

PALLADIUM

- Gross demand for palladium in autocatalysts reached a new record of 6.62 million ounces in 2012, propelled by recovering car output in Japan, further growth in China and a rebound in new registrations in North America.
- Industrial demand for palladium weakened in 2012 to 2.37 million ounces due to less intensive use of palladium in the electrical industry.
- Falling production in China was the cause of a decline to 445,000 oz in gross world demand for palladium for jewellery manufacturing.
- Net physical investment in palladium was positive in 2012 at 470,000 oz. ETF inflows were strong in the first half and the launch of a new investment trust in December added significantly to demand.

AUTOCATALYST

In 2012, for the second year running, gross demand for palladium was at a new all-time high. World demand of 6.62 million ounces represented a 7.5% increase on 2011 and, even more impressively, a rise of nearly two-thirds when compared to the depressed level of 4.05 million ounces during the recession year of 2009. Some of the reasons behind this demand strength were familiar ones, like the continuing increase in gasoline vehicle production in China and the gradual rise in the average ratio of palladium to platinum in autocatalysts for diesel vehicles. Others were germane to 2012. There was a recovery in Japanese vehicle output after so much production capacity was put out of commission by the earthquake and tsunami of March 2011; in the USA, production of light duty cars and trucks soared as consumer confidence increased and buyers finally returned to the showrooms to replace their ageing vehicles. However, recycling of palladium from end-of-life catalysts did not keep pace with gross demand last year, falling by 2% to 1.66 million ounces as weakness in pgm prices caused collectors to hoard stocks of spent converters for a time. Consequently, the increase in net autocatalyst demand to 4.96 million ounces was an 11% advance on the 2011 level.

Europe

Despite a very weak European vehicle market, demand for palladium in European emissions control catalysts held up well, falling by just 2% in 2012 to 1.46 million ounces.

European light duty vehicle sales in 2012 were the worst in 13 years, with new car and light commercial registrations falling by 8.2% year-on-year to 14.8 million units. However, the effect on demand for palladium was alleviated by several factors: a rise in production of gasoline-powered cars by

manufacturers of premium vehicles; an increase in the market share of gasoline vehicles produced in Europe; and the further part substitution of palladium for platinum in diesel-powered vehicles.

Mass market producers, which are highly dependent on demand for cars in their domestic markets, were the most heavily impacted by the continued weakness in the European economy in 2012 and the declining level of vehicle sales. In contrast, output at most of the premium producers increased thanks to sustained growth in sales of their vehicles outside Europe, with the result that European vehicle exports rose for the third successive year.

Demand in Europe's largest export market, North America, was fuelled by rebounding consumer demand for vehicles in the USA, where German brands have been steadily gaining popularity and accounted for one in eight cars sold in the country last year. Vehicle exports to Asia grew to an all-time high, driven by a seemingly insatiable appetite for top-end luxury models in China. As premium vehicles typically contain a higher amount of pgm on their aftertreatment systems than mass market models, the increasing market share of these vehicles partly offset the decline in palladium demand caused by the overall lower vehicle production.

In addition to the higher number of predominantly gasoline vehicle exports, 2012 also saw an increase in the

Palladium Demand: Autocatalyst						
'000 oz						
	Gross		Recycling		Net	
	2011	2012	2011	2012	2011	2012
Europe	1,485	1,455	(390)	(295)	1,095	1,160
Japan	680	785	(100)	(105)	580	680
North America	1,545	1,815	(1,055)	(1,080)	490	735
China	1,155	1,255	(35)	(45)	1,120	1,210
Rest of the World	1,290	1,305	(115)	(135)	1,175	1,170
Total	6,155	6,615	(1,695)	(1,660)	4,460	4,955

Palladium autocatalyst demand in North America was up in 2012.



popularity of gasoline-powered vehicles in home markets, as cash-strapped consumers opted for smaller, cheaper cars, and tax schemes in some markets incentivised the purchase of more fuel-efficient downsized engines. The growing share of gasoline vehicles in an overall declining market provided a further cushion to palladium demand.

In the light duty diesel sector, palladium now represents 30% of the pgm used in emissions control catalysts. 2011 was the first full year of Euro 5 emissions standards for cars sold in Europe, which forced the fitment of diesel particulate filters (DPFs) to meet the new tighter nitrogen oxide (NOx) and particulate matter limits. These systems contained higher levels of palladium than Euro 4 catalysts, partly to offer cost savings to vehicle manufacturers by replacing a portion of the platinum on the catalyst, but also to benefit from the increased thermal durability of palladium-platinum catalysts during high-temperature regeneration of the filter.

Following the strong increase in palladium substitution for platinum in 2011, last year witnessed a more steady expansion in palladium use as automakers and catalyst manufacturers continued to look for further cost savings in emissions aftertreatment. Even so, due to the 10% decline in European diesel vehicle production in 2012, the use of palladium in light duty diesel catalyst systems was lower year-on-year.

For heavy duty diesel vehicles, palladium is used along with platinum in the limited number of Euro V vehicles that contain diesel oxidation catalysts (DOCs) and/or DPFs, and also in newer Euro VI aftertreatment systems. Palladium use in the European heavy duty sector remains small at present but demonstrated some growth last year as a result of the introduction of Euro VI trucks onto the European market.

Japan

Demand for palladium in the Japanese autocatalyst sector grew by 15% in 2012 to reach 785,000 oz. The growth in demand has been driven by a 22% increase in light duty gasoline vehicle output in Japan. This was supported by an expansion of 27% in domestic light duty sales in 2012, and together these were significant contributors to the turnaround from a depressed 2011, which was greatly affected by the March earthquake.

A reduction in light duty diesel production in 2012 allowed gasoline vehicles to take a greater share of output. Nonetheless, the increase in pgm demand has not kept pace with the growth in vehicle production. Thrifting in the pgm mix has resulted in a reduction in average loadings for gasoline catalysts, including a 5% reduction in the average palladium content.

Palladium demand in heavy duty vehicles grew in line with output in 2012, despite some adverse export trade. Over half of trucks manufactured in Japan are sold overseas, and in 2012, fewer were exported to those destinations where the tightest emissions standards are in place. Truck exports to Europe, for example, were 53% fewer than in 2011, even though in that year vehicle output was adversely affected by the March disaster. However, exports to regions in which emissions legislation was being tightened, from a lower base than in Europe, were sufficient to maintain a steady growth in palladium demand. The use of palladium in non-road applications in Japan is not significant at present.

North America

Purchases of palladium in the North American automotive sector increased by 17.5% in 2012 to 1.82 million ounces as a result of strong growth in the production of cars and light trucks as well as continued substitution of platinum by palladium in light duty gasoline vehicles.

Improving economic conditions and access to credit were two of the reasons consumers flocked to vehicle showrooms last year. In addition to new car loans being easily obtainable, the average interest rate dropped to new lows during 2012 and high-risk lending expanded to 25% of all loans in the third quarter of 2012, up from 22% during the same period of 2011. Another underlying factor driving sales was the need to replace older vehicles as the average age of cars and light trucks hit a record 11 years.

High gasoline prices did little to deter sales, but rather encouraged consumers to trade in their inefficient old vehicles for new fuel-saving models. Sales of passenger cars increased

at twice the rate of truck sales and consumers strongly favoured the smallest vehicles in both categories. For all of 2012, sales of compact cars and trucks increased by over 16% and represented 42.5% of all vehicles sold. While this had some negative impact on palladium demand, soaring production more than made up for it.

All told, in 2012 consumers in North America purchased 12.6% more light duty vehicles while production surged by 18.9% to 12.6 million units, only half a million shy of the pre-recession total of 13.1 million vehicles. In addition to strong domestic sales, a combination of a weaker dollar and free trade pacts have made the USA a more attractive place to build vehicles, resulting in foreign manufacturers moving production capacity there for both domestic sales and exports.

China

The growth in light duty output in China raised the production of gasoline vehicles there in 2012 to 16 million vehicles, meaning that one in four new gasoline vehicles manufactured globally was made in China. This growth in production added 100,000 oz of palladium to demand, an increase of 8.7% year-on-year, taking Chinese purchases of palladium for autocatalysts to 1.26 million ounces. Whilst this was an improvement on the previous year, the anticipated introduction of the Euro 5 equivalent emissions legislation for gasoline light duty vehicles, China 5, in Beijing during 2012, did not materialise, thus dampening the full effect on demand that the implementation of those standards might have had.

Some manufacturers, nevertheless, did supply the market with China 5 compliant gasoline passenger cars, which resulted

in either significantly higher average palladium loadings than China 4 equivalent models or the introduction of new, more clean and efficient engines.

Rest of the World

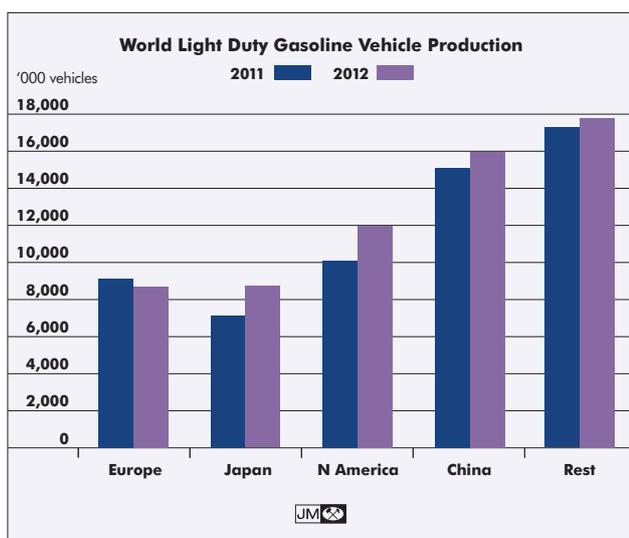
Korea, Mexico and India are substantial buyers of palladium for autocatalysts, each country using well over 100,000 oz of palladium a year. Russia is a growing vehicle manufacturing base which is fast catching up with this group and is likely to join it in 2013. Russian vehicle production continued on a strong growth path in 2012, with light vehicle output expanding by a healthy 11.6% to a new record of 2.1 million units. Following a collapse in vehicle sales in 2009, the Russian auto market has recorded three consecutive years of robust growth. In 2012, buoyed by falling unemployment and an increase in consumer spending, light vehicle registrations grew by 11% to over 2.9 million units, reaching a par with the 2008 peak.

In the last few years, vehicle assembly in Russia has grown at a stronger rate than new car sales as foreign automakers have expanded their production capacity in the country to meet ambitious government targets that allow them to qualify for incentives. As a predominantly gasoline market, palladium demand has benefited from the growth in vehicle output, climbing by nearly a quarter in 2012. Demand was boosted by the increased production of vehicles meeting Euro 4 emissions legislation. Euro 4 rules were introduced in 2010 for new models sold in Russia, but apply to all new vehicles sold in the country from January 2013.

JEWELLERY

Gross demand for palladium in jewellery in 2012, at 445,000 oz, was 60,000 oz below the 2011 level. Demand in China fell for the fourth consecutive year, while in other major markets it was largely unchanged. With the amount of palladium recycled from scrapped jewellery falling to 190,000 oz in 2012, net demand reached 255,000 oz, compared with 295,000 oz in 2011.

In a sign of further retrenchment in the Chinese palladium jewellery industry, gross demand declined by 65,000 oz in 2012 to 240,000 oz. Despite the relatively high margins that continue to be available throughout the palladium jewellery supply chain, anaemic consumer demand for the end-product has led to a larger number of manufacturers and retailers deciding to no longer work with or carry a stock of palladium jewellery. Many of those who remain active are doing so only as an



See notes to table on page 26.

Palladium Demand: Jewellery '000 oz						
	Gross ¹		Recycling ²		Net ³	
	2011	2012	2011	2012	2011	2012
Europe	60	65	0	0	60	65
Japan	70	70	(20)	(15)	50	55
North America	45	45	0	0	45	45
China	305	240	(190)	(175)	115	65
Rest of the World	25	25	0	0	25	25
Total	505	445	(210)	(190)	295	255

after-sales service to facilitate the exchange of unsold stock or consumer returns, although there does remain some latent demand for palladium jewellery in lower tier cities.

The failure of palladium jewellery to establish a secure market position in China has largely been due to the absence of effective and sustained marketing, a lack of perceived value and quality and a particularly volatile price in recent years. Manufacturers have also been focusing on meeting strong consumer demand for gold and platinum jewellery items.

In Japan, palladium's use as an alloy in white gold and platinum jewellery pieces remained steady overall, while growth in the diminutive plain palladium jewellery market was limited, leaving gross demand in 2012 stationary at 70,000 oz.

Demand in North America was likewise steady at 45,000 oz, with the latest wave of market promotion that began in 2011 having limited success to date. One challenge for the industry is that palladium jewellery tends to be bracketed with non-precious alternatives like titanium and stainless steel jewellery, marking it out as a relatively expensive option in this segment.

The only major market to exhibit growth in 2012 was Europe, where demand rose by 5,000 oz to 65,000 oz. In the UK, where palladium retains a strong position in the male wedding band market, the number of British-made hallmarked pieces soared by 14.3% in 2012, while the popularity of lower fineness Pd500 jewellery, which has a palladium content of 50% compared to the 95% of the standard alloy, continued to grow.

INDUSTRIAL DEMAND

The use of palladium in various industrial sectors came to 2.37 million ounces in 2012, 100,000 oz lower than the previous year. The use of palladium in dental restorations, and in several minor applications such as petroleum refining catalysts, stationary source pollution control and industrial alloys, was largely stable. Chemical demand increased due to another year of expansion in capacity

in China for manufacturing chemical intermediates using palladium catalysts, but these gains were offset by demand lost in the electrical sector, where base metals continued to replace palladium in capacitor electrodes. On a net basis, a fall in the recovery of palladium from electronic scrap by 10% to 430,000 oz in 2012 made up for some of the decline.

Chemical

Demand for palladium in the chemical industry in 2012 grew by 20% to 530,000 oz. The largest chemical sector use of palladium is in catalysts for the production of purified terephthalic acid (PTA). PTA is an intermediate in the manufacture of polyethylene terephthalate (PET), which is used predominantly to make polyester textile and plastic containers. China remains the key country for PTA production and, despite moving towards over-capacity, has continued to expand existing plants and to build new ones. However, China may now be near to the peak in its construction cycle.

Demand for palladium as a catchment gauze in the production of nitric acid grew by close to 5% in 2012. Palladium is used to capture platinum and rhodium lost from the main burner, typically in low and medium pressure nitric acid plants. Demand for hydrogen peroxide, which is produced using a palladium catalyst, also grew steadily in 2012, driven by demand for paper bleaching, oxidation of chemical products and environmental effluent treatment.

Palladium Demand: Chemical '000 oz			
	2010	2011	2012
Europe	105	80	85
Japan	20	20	15
North America	65	80	85
China	65	145	215
Rest of the World	115	115	130
Total	370	440	530

Dental

Demand for palladium in dental applications fell by 2% to 530,000 oz in 2012, largely due to the continuing overall global downward trend in the use of dental alloys. This decline is a consequence of improved dental care, reducing the need for restorative treatments, and the increasing use and popularity of non-precious materials. Ceramic treatments utilising the latest dental technology such as laser sintering and 3D

printing techniques, or, alternatively, cheaper base metals, are continuing to eat into the pgm share at opposite ends of the dental alloy market spectrum. As a result, in 2012 demand for palladium alloys fell slightly in two of the three largest markets, North America and Europe, whilst demand in Japan was flat.

In Japan, demand for the state-subsidised Kinpala palladium-gold alloy appears to have reached a plateau at the same time that recovery of scrap material has increased, resulting in broadly stable use last year. In North America, up until 2008 the market share of palladium dental alloys was increasing due to the rising cost of gold alloys. However, since that time demand for palladium has been in steady decline despite gold prices continuing to be significantly higher than palladium prices. As in Japan and Europe, both gold and palladium alloys are facing competition from base metals and ceramics. Most of the switch from gold to palladium has already occurred, and to further reduce costs, dental laboratories are changing to alloys with lower or no palladium content.

Palladium Demand: Dental '000 oz			
	2010	2011	2012
Europe	80	80	75
Japan	250	220	220
North America	250	225	220
China	0	0	0
Rest of the World	15	15	15
Total	595	540	530

Electrical

The electrical sector experienced a tough year in 2012, with many electronic component markets posting a decline in sales and production on the previous year. The evidence for this comes from data on production of silicon for making semiconductors, which are used in most electronic applications. Silicon output grew only marginally last year.

Palladium demand for electronic plating and components declined by 13% to 1.20 million ounces in 2012. For several years multi-layer ceramic capacitors (MLCCs), which are one of the fundamental passive components of electronic circuitry, have accounted for the largest use of palladium in the sector.

The number of MLCCs produced increases annually, driven by the ever-growing complexity of electronic devices such as smart phones, tablets and automotive electronics. However, this growth is no longer able to offset the effects of substitution of palladium in MLCC electrodes by nickel and

Palladium capacitors are increasingly being confined to military and aerospace applications.



copper, as well as thrifting of palladium in remaining products, which are powerful trends affecting palladium demand at present. Smaller chip capacitors require electronic pastes with reduced particle size and thus greater surface area, with the result that consistent performance and reliability can be obtained using less metal. Due to improvements in base metals technology, palladium-containing MLCCs have become increasingly confined to niche areas like military and aerospace applications, in which the high reliability of precious metals is of paramount concern.

Palladium demand for electronic plating, on the other hand, remained robust in 2012, with the metal continuing to benefit from its substantial discount to gold, which palladium can replace as a material for connectors and circuit boards. Palladium plating in the lead-frame market profited from the international move away from lead (Pb) solder. Manufacturers used Pb solder for a long time and trusted its reliability and alternatives are difficult to find. Pre-plating with palladium allows the lead-frames to maintain reliability at the high temperature required for Pb-free plating and soldering.

Palladium Demand: Electrical '000 oz						
	Gross		Recycling		Net	
	2011	2012	2011	2012	2011	2012
Europe	190	185	(190)	(160)	0	25
Japan	300	310	(55)	(55)	245	255
North America	145	140	(85)	(80)	60	60
China	270	185	(45)	(40)	225	145
Rest of the World	470	380	(105)	(95)	365	285
Total	1,375	1,200	(480)	(430)	895	770

INVESTMENT

Net physical investment demand for palladium reached a positive 470,000 oz in 2012, compared to liquidation of 565,000 oz in 2011. This was due primarily to a return to net investment in the ETF market following heavy profit-taking the previous year, as well as new demand from the Sprott Physical Platinum and Palladium Trust.

Net demand from ETF investors amounted to 285,000 oz in 2012, effectively recovering just over half of the 530,000 oz liquidated the previous year. A return to investment growth in the two largest funds, based in London and New York, as well as a more moderate swing in the London-based Deutsche Bank ETF, were responsible for the positive demand. Net investment in the ETF Securities London fund marked the first annual increase in holdings in the fund since 2009.

ETF investment at the beginning of 2012 started strongly. Net investment of over 200,000 oz in the first two months, 140,000 oz of which occurred in February alone, traced a strong price recovery. Growth in net holdings extended for a further three months, albeit at a somewhat more modest pace, despite a retracement in the price to below \$600. Over the first five months net investment amounted to an impressive 350,000 oz.

Further net investment in early June took total holdings up to the 2012 high of 2.10 million ounces, but later in June and throughout July net disinvestment accompanied a plunge in the price to a low of \$564. The violence that accompanied the illegal strikes in South Africa in August sharply boosted the palladium price but the response from investors was muted. A relatively modest 15,000 oz was added to the palladium ETFs,

Palladium Demand: Investment			
	'000 oz		
	2010	2011	2012
Europe	(5)	(35)	(165)
Japan	10	5	0
North America	1,090	(535)	305
China	0	0	0
Rest of the World	0	0	0
Total	1,095	(565)	470

just 15% of the volume added to platinum holdings during the same month.

Investors were still inactive in early September, remaining on the sidelines despite the price of palladium continuing to increase strongly. A correction during the second half of the month resulted in net liquidation of more than 45,000 oz.

It was not until the price sustained a recovery to above \$675 at the end of November 2012 that any significant appetite for investment returned. In December investors added 35,000 oz to holdings, the largest increment since May, for total fund holdings by the end of the year to stand at just over two million ounces.

The new Sprott Physical Platinum and Palladium Trust used the \$280 million raised in the process of the initial offering to purchase equal dollar amounts of platinum and palladium. The trust acquired just over 185,000 oz of palladium in 2012, more than double the amount of platinum held in the product.

As there was no primary production of palladium coins in 2012, selling by investors in the secondary market led to metal being returned to fabricators, resulting in marginally negative palladium coin demand.

