

PALLADIUM

Palladium demand grew by 3.5 per cent to 6.84 million ounces in 2007. Gross autocatalyst demand grew to almost two thirds of this total or 4.45 million ounces due to the continued replacement of platinum by palladium in autocatalysts. Demand rose in the electronics sector to 1.29 million ounces with retail sales climbing strongly. Palladium demand from the jewellery trade continued to fall from its 2005 peak to 740,000 oz in 2007. Investment demand was reignited by the launch of two palladium exchange traded funds and rose to 260,000 oz.

AUTOCATALYST

The widespread replacement of platinum by palladium in gasoline catalysts and, to a lesser extent, in diesel catalysts drove palladium autocatalyst demand 10.8 per cent higher in 2007 to 4.45 million ounces. Increases in the platinum and rhodium prices in recent years have maintained the financial incentive to make this change in catalyst formulation. Healthy growth in vehicle production in Asia also contributed to this rising demand for palladium.

Europe

European autocatalyst demand for palladium grew by 10,000 oz, to 900,000 oz in 2007. European Union production of passenger cars rose by 6.6 per cent to 17.1 million units for the year, despite weak car sales in the key German market, where demand was constrained by new rules on consumer sales taxes. However, a fall in the market share of gasoline cars

in Europe trimmed the growth in palladium purchases.

In fact, palladium usage in three-way, or gasoline, catalysts fell. While the number of gasoline-fuelled vehicles manufactured and sold was almost the same as in the previous year, a substantial amount of thrifting was carried out by the European auto makers. Euro 4 emissions

regulations, which came into force in early 2006, obliged manufacturers to increase pgm loadings. Since that date, the car companies have thrifted the average palladium content of a catalyst without adversely affecting performance. The negative effect of this fall in catalyst loadings on palladium demand outweighed the impact of further replacement of platinum in the minority of current gasoline catalysts where it was still in use.

In the diesel sector, palladium usage increased in

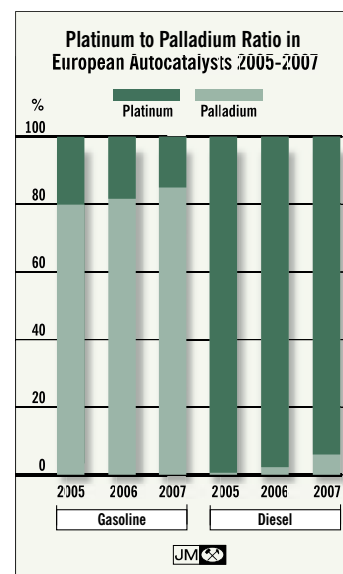
2007. However, very much less palladium is used than platinum. Until recently, diesel oxidation catalysts (DOCs) used platinum as the sole catalytic metal. However, as the price differential between these metals has grown, palladium-platinum formulations have been increasingly utilised. Current catalyst technology employs at least twice as much platinum as palladium in an individual catalyst but research is focusing on maximising the proportion of palladium that can be used. With a rise in the number of vehicle models where a mixed palladium-platinum catalyst is used, palladium usage on diesel cars and trucks increased in 2007 to above 100,000 oz.

Japan

Japanese autocatalyst demand for palladium grew by 6.3 per cent in 2007 to a total of 845,000 oz. The number of cars and light trucks produced rose by 0.9 per cent to 11.5 million units. Domestic sales, in contrast, fell and accounted for just under half of this figure.

Fuel quality issues and the desire to avoid expensive product recalls have forced Japanese car makers to use platinum in many of their catalysts used on export models. However, with improving fuel quality in many countries, the use of palladium on catalysed export vehicles is becoming feasible more often. Palladium demand in this sector consequently rose in 2007.

To limit their overall platinum consumption, the Japanese auto makers have also moved to fit



Palladium use is growing in both the diesel and the gasoline sector in Europe. However, it remains a relatively minor component in all the diesel catalysts where it is used.

Palladium Demand: Autocatalyst '000 oz		
	2006	2007
Europe	890	900
Japan	795	845
North America	1,415	1,655
China	220	275
Rest of the World	695	775
Total	4,015	4,450
Autocatalyst Recovery	(805)	(1,000)

The launch of two
new exchange
traded funds
backed by
physical palladium
contributed
280,000 oz
of investment
demand in 2007.



palladium-based technology to new models being introduced into their domestic market. Palladium use on vehicles made and sold in Japan has therefore moved higher, even in a weak sales environment. Palladium usage has been further boosted by efforts to reduce rhodium consumption. At recent price levels, some car companies have used additional palladium to replace some of the rhodium in a formulation.

North America

The North American autocatalyst sector purchased 17.0 per cent more palladium in 2007, at 1.66 million ounces, than in the previous year. Light duty vehicle sales fell from 16.6 million units to 16.2 million. The number of cars manufactured in North America also fell by almost 500,000.

The economic slowdown in the USA continued to have an impact on the North American automotive industry, with sales falling for the second consecutive year. However, the 2006 trend towards smaller vehicles, which developed as a result of fuel price rises, did not continue. Sports utility vehicle, or SUV, sales have in fact grown. High oil prices have, though, dented demand for the very largest, and least fuel-efficient, trucks and SUVs.

Despite the decline in vehicle sales, palladium usage has continued to benefit from the substantial price difference between this metal and platinum. On gasoline vehicles, the total amount of palladium is already much higher than the amount of platinum being used. In the diesel sector, platinum is the more important metal. Just as in Europe, palladium is being introduced into diesel oxidation catalysts and diesel particulate filters (DPFs) to replace some of the platinum. Palladium remains the minor component in every case but the percentage of diesel catalysts incorporating some palladium increased to the extent that consumption of palladium in the diesel sector exceeded 100,000 oz in 2007.

China

Autocatalyst palladium demand in China rose by 55,000 oz in 2007 to an annual total of 275,000 oz. As the Chinese economy continued to grow rapidly, consumer purchases of cars were very strong. With

every car now sold in this market having a catalyst, palladium consumption has been driven higher.

The Chinese passenger vehicle market is now the second largest in the world, having overtaken Japan in sales terms. However, despite growing by more than 25 per cent last year, Chinese car production is significantly lower than sales, at 5.5 million units in 2007. Only 300,000 vehicles are currently exported each year. Euro 3 equivalent emissions rules were scheduled to come into force in July of 2007 but their implementation was delayed due to questions over domestic fuel quality. However, the auto makers still fitted new catalyst formulations to their vehicles, driving the average pgm content of a new car higher.

Rest of the World

Palladium demand for autocatalysts in the Rest of the World region rose by 80,000 oz in 2007 to 775,000 oz. Light duty vehicle sales grew in most countries: in India they leapt 20 per cent to 1.7 million units. With car makers increasingly locating manufacturing in low-cost areas, production grew too in this region.

Of particular note, Korean vehicle production rose above 4 million units for the first time with a record 2.85 million of these destined for export markets. By contrast, Mexican output fell, with lower exports to the struggling US market largely responsible.

We now report Russian and ex-CIS states' autocatalyst demand in the Rest of the World region. The Russian domestic market saw sales of more than 2.3 million vehicles in 2007, although many of these were assembled elsewhere and use European autocatalyst formulations. Local manufacturers typically use palladium-rhodium catalyst technology due to its low cost relative to platinum formulations. Russian demand reached 40,000 oz in 2007.

Autocatalyst Recovery

The amount of palladium recovered from end-of-life autocatalysts rose strongly, by 24.2 per cent, to 1.00 million ounces in 2007.

The weight of metal reclaimed grew in all regions but over half of the global total was from the mature North American market. A typical end-of-life

vehicle currently being scrapped is in the region of 8 to 12 years old. Growth in the volume of palladium recycled therefore mainly reflects the amount of this metal used on autocatalysts from 1996 to 2000, the peak for palladium consumption in this market.

Roughly 10 million cars are scrapped in the European Union each year and an increasing number of these are recycled, demonstrating the impact of recent end-of-life vehicle legislation and a growing awareness of the value of used catalysis. Demand for palladium for use in European autocatalysts peaked around the end of the millennium and the average palladium content of a scrapped catalyst increased last year and will rise again in 2008. As a result, the amount of palladium recovered from spent autocatalysts in Europe rose to 300,000 oz.

The amount of palladium recovered from used catalytic converters in other regions grew too but remains small. In Japan, many end-of-life vehicles are exported to East Asia instead of being recycled in Japan. In China and the Rest of the World region, palladium recovery is low as most vehicles currently being scrapped did not have catalysis fitted originally.

JEWELLERY

Global jewellery demand for palladium, excluding purchases of jewellery scrap, fell by a weighty 25.6 per cent in 2007 to a net figure of 740,000 oz. There was some growth in the relatively small markets of Europe and North America. However, a fall in demand in the much larger Chinese market accounted for almost all of this 255,000 oz worldwide decline.

European purchases of palladium for the jewellery industry climbed to 45,000 oz last year. Palladium is

used in two different ways: as a component in some white gold alloys and as palladium jewellery itself. Palladium use in white gold manufacturing was roughly 25,000 oz and is growing due to European regulatory restrictions on the use of the traditional whitening agent, nickel. Pd950 (a 95 per cent palladium alloy) jewellery, however, is a new



Much of the European palladium jewellery being manufactured takes advantage of the metal's low density to employ chunky designs.

product and the jewellery trade is exploring possible market niches for it. Its light weight and low cost compared to gold and platinum have driven demand higher for items such as men's wedding bands and large designer pieces.

Palladium jewellery is also still in the early stages of development in North America and manufacturers and retailers are developing its market there as well. The high price differential between palladium and the better-known platinum and gold has encouraged manufacturers to start to work with this material. Substantial price increases on diamonds have placed pressure on bridal ring budgets. Some couples have therefore looked to save money on men's rings and have moved to cheaper materials, including palladium. Both of these trends have helped in driving palladium demand higher, to 50,000 oz in 2007.

Japanese jewellery manufacturers bought 120,000 oz of palladium for use as an alloying agent in white gold and platinum alloys. A sluggish economy, and pressure on jewellery sales from competition for disposable income, forced palladium demand down by 7.7 per cent last year. There is hardly any palladium-only jewellery on sale in Japan.

China, however, remains the key market for palladium jewellery, representing more than two-thirds of overall demand. This is despite a fall in purchases of metal, excluding scrap, from 760,000 oz in 2006 to 500,000 oz in 2007.

Jewellery manufacturers in China increased their use of recycled palladium last year. Most of this secondary metal came from unsold retail jewellery

Palladium Demand: Jewellery '000 oz		
	2006	2007
Europe	40	45
Japan	130	120
North America	40	50
China	760	500
Rest of the World	25	25
Total	995	740

stocks, although some was from industrial sources (it should be noted that we report palladium scrap sourced from outside the jewellery sector as demand for new metal). Much of the original stock of Pd950 which was made in 2004 and 2005 has now been returned for recycling and remaking into the higher-purity Pd990. Surveys of retail outlets in China suggest that most stock now held is in the form of Pd990. This implies that the amount of palladium recovered from unwanted Pd950 pieces may decline and that demand may begin to improve: purchases of palladium in the first quarter of 2008 by manufacturers were indeed healthy.

Palladium jewellery in China is still at an early stage of its product life cycle and the trade is working to address many issues. For instance, the range of palladium products is more limited than those manufactured in platinum and in white gold as relatively few gem-set items are produced. Manufacturing margins have decreased since the creation of this market in 2004/2005, making some manufacturers less keen to work with palladium: margins per gram in 2007 were comparable with those for platinum. However, the jewellery trade's perception of product quality continued to improve.

At the consumer level, awareness of palladium as a jewellery metal is growing but there remain many areas of the country where it is not yet well-known. Retailers also pay less of the material price when buying back second-hand palladium than they do for gold or platinum, and this has damaged the attraction of palladium jewellery for consumers somewhat.

The picture for retail sales remains varied across the country. Palladium jewellery is virtually absent from Beijing and Shanghai and is not popular in some other cities. However, large quantities of palladium are on sale – and selling well – in many metropolitan areas.

CHEMICAL

European chemical purchases of palladium fell as less metal was purchased for new plants in 2007 than in 2006. Elsewhere, however, a possible global economic slowdown has had little impact on the market for commodity chemicals, which continues to be strong, with new capacity being installed. Overall, chemical sector demand for palladium fell from 440,000 oz in 2006 to 370,000 oz last year.

In the nitric acid sector, the elevated platinum price makes the use of palladium catchment gauzes (which reduce platinum losses) economically attractive in higher pressure as well as low and medium pressure plants. However, adding extra gauzes does reduce plant throughput and the use of catchments is thus not universal. There have also been some efforts to introduce more palladium into the main catalyst gauzes, to allow a reduction in platinum inventories.

Purchases of palladium for the manufacture of purified terephthalic acid (PTA) were stable. There has been little activity in this sector in Europe, Japan or North America. Expansion continues, though, in China and the Rest of the World region. The situation is similar in the vinyl acetate monomer (VAM) industry. This uses a palladium-gold heterogeneous catalyst to produce VAM, a component of many resins and plastics. With demand for these buoyant, new production capacity was installed in 2007.

There was also growth in global hydrogen peroxide production capacity, most of which uses palladium catalysts.

Hydrogen peroxide can be reacted with propylene to form propylene oxide. This process is relatively clean and produces no side products other than water. Rising environmental costs have made this hydrogen peroxide route attractive, increasing purchases of palladium for this catalyst last year.

Palladium Demand: Chemical '000 oz		
	2006	2007
Europe	175	100
Japan	25	25
North America	80	80
China	65	65
Rest of the World	95	100
Total	440	370

DENTAL

Net dental industry demand for palladium rose marginally in 2007, to 635,000 oz or 15,000 oz higher than in the previous year. Japanese demand rose by 1.9 per cent to 275,000 oz despite downward pressure from a slow reduction in the number of dental treatments. Demand from the US dental sector also edged higher. Palladium purchases for use in the dental industry in Europe, China and the Rest of the World region remained almost flat.

In Japan, both an ageing population and a long-term trend for the patient to bear a greater part of the cost of any treatment are leading to a lower number

Palladium Demand: Dental '000 oz		
	2006	2007
Europe	75	75
Japan	270	275
North America	260	265
China	5	5
Rest of the World	10	15
Total	620	635

of visits to dentists. Resin is being used more frequently as well. Although this does also employ palladium for structural strength, the amount used is less than with the traditional Kinpala alloy of palladium and gold. However, the government subsidy for the Kinpala alloy was above the price of the component materials during 2007, allowing dentists

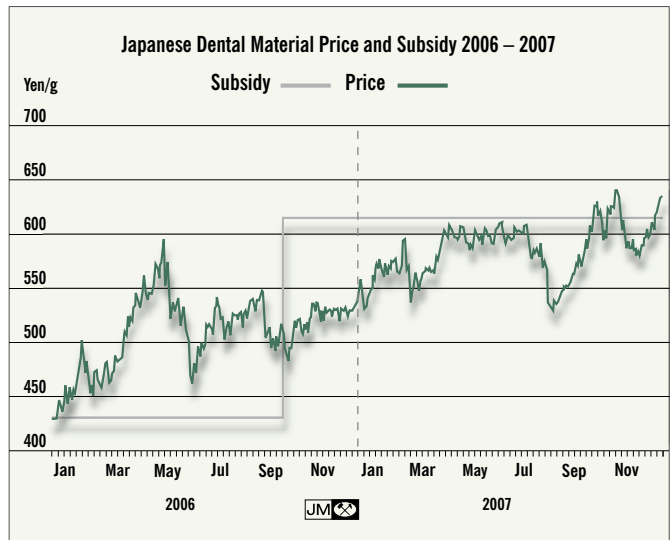
to pass on cost savings to patients. Use of palladium therefore rose slightly, by 5,000 oz, to 275,000 oz.

In North America, palladium is also used for crowns and bridgework. In these applications, it often competes with gold alloys and the price differential in favour of palladium was positive for demand. There is also competition from new, non-precious metal technology such as ceramics. However, the dental sector is conservative and, with market shares changing only slowly for dental materials, palladium demand inched higher, to 265,000 oz in 2007.

In Europe, there was little change in the amount of palladium used for restorative dental work – principally in Italy – although newer ceramic technology is slowly capturing market share. Some palladium dental alloys were launched in the German market in 2007, which could add to demand in the medium-term.

Although dental laboratories and technicians have always been keenly interested in recycling scrap materials from their production processes, high metal

Palladium is one of a range of precious metals used in dental treatments.



prices have reinforced this tendency. The final quarter of 2007 therefore saw increased amounts of material returning from this source for recycling.

ELECTRONICS

The electronics industry purchased a net 1.29 million ounces of palladium in 2007. This was 80,000 oz more than in the previous year and represented the sixth successive year of demand growth. Demand is particularly strong in China and the Rest of the World region. Electronics manufacturing is increasingly being relocated to these two areas and demand for palladium is rising here accordingly.

Palladium consumption in multi-layer ceramic capacitors, or MLCC, represents more than half of gross electronics sector demand. These components are almost ubiquitous in all types of electronic circuitry and are made of alternating layers of an insulating (dielectric) material and electrodes. The internal electrodes are typically made from palladium (or a palladium alloy with silver) or nickel.

Although there are always cost pressures in this industry, the main driver for technological development is miniaturisation. “Real estate” or space on circuit boards is at a premium

The subsidy from the Japanese Government for the use of the Kinpala dental alloy exceeded the cost of the precious metal components throughout most of 2007.

Palladium Demand: Electronics '000 oz		
	2006	2007
Europe	105	155
Japan	275	285
North America	190	195
China	315	320
Rest of the World	320	330
Total	1,205	1,285



Short lifetimes of consumer electronics means that very large quantities are scrapped. With commodity prices high, recycling is therefore growing.

and component sizes are shrinking rapidly. The very smallest 0201 capacitors (0.6 by 0.3 by 0.3 mm) have more than doubled their share of the market in only two years. This reduction in the average MLCC size has driven down palladium content per capacitor but the number of capacitors continues to grow very rapidly. Thrifting has not been seen in this market recently but there is still some slow switching from palladium technology to base metal (nickel) capacitors. Overall, therefore, palladium use in MLCC rose in 2007.

The use of palladium in other electronics applications also grew in 2007. Palladium competes with gold as a material for use in plating. The upwards progress of the gold price, towards \$1,000 an ounce, meant that palladium remained an attractive material for this purpose. Substantial amounts of palladium were also used in hybrid integrated circuits (HICs).

Recovery of palladium from end-of-life electronics remained flat. Both European legislation and a general trend towards greater environmental awareness amongst companies and individuals have driven recycling rates for scrap IT and electronic goods higher. However, miniaturisation of the individual components in the past means that the amount of palladium per scrapped device has not risen. Typical recovery processes focus on the highest value materials first at the expense of those of lower value which may or may not be reclaimed. With these trends pulling in opposite directions, the effect on palladium recycling volumes has been broadly neutral.

INVESTMENT

Net demand for palladium investment products soared from 50,000 oz in 2006 to 260,000 oz in 2007. The major change was the introduction of two palladium exchange traded funds (ETFs) which drove investment purchases sharply higher. Demand from the sale of coins and small bars – in North America – was negative as consumers sold back more of these than they purchased.

European investment demand in fact reached an unprecedented level of 280,000 oz in 2007, almost entirely due to investment in exchange traded funds. Both funds are fully backed by allocated metal, meaning that any palladium purchased is not available to the market and is therefore considered as demand.

Investor interest in 2007 was heavily biased towards the Swiss fund rather than the London-based fund. The former has larger unit sizes, in terms of weight of palladium per share, and is therefore more suitable for larger fund investors rather than individual retail investors. The legal structure of this fund also allows Swiss pension funds effectively to hold physical metal where this was previously impossible. Indeed, this was made clear when the pension fund of Swiss pharmaceutical manufacturer Novartis announced its intention to invest in this and in other precious metal exchange traded funds as they were launched.

Palladium Demand: Investment '000 oz		
	2006	2007
Europe	0	280
Japan	0	0
North America	50	(20)
China	0	0
Rest of the World	0	0
Total	50	260

OTHER

Palladium demand for other applications increased from 85,000 oz in 2006 to 95,000 oz last year (we now report investment numbers separately to other applications). A number of small end uses such as in petroleum refining catalysts and gas sensors contributed to this total.

Palladium Demand: Other '000 oz		
	2006	2007
Europe	25	20
Japan	10	10
North America	30	40
China	10	10
Rest of the World	10	15
Total	85	95