surplus over the last two years has been accompanied by a slide in prices, from above $1,000 at the beginning of last year to a low below $600 in mid-2016.

Primary supplies of rhodium are expected to fall this year, mainly due to a decline in output from some of the large South African producers. This will more than offset slightly higher shipments from Zimbabwean miners.

The large western Bushveld mining complexes owned and operated by Anglo American, Impala Platinum and Lonmin mainly exploit the rhodium-rich UG2 orebody, and account for more than half of total rhodium production from South Africa. However, several of these mines reported a difficult first half of 2016: we estimate that mined output of rhodium from Anglo's Rustenburg mines, Impala's lease area and the Lonmin Marikana operation recorded a double-digit decline in the January to June period. This was due to a combination of shaft closures, safety stoppages, and serious fire damage at one of Impala Platinum's shafts. For the full year, we think that underlying rhodium production in South Africa will be down 2% to 3% compared with 2015.

Our rhodium supply figure for this year incorporates a further modest contribution from the sale of stocks, mainly because some producers ended 2015 with above-normal pipeline inventories. However, this will be partly offset by stockpiling of concentrates during the refurbishment of Anglo American's Waterval smelter, which was shut down for maintenance following a furnace run-out in September.

Rhodium supplies from Zimbabwe will set a new all-time high in 2016. Zimplats has recovered from the temporary closure of its Bimha mine due to subsidence in 2014, and will mine and treat record quantities of ore this year. In addition, pgm output will be boosted by the processing of some stockpiled material that was accumulated following a smelter outage last year. Unki and Mimosa are also on course to match or exceed previous production records. However, supplies from other regions will be flat.

Rhodium Supply and Demand '000 oz			
Supply	**2014**	**2015**	**2016**
South Africa	469	611	593
Russia	80	80	80
Others	66	63	70
Total Supply	**615**	**754**	**743**
Gross Demand			
Autocatalyst	791	763	778
Other	189	171	186
Total Gross Demand	**980**	**934**	**964**
Recycling	-307	-273	-283
Total Net Demand	**673**	**661**	**681**
Movements in Stocks	-58	93	62

The rhodium market is dominated by a single application: autocatalyst. Since the mid-2000s, gross rhodium demand from the auto sector alone has exceeded primary mine supply in most years, making the rhodium market unusually dependent upon recycling. Typically, the recycling of spent autocatalysts accounts for over a quarter of total primary and secondary supply – compared with 15% for platinum and 22% for palladium.

Johnson Matthey
Precious Metals Management

"Most of this year's growth in rhodium recycling will come from China and the Rest of the World region."

Recoveries of rhodium from catalysts removed from end-of-life vehicles are expected to rise by 4% this year – well below the 9% increase we predicted in our May 2016 report. Refinery intakes of spent catalysts have been depressed since late 2014; as discussed on page 5, weak steel prices have resulted in fewer vehicles reaching scrap yards, while low pgm prices have encouraged periodic hoarding of catalyst scrap in some parts of the collection circuit. We had expected to see a rebound in collection levels this year, but in the first nine months of 2016 there was little evidence of any return to normal in scrap volumes in the USA and Europe.

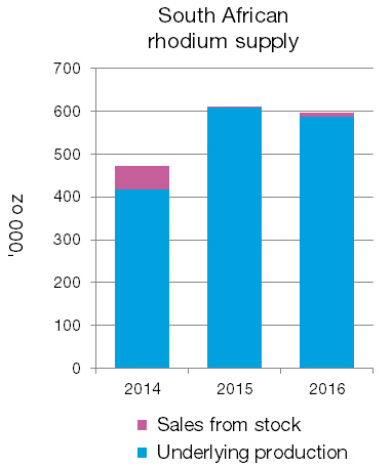
Most of this year's growth will come from China and the Rest of World region, where catalyst-equipped cars are now arriving in scrap yards in greater numbers. However, recoveries of rhodium from European scrap will fall slightly, despite a small increase in platinum recycling. In this region, there is a long-term declining trend in the average rhodium content of scrap, reflecting the rise in diesel market share and the increased use of platinum-only oxidation catalysts in the late 1990s and early 2000s.

"Industrial rhodium use will rise this year, due to robust demand for platinum–rhodium alloys in glassmaking."

Autocatalyst scrap recoveries do not yet reflect the heavy thrifting of rhodium loadings in gasoline catalysts that has occurred over the last decade, as these vehicles are not yet being scrapped in significant numbers. This thrifting occurred first in North America and Europe, particularly during the 2005–2011 period, and subsequently in Japan, where rhodium loadings were until recently significantly higher than in other regions.

Thrifting of rhodium loadings in the USA and Europe has slowed in the last four years, but Japanese car companies continue to reduce the rhodium content of their catalysts, both on vehicles manufactured at their domestic plants and at their transplants in Asia. New information suggests that we previously underestimated the extent of thrifting by Japanese manufacturers in the 2013–2015 period, and we have adjusted our demand estimates for these years accordingly.

Despite this, world demand for rhodium in autocatalysts should rise this year, reflecting growth in car production in many major markets. Both North America and Europe will see steady gains in output of light duty gasoline vehicles, while Chinese car production is expected to grow by 9%. Meanwhile, in India, where the diesel segment has taken much of the market growth seen in recent years, a change in consumer preferences in favour of gasoline cars is forecast to lift output by as much as a third.



The use of rhodium in its traditional industrial applications in the glass, chemical and electrical sectors will rise by 13% this year, mainly due to robust demand for platinum–rhodium alloys used in glassmaking: Chinese companies are investing in new fibreglass capacity both at their domestic and their overseas plants.

However, demand in other applications, including investment, will decline slightly. The launch of a new South African rhodium ETF in late 2015 has not led to any additional demand from investors: while the new product as of mid-October held some 34,000 oz of metal, this purchasing has been more than offset by redemptions in the European rhodium ETF: these movements reflect the repatriation of holdings by South African investors.

Outlook for Rhodium
SUPPLY & DEMAND IN 2017

OUTLOOK: RHODIUM

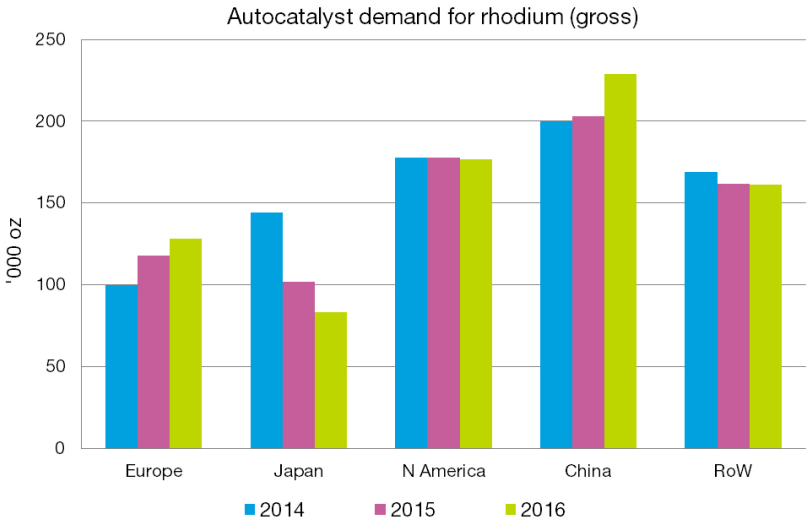
- The rhodium market will remain in surplus in 2017, even though demand is expected to rise.
- Auto demand should show steady growth, in line with higher vehicle output and tighter legislation.
- Primary rhodium supply will be flat in 2017, but recycling could improve if steel prices rise.

Sales of rhodium to auto companies are predicted to rise again in 2017, leaving total gross demand up by 2–3%, while primary supplies are expected to be flat. Recoveries of rhodium from autocatalyst scrap have been weak for the past two years, so there is potential for some increase in secondary supplies; however, it will probably require a significant recovery in steel and pgm prices before auto scrap volumes return to normal. The extent of any growth in recycling will determine whether the rhodium market moves closer to balance, or remains in surplus.

Global supplies of rhodium are derived primarily from platinum mining in South Africa, which accounts for 80% of primary production, compared to around 72% of platinum and under 40% of palladium. In particular, rhodium output is heavily dependent upon volumes of mining from the rhodium-rich UG2 reef.

In recent years, UG2 has accounted for an increasing share of the pgm ores extracted by South African mines, but this trend is set to reverse over the next few years, as Merensky output ramps up at Royal Bafokeng Platinum's Styldrift, Platinum Group Metals Limited's Maseve, and two new shafts at the Impala lease area. Thus, even if ore volumes increase marginally, UG2 mining volumes are likely to remain flat at best. This will limit the potential for any significant gains in rhodium production in the next few years.

In contrast, there is some prospect of higher rhodium recovery from secondary materials, although the trajectory of growth is difficult to predict. Over the last three years, refinery intakes of autocatalyst scrap have been depressed by weak steel and pgm prices; conversely, if steel and pgm prices were to rise next year, it is likely that scrap volumes and metal recoveries would improve. However, there is considerable uncertainty regarding the likely timing and size of this recovery.



The rhodium market was in surplus in 2016, and this is likely to remain the case next year. While consumption trends are expected to be broadly positive, overall growth in gross demand from the automotive and other industries is unlikely to exceed 5%, which would leave the market adequately supplied even if recycling remains flat.

Autocatalyst demand is predicted to show steady growth, in line with forecasts of 2% growth in global

"In both China and the USA, higher rhodium content per vehicle will compensate for flat gasoline car output next year."

production of gasoline vehicles. Rhodium consumption will also benefit from tightening emissions legislation in the two largest gasoline markets, China and the USA.

China 5 standards for light duty gasoline vehicles will be implemented nationally from January 2017, and the pgm content of three way catalysts is expected to increase as a result. In North America, the gradual phase-in of US Federal Tier 3 and California LEV III regulations will also be positive for rhodium loadings. In both regions, a higher rhodium content per vehicle should more than compensate for an expected flattening-off in car output next year.

We also predict some growth in rhodium usage in Europe and the Rest of World region, mainly as a consequence of rising output of gasoline cars. European light duty gasoline output should grow by around 3% next year, the Indian gasoline market is expected to post double-digit gains, while markets such as Indonesia, Iran, Russia and Brazil – which have all suffered downturns in recent years – are expected to see some recovery in car output in 2017.

Looking further ahead, emissions standards for gasoline vehicles are set to tighten significantly in most major markets over the next few years. Starting in September 2017, Europe will adopt a tighter particle number limit on gasoline vehicles under Euro 6c, while RDE testing will be introduced under Euro 6d-TEMP from the same date. Japanese vehicles will be subject to a new emissions testing cycle from 2018, while we also expect to see the introduction of real driving emissions standards in Japan within the next five years. In North America, the implementation of US Federal Tier 3 and California LEV III standards will take place progressively over the period to 2025. China plans to introduce China 6a regulations in 2020 and China 6b in 2023, while India is expected to move directly from Bharat 4 to Bharat 6 (equivalent to Euro 4 and Euro 6, respectively) from 2020. These developments will result in upward pressure on gasoline pgm loadings in all these markets.

"Demand in other industries should remain firm with strong sales of rhodium chemical catalysts."

Demand for rhodium from other industries should remain firm next year, with strong sales of rhodium catalysts to the chemicals industry; however, Chinese investment in new fibreglass capacity may retreat from the highs seen in 2016.

A combination of low prices and increased interest in physical precious metals investment among small investors has been positive for sales of rhodium bars in the last year or two, and fabricators anticipate further growth next year, albeit from a low base. In contrast, the launch of a new South African ETF in late 2015 failed to stimulate the rhodium investment market, and at present there appears to be little appetite for rhodium among institutional investors.

PLATINUM '000 oz - Supply and Demand							
							Forecast
		2011	2012	2013	2014	2015	2016
Supply[1]	South Africa	4,860	4,110	4,208	3,547	4,571	4,347
	Russia[2]	835	801	736	700	670	652
	North America	350	306	318	339	318	369
	Zimbabwe[3]	340	337	410	401	401	486
	Others[3]	100	126	163	156	149	153
	Total Supply	**6,485**	**5,680**	**5,835**	**5,143**	**6,109**	**6,007**
Demand[4]	Autocatalyst[4]	3,185	3,158	3,020	3,120	3,267	3,318
	Chemical	470	452	528	523	567	634
	Electrical[4]	230	176	218	225	229	238
	Glass	515	153	90	212	160	263
	Investment	460	450	871	277	451	487
	Jewellery[4]	2,475	2,783	3,028	2,897	2,829	2,572
	Medical and Biomedical[5]	230	223	214	213	215	217
	Petroleum	210	112	159	165	139	145
	Other	320	395	433	438	439	457
	Total Gross Demand	**8,095**	**7,902**	**8,561**	**8,070**	**8,296**	**8,331**
Recycling[6]	Autocatalyst	-1,240	-1,120	-1,206	-1,282	-1,127	-1,161
	Electrical	-10	-22	-24	-27	-29	-32
	Jewellery	-810	-895	-790	-762	-574	-709
	Total Recycling	**-2,060**	**-2,037**	**-2,020**	**-2,071**	**-1,730**	**-1,902**
	Total Net Demand[7]	**6,035**	**5,865**	**6,541**	**5,999**	**6,566**	**6,429**
	Movement in Stocks[8]	**450**	**-185**	**-706**	**-856**	**-457**	**-422**

PLATINUM '000 oz - Gross Demand by Region							
							Forecast
		2011	2012	2013	2014	2015	2016
Europe	Autocatalyst	1,505	1,323	1,281	1,487	1,658	1,767
	Chemical	120	110	98	103	120	123
	Electrical	20	17	15	14	12	13
	Glass	30	2	6	11	11	11
	Investment	155	135	-40	-73	-88	45
	Jewellery	175	179	219	204	203	183
	Medical and Biomedical	90	78	72	72	71	70
	Petroleum	35	-3	-12	22	-2	9
	Other	95	115	117	115	110	111
	Total	**2,225**	**1,956**	**1,756**	**1,955**	**2,095**	**2,332**
Japan	Autocatalyst	500	591	533	475	413	391
	Chemical	35	35	42	42	41	43
	Electrical	25	21	27	28	28	29
	Glass	130	-3	-20	-96	4	4
	Investment	250	98	-40	19	700	494
	Jewellery	310	312	309	313	314	305
	Medical and Biomedical	20	20	19	19	16	16
	Petroleum	5	3	-1	3	3	3
	Other	40	63	70	71	69	69
	Total	**1,315**	**1,140**	**939**	**874**	**1,588**	**1,354**
N. America	Autocatalyst	370	395	345	356	402	382
	Chemical	95	106	102	113	115	104
	Electrical	25	21	19	18	18	21
	Glass	-5	7	7	12	10	29
	Investment	10	187	57	7	-32	84
	Jewellery	185	187	213	220	240	233
	Medical and Biomedical	90	89	85	83	85	86
	Petroleum	50	46	23	24	37	42
	Other	110	118	124	122	122	122
	Total	**930**	**1,156**	**975**	**955**	**997**	**1,103**
China	Autocatalyst	105	93	130	130	135	165
	Chemical	100	89	146	109	149	169
	Electrical	30	31	36	38	40	40
	Glass	10	53	92	211	111	149
	Investment	0	0	0	0	0	0
	Jewellery	1,680	1,950	2,100	1,935	1,796	1,515
	Medical and Biomedical	10	15	17	17	19	19
	Petroleum	15	21	56	30	32	20
	Other	30	40	49	52	56	69
	Total	**1,980**	**2,292**	**2,626**	**2,522**	**2,338**	**2,146**
RoW	Autocatalyst	705	756	731	672	659	613
	Chemical	120	112	140	156	142	195
	Electrical	130	86	121	127	131	135
	Glass	350	94	5	74	24	70
	Investment	45	30	894	324	-129	-136
	Jewellery	125	155	187	225	276	336
	Medical and Biomedical	20	21	21	22	24	26
	Petroleum	105	45	93	86	69	71
	Other	45	59	73	78	82	86
	Total	**1,645**	**1,358**	**2,265**	**1,764**	**1,278**	**1,396**
	Grand total	**8,095**	**7,902**	**8,561**	**8,070**	**8,296**	**8,331**

PLATINUM Tonnes - Supply and Demand							
							Forecast
		2011	2012	2013	2014	2015	2016
Supply[1]	South Africa	151.2	127.8	130.9	110.3	142.2	135.2
	Russia[2]	26.0	24.9	22.9	21.8	20.8	20.3
	North America	10.9	9.5	9.9	10.5	9.9	11.5
	Zimbabwe[3]	10.6	10.5	12.8	12.5	12.5	15.1
	Others[3]	3.1	3.9	5.1	4.9	4.6	4.8
	Total Supply	**201.7**	**176.6**	**181.6**	**160.0**	**190.0**	**186.9**
Demand[4]	Autocatalyst[4]	99.1	98.2	93.8	97.1	101.6	103.3
	Chemical	14.6	14.1	16.4	16.3	17.6	19.7
	Electrical[4]	7.2	5.5	6.8	7.1	7.2	7.4
	Glass	16.0	4.7	2.9	6.6	4.9	8.1
	Investment	14.3	13.9	27.2	8.6	14.1	15.2
	Jewellery[4]	77.0	86.6	94.1	90.0	88.1	80.0
	Medical and Biomedical[5]	7.2	7.0	6.6	6.6	6.6	6.8
	Petroleum	6.5	3.5	4.9	5.1	4.3	4.5
	Other	10.0	12.3	13.5	13.6	13.6	14.2
	Total Gross Demand	**251.8**	**245.8**	**266.2**	**251.0**	**258.0**	**259.2**
Recycling[6]	Autocatalyst	-38.6	-34.9	-37.5	-39.9	-35.0	-36.2
	Electrical	-0.3	-0.7	-0.7	-0.8	-0.9	-1.0
	Jewellery	-25.2	-27.9	-24.6	-23.7	-17.9	-22.1
	Total Recycling	**-64.1**	**-63.5**	**-62.8**	**-64.4**	**-53.8**	**-59.3**
	Total Net Demand[7]	**187.7**	**182.3**	**203.4**	**186.6**	**204.2**	**199.9**
	Movement in Stocks[8]	**14.0**	**-5.7**	**-21.8**	**-26.6**	**-14.2**	**-13.0**

PLATINUM Tonnes - Gross Demand by Region							
							Forecast
		2011	2012	2013	2014	2015	2016
Europe	Autocatalyst	46.8	41.1	39.8	46.3	51.6	55.0
	Chemical	3.7	3.4	3.0	3.2	3.7	3.8
	Electrical	0.6	0.5	0.5	0.4	0.4	0.4
	Glass	0.9	0.1	0.2	0.3	0.3	0.3
	Investment	4.8	4.2	-1.2	-2.3	-2.7	1.4
	Jewellery	5.4	5.6	6.8	6.3	6.3	5.7
	Medical and Biomedical	2.8	2.4	2.2	2.2	2.2	2.2
	Petroleum	1.1	-0.1	-0.4	0.7	-0.1	0.3
	Other	3.0	3.6	3.6	3.6	3.4	3.5
	Total	**69.2**	**60.8**	**54.5**	**60.7**	**65.1**	**72.6**
Japan	Autocatalyst	15.6	18.4	16.6	14.8	12.8	12.2
	Chemical	1.1	1.1	1.3	1.3	1.3	1.3
	Electrical	0.8	0.6	0.8	0.9	0.9	0.9
	Glass	4.0	-0.1	-0.6	-3.0	0.1	0.1
	Investment	7.8	3.0	-1.2	0.6	21.8	15.4
	Jewellery	9.6	9.7	9.6	9.7	9.8	9.5
	Medical and Biomedical	0.6	0.6	0.6	0.6	0.5	0.5
	Petroleum	0.2	0.1	0.0	0.1	0.1	0.1
	Other	1.2	2.0	2.2	2.2	2.1	2.1
	Total	**40.9**	**35.4**	**29.3**	**27.2**	**49.4**	**42.1**
N. America	Autocatalyst	11.5	12.3	10.7	11.1	12.5	11.9
	Chemical	3.0	3.3	3.2	3.5	3.6	3.2
	Electrical	0.8	0.7	0.6	0.6	0.6	0.7
	Glass	-0.2	0.2	0.2	0.4	0.3	0.9
	Investment	0.3	5.8	1.8	0.2	-1.0	2.6
	Jewellery	5.8	5.8	6.6	6.8	7.5	7.2
	Medical and Biomedical	2.8	2.8	2.6	2.6	2.6	2.7
	Petroleum	1.6	1.4	0.7	0.7	1.2	1.3
	Other	3.4	3.7	3.9	3.8	3.8	3.8
	Total	**28.9**	**36.0**	**30.3**	**29.7**	**31.1**	**34.3**
China	Autocatalyst	3.3	2.9	4.0	4.0	4.2	5.1
	Chemical	3.1	2.8	4.5	3.4	4.6	5.3
	Electrical	0.9	1.0	1.1	1.2	1.2	1.2
	Glass	0.3	1.6	2.9	6.6	3.5	4.6
	Investment	0.0	0.0	0.0	0.0	0.0	0.0
	Jewellery	52.3	60.7	65.3	60.2	55.9	47.1
	Medical and Biomedical	0.3	0.5	0.5	0.5	0.6	0.6
	Petroleum	0.5	0.7	1.7	0.9	1.0	0.6
	Other	0.9	1.2	1.5	1.6	1.7	2.1
	Total	**61.6**	**71.4**	**81.5**	**78.4**	**72.7**	**66.6**
RoW	Autocatalyst	21.9	23.5	22.7	20.9	20.5	19.1
	Chemical	3.7	3.5	4.4	4.9	4.4	6.1
	Electrical	4.0	2.7	3.8	4.0	4.1	4.2
	Glass	10.9	2.9	0.2	2.3	0.7	2.2
	Investment	1.4	0.9	27.8	10.1	-4.0	-4.2
	Jewellery	3.9	4.8	5.8	7.0	8.6	10.5
	Medical and Biomedical	0.6	0.7	0.7	0.7	0.7	0.8
	Petroleum	3.3	1.4	2.9	2.7	2.1	2.2
	Other	1.4	1.8	2.3	2.4	2.6	2.7
	Total	**51.2**	**42.2**	**70.6**	**55.0**	**39.7**	**43.6**
	Grand total	**251.8**	**245.8**	**266.2**	**251.0**	**258.0**	**259.2**

PALLADIUM '000 oz - Supply and Demand							
							Forecast
		2011	2012	2013	2014	2015	2016
Supply[1]	South Africa	2,560	2,359	2,465	2,125	2,684	2,571
	Russia: Primary[2]	2,705	2,627	2,628	2,589	2,434	2,487
	Russia: Stock Sales[2]	775	260	100	0	0	0
	North America	900	811	831	912	864	922
	Zimbabwe[3]	265	266	322	327	320	379
	Others[3]	155	162	152	150	142	126
	Total Supply	**7,360**	**6,485**	**6,498**	**6,103**	**6,444**	**6,485**
Demand[4]	Autocatalyst[4]	6,155	6,673	7,051	7,500	7,655	7,840
	Chemical	440	524	490	408	481	441
	Dental	540	510	457	468	475	452
	Electrical[4]	1,375	1,190	1,070	1,014	950	944
	Investment	-565	467	-8	943	-659	-357
	Jewellery[4]	505	442	354	272	225	215
	Other	110	104	109	111	133	150
	Total Gross Demand	**8,560**	**9,910**	**9,523**	**10,716**	**9,260**	**9,685**
Recycling[6]	Autocatalyst	-1,695	-1,675	-1,905	-2,189	-1,939	-2,032
	Electrical	-480	-443	-463	-474	-475	-477
	Jewellery	-210	-194	-157	-89	-46	-40
	Total Recycling	**-2,385**	**-2,312**	**-2,525**	**-2,752**	**-2,460**	**-2,549**
	Total Net Demand[7]	**6,175**	**7,598**	**6,998**	**7,964**	**6,800**	**7,136**
	Movement in Stocks[8]	**1,185**	**-1,113**	**-500**	**-1,861**	**-356**	**-651**

PALLADIUM '000 oz - Gross Demand by Region							
							Forecast
		2011	2012	2013	2014	2015	2016
Europe	Autocatalyst	1,485	1,427	1,493	1,583	1,624	1,639
	Chemical	80	79	76	-19	77	80
	Dental	80	81	80	77	70	65
	Electrical	190	151	119	105	102	101
	Investment	-35	163	-14	-74	-200	-98
	Jewellery	60	64	61	60	59	60
	Other	25	24	24	25	27	30
	Total	**1,885**	**1,989**	**1,839**	**1,757**	**1,759**	**1,877**
Japan	Autocatalyst	680	799	772	785	773	782
	Chemical	20	17	18	18	17	17
	Dental	220	220	184	205	227	217
	Electrical	300	320	245	236	214	210
	Investment	5	0	-4	-2	4	1
	Jewellery	70	70	70	67	66	64
	Other	10	9	9	9	9	9
	Total	**1,305**	**1,435**	**1,294**	**1,318**	**1,310**	**1,300**
N. America	Autocatalyst	1,545	1,803	1,771	1,961	2,026	1,944
	Chemical	80	87	70	74	79	81
	Dental	225	190	168	160	152	144
	Electrical	145	163	159	153	147	146
	Investment	-535	304	10	-205	-181	-60
	Jewellery	45	44	43	44	44	44
	Other	45	39	43	43	59	52
	Total	**1,550**	**2,630**	**2,264**	**2,230**	**2,326**	**2,351**
China	Autocatalyst	1,155	1,325	1,499	1,623	1,662	1,944
	Chemical	145	213	210	230	224	177
	Dental	0	3	8	8	8	7
	Electrical	270	176	168	170	168	170
	Investment	0	0	0	0	0	0
	Jewellery	305	238	155	78	34	25
	Other	10	14	15	16	17	34
	Total	**1,885**	**1,969**	**2,055**	**2,125**	**2,113**	**2,357**
RoW	Autocatalyst	1,290	1,319	1,516	1,548	1,570	1,531
	Chemical	115	128	116	105	84	86
	Dental	15	16	17	18	18	19
	Electrical	470	380	379	350	319	317
	Investment	0	0	0	1,224	-282	-200
	Jewellery	25	26	25	23	22	22
	Other	20	18	18	18	21	25
	Total	**1,935**	**1,887**	**2,071**	**3,286**	**1,752**	**1,800**
	Grand total	**8,560**	**9,910**	**9,523**	**10,716**	**9,260**	**9,685**

PALLADIUM Tonnes - Supply and Demand							
							Forecast
		2011	2012	2013	2014	2015	2016
Supply[1]	South Africa	79.6	73.4	76.7	66.1	83.5	80.0
	Russia: Primary[2]	84.1	81.7	81.7	80.5	75.7	77.4
	Russia: Stock Sales[2]	24.1	8.1	3.1	0.0	0.0	0.0
	North America	28.0	25.2	25.8	28.4	26.9	28.7
	Zimbabwe[3]	8.2	8.3	10.0	10.2	10.0	11.8
	Others[3]	4.8	5.0	4.7	4.7	4.4	3.9
	Total Supply	**228.9**	**201.7**	**202.0**	**189.9**	**200.5**	**201.8**
Demand[4]	Autocatalyst[4]	191.4	207.5	219.3	233.2	238.0	243.9
	Chemical	13.7	16.3	15.3	12.8	15.0	13.7
	Dental	16.8	15.8	14.1	14.6	14.8	14.0
	Electrical[4]	42.8	37.1	33.2	31.6	29.6	29.3
	Investment	-17.6	14.6	-0.2	29.3	-20.5	-11.1
	Jewellery[4]	15.7	13.8	11.0	8.5	7.1	6.8
	Other	3.4	3.2	3.4	3.5	4.1	4.7
	Total Gross Demand	**266.2**	**308.3**	**296.1**	**333.5**	**288.1**	**301.3**
Recycling[6]	Autocatalyst	-52.7	-52.2	-59.2	-68.1	-60.3	-63.2
	Electrical	-14.9	-13.7	-14.4	-14.8	-14.8	-14.9
	Jewellery	-6.5	-6.0	-4.9	-2.7	-1.4	-1.3
	Total Recycling	**-74.2**	**-71.9**	**-78.5**	**-85.6**	**-76.5**	**-79.4**
	Total Net Demand[7]	**192.1**	**236.4**	**217.6**	**247.9**	**211.6**	**221.9**
	Movement in Stocks[8]	**36.9**	**-34.7**	**-15.6**	**-58.0**	**-11.1**	**-20.1**

PALLADIUM Tonnes - Gross Demand by Region							
							Forecast
		2011	2012	2013	2014	2015	2016
Europe	Autocatalyst	46.2	44.4	46.4	49.2	50.5	51.0
	Chemical	2.5	2.5	2.4	-0.6	2.4	2.5
	Dental	2.5	2.5	2.5	2.4	2.2	2.0
	Electrical	5.9	4.7	3.7	3.3	3.2	3.1
	Investment	-1.1	5.1	-0.4	-2.3	-6.2	-3.0
	Jewellery	1.9	2.0	1.9	1.9	1.8	1.9
	Other	0.8	0.7	0.7	0.8	0.8	0.9
	Total	**58.6**	**61.9**	**57.2**	**54.7**	**54.7**	**58.4**
Japan	Autocatalyst	21.2	24.8	24.0	24.4	24.0	24.3
	Chemical	0.6	0.5	0.6	0.6	0.5	0.5
	Dental	6.8	6.8	5.7	6.4	7.1	6.7
	Electrical	9.3	10.0	7.6	7.3	6.7	6.5
	Investment	0.2	0.0	-0.1	-0.1	0.1	0.0
	Jewellery	2.2	2.2	2.2	2.1	2.1	2.0
	Other	0.3	0.3	0.3	0.3	0.3	0.3
	Total	**40.6**	**44.6**	**40.3**	**41.0**	**40.8**	**40.3**
N. America	Autocatalyst	48.1	56.1	55.1	61.0	63.0	60.5
	Chemical	2.5	2.7	2.2	2.3	2.5	2.5
	Dental	7.0	5.9	5.2	5.0	4.7	4.5
	Electrical	4.5	5.1	4.9	4.8	4.6	4.5
	Investment	-16.6	9.5	0.3	-6.4	-5.6	-1.9
	Jewellery	1.4	1.4	1.3	1.4	1.4	1.4
	Other	1.4	1.2	1.3	1.3	1.8	1.6
	Total	**48.2**	**81.9**	**70.3**	**69.4**	**72.4**	**73.1**
China	Autocatalyst	35.9	41.2	46.6	50.5	51.7	60.5
	Chemical	4.5	6.6	6.5	7.2	7.0	5.5
	Dental	0.0	0.1	0.2	0.2	0.2	0.2
	Electrical	8.4	5.5	5.2	5.3	5.2	5.3
	Investment	0.0	0.0	0.0	0.0	0.0	0.0
	Jewellery	9.5	7.4	4.8	2.4	1.1	0.8
	Other	0.3	0.4	0.5	0.5	0.5	1.1
	Total	**58.6**	**61.2**	**63.8**	**66.1**	**65.7**	**73.4**
RoW	Autocatalyst	40.1	41.0	47.2	48.1	48.8	47.6
	Chemical	3.6	4.0	3.6	3.3	2.6	2.7
	Dental	0.5	0.5	0.5	0.6	0.6	0.6
	Electrical	14.6	11.8	11.8	10.9	9.9	9.9
	Investment	0.0	0.0	0.0	38.1	-8.8	-6.2
	Jewellery	0.8	0.8	0.8	0.7	0.7	0.7
	Other	0.6	0.6	0.6	0.6	0.7	0.8
	Total	**60.2**	**58.7**	**64.5**	**102.3**	**54.5**	**56.1**
	Grand total	**266.2**	**308.3**	**296.1**	**333.5**	**288.1**	**301.3**

RHODIUM '000 oz - Supply and Demand							
							Forecast
		2011	2012	2013	2014	2015	2016
Supply[1]	South Africa	641	577	554	469	611	593
	Russia[2]	70	90	80	80	80	80
	North America	23	22	23	24	23	24
	Zimbabwe[3]	29	28	36	36	35	41
	Others[3]	2	3	7	6	5	5
	Total Supply	**765**	**720**	**700**	**615**	**754**	**743**
Demand[4]	Autocatalyst[4]	715	775	770	791	763	778
	Chemical	72	80	87	91	101	102
	Electrical	6	6	5	3	3	4
	Glass	77	35	46	57	37	54
	Other	38	63	87	38	30	26
	Total Gross Demand	**908**	**959**	**995**	**980**	**934**	**964**
Recycling[6]	Autocatalyst	-277	-252	-278	-307	-273	-283
	Total Recycling	**-277**	**-252**	**-278**	**-307**	**-273**	**-283**
	Total Net Demand[7]	**631**	**707**	**717**	**673**	**661**	**681**
	Movement in Stocks[8]	**134**	**13**	**-17**	**-58**	**93**	**62**

RHODIUM Tonnes - Supply and Demand							
							Forecast
		2011	2012	2013	2014	2015	2016
Supply[1]	South Africa	19.7	17.9	17.2	14.6	19.0	18.4
	Russia[2]	2.2	2.8	2.5	2.5	2.5	2.5
	North America	0.3	0.7	0.7	0.7	0.7	0.7
	Zimbabwe[3]	0.6	0.9	1.1	1.1	1.1	1.3
	Others[3]	0.1	0.1	0.2	0.2	0.2	0.2
	Total Supply	**22.8**	**22.4**	**21.7**	**19.1**	**23.5**	**23.1**
Demand[4]	Autocatalyst[4]	22.6	24.1	24.0	24.6	23.7	24.2
	Chemical	2.1	2.5	2.7	2.9	3.1	3.1
	Electrical	0.1	0.2	0.1	0.1	0.1	0.1
	Glass	2.1	1.0	1.4	1.8	1.2	1.6
	Other	0.7	2.0	2.8	1.2	1.0	0.8
	Total Gross Demand	**27.6**	**29.8**	**31.0**	**30.6**	**29.1**	**29.8**
Recycling[6]	Autocatalyst	-7.5	-7.8	-8.6	-9.5	-8.5	-8.8
	Total Recycling	**-7.5**	**-7.8**	**-8.6**	**-9.5**	**-8.5**	**-8.8**
	Total Net Demand[7]	**20.1**	**22.0**	**22.4**	**21.1**	**20.6**	**21.0**
	Movement in Stocks[8]	**2.7**	**0.4**	**-0.7**	**-2.0**	**2.9**	**2.1**

IRIDIUM '000 oz - Demand							
							Forecast
		2011	2012	2013	2014	2015	2016
Demand	Chemical	19	19	20	20	20	21
	Electrical	195	28	35	44	80	67
	Electrochemical	76	73	50	55	57	57
	Other	42	75	81	89	94	99
	Total Demand	**332**	**195**	**186**	**208**	**251**	**244**

IRIDIUM Tonnes - Demand							
							Forecast
		2011	2012	2013	2014	2015	2016
Demand	Chemical	0.6	0.6	0.6	0.6	0.6	0.7
	Electrical	6.1	0.9	1.1	1.4	2.5	2.1
	Electrochemical	2.4	2.3	1.6	1.7	1.8	1.8
	Other	1.3	2.3	2.5	2.8	2.9	3.1
	Total Demand	**10.4**	**6.1**	**5.8**	**6.5**	**7.8**	**7.7**

RUTHENIUM '000 oz - Demand							
							Forecast
		2011	2012	2013	2014	2015	2016
Demand	Chemical	273	134	312	246	215	234
	Electrical	536	247	337	360	458	487
	Electrochemical	130	172	146	154	158	161
	Other	58	79	106	108	117	122
	Total Demand	**997**	**632**	**901**	**868**	**948**	**1,004**

RUTHENIUM Tonnes - Demand							
							Forecast
		2011	2012	2013	2014	2015	2016
Demand	Chemical	8.5	4.2	9.7	7.7	6.7	7.3
	Electrical	16.7	7.7	10.5	11.2	14.2	15.1
	Electrochemical	4.0	5.3	4.5	4.8	4.9	5.0
	Other	1.8	2.5	3.3	3.4	3.6	3.8
	Total Demand	**31.0**	**19.7**	**28.0**	**27.1**	**29.4**	**31.2**

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 states is included in the Rest of the World region. Russian supply figures for palladium have been split into sales from primary mining and sales of stocks.

[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 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 is scrapped 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.

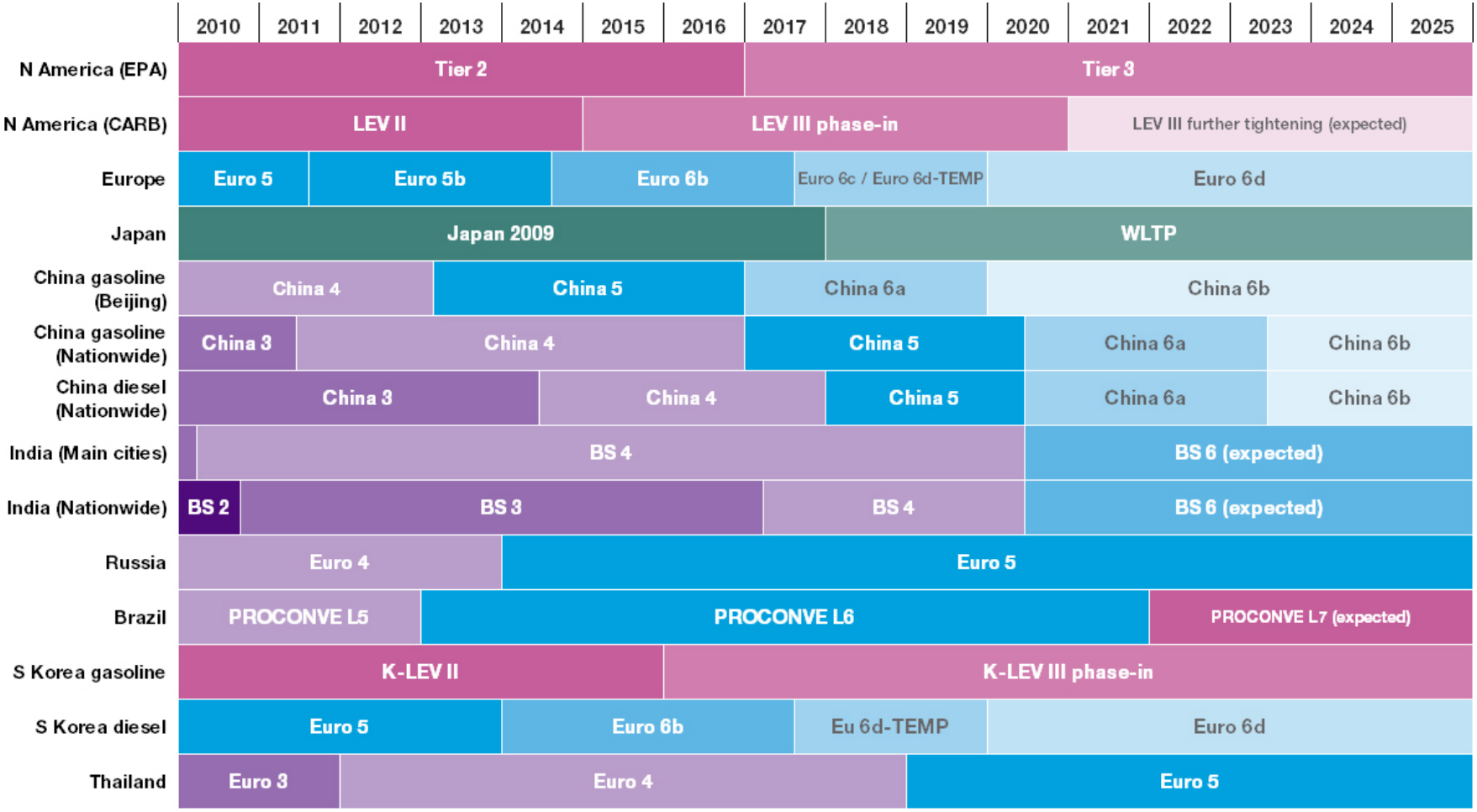
[7]**Net demand** figures are equivalent to the sum of gross demand in an application less any metal recovery from open loop scrap in that application, whether the recycled metal is reused in that industry or sold into another application. Where no recycling figure is given for an application, gross 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 Metals 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 are subject to frequent change; dates shown represent best available current view.

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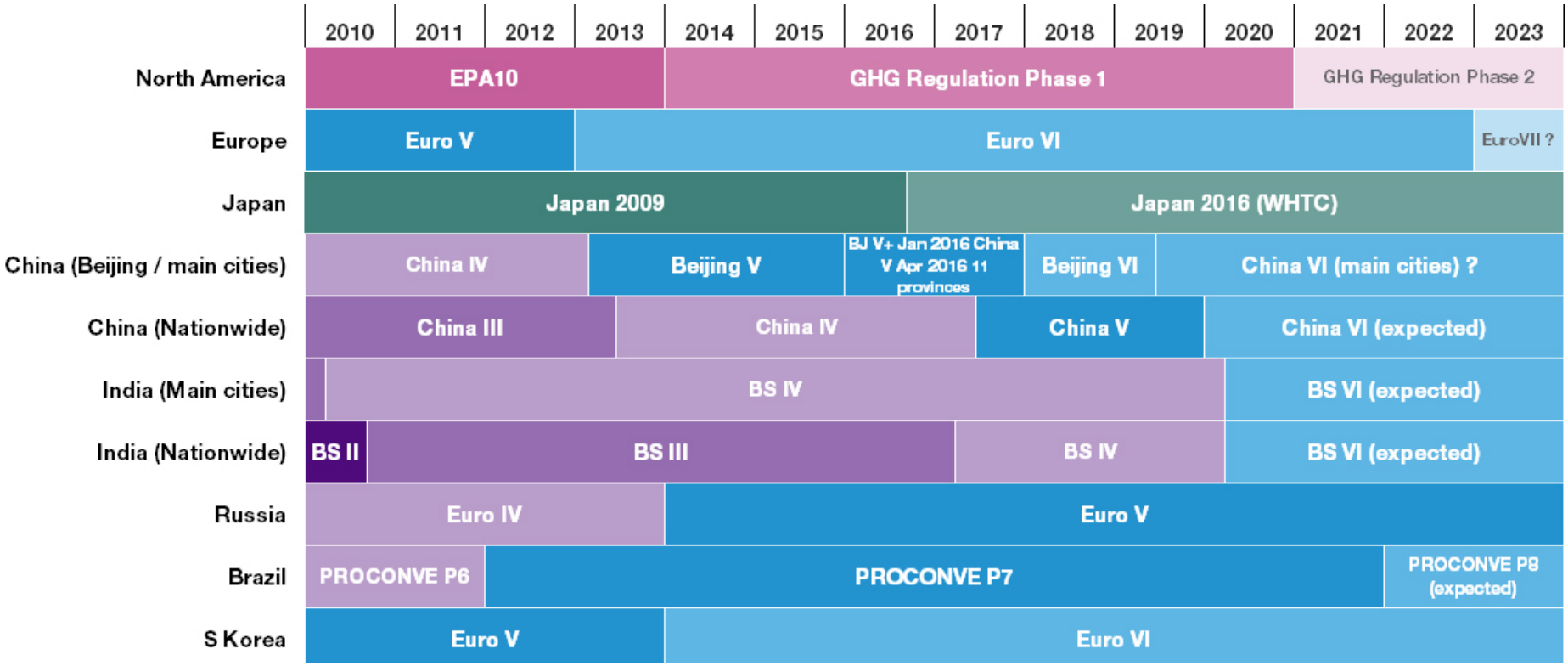
EMISSIONS LEGISLATION: HEAVY DUTY DIESEL



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

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