

The CASE for PALLADIUM



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The Case for Palladium

Prescient or Perceptive Palladium View

Game Change

Palladium – Long on Supply for Past 20 Years

Every so often a convergence of events results in a seismic shift, a tipping point or simply an abrupt change in outlook. Such can occur unexpectedly with surprising outcomes even when signs of change are obvious. We call this being blindsided, suggesting a lack of attention.

Such signs of change currently appear to be emerging in the case of palladium. In the past a convergence of circumstances over a protracted period of time has affected palladium's supply and demand fundamentals, including its production and consumption – the difference being above-ground supplies and investment trends, and speculative ebbs and flows. With only brief exceptions, the palladium market has been in a long supply condition for twenty years. Prior to that

twenty-year period it had been chronically short of demand. Either situation results in a soft market and low prices. Either can result in lethargic inattention to emerging change.

Indeed, at a September 2009 New York City gathering, veteran PGM market observers were asked to forecast prices for platinum and palladium one year out. Their estimates for platinum clustered around \$1,500 per ounce, and for palladium around \$325 per ounce – a ratio of 4.6 to 1 (22%). At the time platinum was \$1,336 and palladium was \$299 – a ratio of 4.5 to 1 (22%). One might speculate the market observers were inattentive to emerging changes and simply based their outlooks for palladium on its existing market-price ratio to platinum. Indeed, some eyebrows were raised when one lone market observer, while agreeing with the platinum consensus at \$1,500, projected palladium at \$600 one year out – a ratio of 2.5 to 1 (40%).

The market has adjusted quite aggressively since September 2009. At March 19, 2010, platinum was \$1,617 and palladium was \$476 – or a ratio of 3.4 to 1 (29%). But when

viewed in a more historical context, they had simply moved back to their ratio in January 2007 when platinum was \$1,138 and palladium was \$336 – a ratio of 3.34 to 1 (30%).



Perhaps then, rather than focusing on the price outlook alone, a more challenging riddle for PGM market observers to solve is the appropriate price ratio between platinum and palladium in the near and longer term. Or more succinctly – where is equilibrium between the two?

Indicators of an emerging “change in outlook” are readily apparent if one overlays the growth trajectory in palladium consumption on top of the constrained circumstances of palladium production. The change in outlook framed simply in terms of demand can be described as follows. New emission control technology created an enormous surge in palladium demand twenty years ago: *demand* which has exceeded current production by an estimated 25% for twenty years now – owing to a massive Russian inventory supply existing at the time; *demand* driven by society’s continuing requirement for ever-improving air quality standards; *demand*, 20 years ago and now, driven by palladium’s comparative price/cost advantage over its higher priced sister metals, platinum and rhodium; *demand* with no convenient substitute for the unique catalytic properties of the PGMs; *demand* which, following a premature signal of market shortages, triggered a palladium price bubble nine years ago; *demand* that for the most part has a highly inelastic growth trajectory; *demand* for a scarce, rare metal with a mostly inflexible flat production base –

And, *demand* measured mostly against supply rather than production – a formula for being blindsided while a massive source of additional supply (Russian government inventories) has existed. In particular, this formula for being blindsided is exacerbated because the size of the inventory has been a closely guarded state secret, opaquely hidden from the market’s view throughout the twenty year period. Under such circumstances, efforts to project when the inventory will run out have grown old for analysts over time – and market observers have grown complacent as to its implications.

But whatever it’s called – game change; tipping point; defining moment – a market re-rating for palladium is underway in which a new equilibrium between platinum and palladium will emerge.

The following palladium assessment considers what is known from two convergent views: 1) the massive Russian palladium inventory is either near to, or at exhaustion, and 2) whatever is left of the Russian palladium inventory will only have a marginal impact on the market “going forward,” given robust, ever-expanding and price-inelastic demand for palladium. The assessment is called “the case for palladium.”

A Bit of Air Quality History

Catalytic Converters Advance Quality of Life Now Dependent on Palladium

Society has advanced a long way in the last 35 years. Smog generated by auto emissions is a scourge of the distant past for Los Angeles, and now need not exist anyplace in the world, given that today’s catalytic converters are capable of eliminating over 90% of the harmful emissions from car and truck engines. And, today, over 85% of new cars built in the world are being fitted with catalytic converters – although some local models are not yet required to meet current stringent U.S. and European emission standards.

In both gasoline and diesel engine types, catalytic converters reduce emissions of nitrous oxides (NO_x) to nitrogen and oxygen. Hydrocarbons (HC) are oxidized to water and carbon dioxide. Carbon monoxide (CO) is oxidized to carbon

dioxide. Separately, diesel engine emissions also contain particulate matter (DPM) or simply unburned carbon soot, which is generally captured in a diesel particulate filter (DPF) where it also is oxidized to carbon dioxide.

A close observer of politics would recognize that governments tend to “gradually impose” new and costly regulations on industry, in particular when the cost thereof is to be passed directly on to the public. Such was the case for auto emissions. Thus, the first catalytic converters for gasoline engine emissions introduced for California in the 1975 model year were, by design, far less efficient in converting harmful emissions and required far less loadings of platinum than regulations require today. But, a tiered regulatory schedule dictated increasingly strict catalytic conversion efficiencies overtime, which required progressively heavier loadings of platinum – and which today is dependent on palladium.

Palladium dominates catalytic converter technology

Palladium Catalytic Converter Technology first emerged in 1989

Developed by Ford Motor Company – concerned regulation would overwhelm supply of platinum

Ford Motor Company concluded in the 1980s that, based upon the tiered regulatory schedule going forward, there would not be enough platinum in the world to accommodate the conversion efficiencies mandated for mid-1990’s and, as a result, catalytic converter costs would skyrocket. Consequently, Ford scientists redirected their research efforts and in 1989 they first introduced a palladium-based catalytic converter technology – effectively more than doubling the available supply of metal with these rare catalytic properties, as roughly equal amounts of both platinum and palladium are produced in the world each year.

Palladium, at the time being less costly, rapidly replaced platinum and became the metal of choice as the efficiency of the gasoline engine catalytic converters improved and metal

loadings were ratcheted up under the increasingly stringent regulatory standards of the mid 1990s.

In the early 2000s, when diesel engine emission treatment technology was being considered, scientists had concluded the low temperature diesel emissions could only be treated using platinum. Subsequent research, driven by the same fundamental economic driver, – i.e. cost – demonstrated the feasibility of using some palladium, and then increasing levels of palladium, in diesel engine catalytic converters and diesel particulate matter filters (DPF). By late 2009 technology had emerged reportedly allowing palladium to displace up to 50% of the platinum loadings in diesel catalytic converters, and with the technology in hand, movement toward 50% palladium loadings is now underway. This is a significant development considering over 50% of new European-built cars are diesel and considering diesel catalytic converters require two times more PGMs than equivalent gasoline engines.

Further regarding cost driven research: the initial application of palladium in both gasoline and diesel catalytic converters required using a larger amount of palladium than of the platinum it was replacing. Today with technological advances thrifting down the use of both metals, the substitution (replacement) ratio is nearly one for one for gasoline emissions – and scientists expect to move nearer to one for one in time for diesel.

And as astonishing as it may seem, despite 35-plus years of cost-driven catalytic converter research, no effective substitute for the use of platinum, palladium and rhodium in converting or reducing gasoline and diesel emissions has ever been identified. Applications can use any one or all of these three PGMs, driven primarily by the relative economics. But no other substance has the catalytic efficiency of PGMs.

Thus, based upon price/cost driven economics, palladium today has become the dominant catalyst worldwide for use in catalytic converters, given the almost universal prevalence

of the gasoline engine with its palladium-based catalytic technology and palladium's growing position in treating diesel engine emissions.

Twenty year old coincidence, continued impact

The Russian Palladium Inventory

Liquidated – over 20 year Time Period

The past twenty years produced coincidental events that facilitated both the compliance with regulatory requirements for clean air and the move to palladium for catalytic converters.

1. Researchers (at Ford) introduced the use of palladium in catalytic converters, formulated 20 years ago in 1989, in anticipation of surging developed-world emission control regulations and impending shortages of platinum.
2. The collapse of the Soviet Union and the emergence of the Russian Federation 20 years ago in 1989 for the first time gave the Western world access to metal from the significant Soviet-era government strategic stockpile of palladium – usually referred to simply as the Russian palladium inventory. Although the size of the stockpile remains a state secret, the inventory is estimated by analysts to have held 27 to 30 million ounces in 1990.
3. The 1989 timing of the development of palladium technology for catalytic converters and the collapse of the Soviet Union, while purely coincidental, resulted in palladium from the Russian inventory coming available just as palladium usage for catalytic converters surged during the mid 1990s.
4. Over the past 20 years roughly 104 million ounces of platinum and 110 million ounces of palladium have been newly produced worldwide from mines. The nearly equal quantities for the 20-year period are only coincidental given they represent a combination of platinum-rich PGM mine production from South Africa and Zimbabwe, and palladium-rich PGM mine production from Russia, Canada, and the U.S.A.

5. Absent the Russian inventory sales, the tightness in the PGM markets would have become intense over time, probably resulting in different pricing relationships than exist today and perhaps reducing the role that palladium has played in catalytic converter technology. While significant inventories (an estimated 7 to 8 million ounces) of palladium also are held in Swiss banks, much of this appears to be held for long-term investment and so has had less market impact.

The size of the Russian inventory is a perplexing Russian state secret, which has driven all sorts of erratic market behavior. In early 2001 the price of palladium soared to \$1,097 following a buying frenzy resulting from the growing dependency on palladium for catalytic converters, and a premature worry that Russian inventory was either at a point of exhaustion or that Russia would cease inventory sales. By 2003 the palladium price had fallen back to \$150 as the market recognized the reality of continuing Russian inventory sales and endured the liquidation of palladium stocks accumulated during the late 1990s by speculators and auto companies alike – which accumulation had been the principal driver of the palladium price surge in the first place.

Analysts have attempted to determine the size of the Russian inventory by gauging production from Norilsk, its primary source, over the 50 year period from 1939 to 1990. Beginning in the early 1990s, Norilsk production was made available commercially in the market place and no longer placed in the strategic inventory. Most conclude that the size of the Russian palladium inventory as of the early 1990s was between 27 and 30 million ounces.

Analysts have also attempted to determine the extent of sales from the inventory since 1990. Based upon shipments out of Russia, inventory sales to date appear to have been between 25 and 30 million ounces. Most conclude that no more than 2 to 3 million ounces now remain in the inventory with some projecting that the inventory has been all but fully liquidated. In the words of one observer, “the Russian inventory has been resolved and will not be a factor in the market going forward.”

Thus, a day of reckoning looms ahead. The world has consumed palladium at an unsustainable rate far in excess of primary mine production for 20 years, with the 110 million ounces of primary mine production augmented by up to 30 million ounces of liquidated inventory. That equates to over 25% more palladium supplied to the market than was actually produced during that period.

Put another way, on average per year over the last 20 year period, 5.5 million ounces of primary palladium production was sold, augmented by 1.5 million ounces of inventory liquidation. That is now close to or at its end and the market shortly will have to adjust to a new reality in a “post Russian inventory” setting. The adjustment will be reflected in price.

At present the situation shows –

- Up to 50% of platinum and palladium production is used now for catalytic converters.
- Converter applications increasingly favor palladium, driven by price/cost economics.
- The Russian strategic palladium inventory is liquidated – either gone, or close to being so.

If that's history – where we stand at the moment

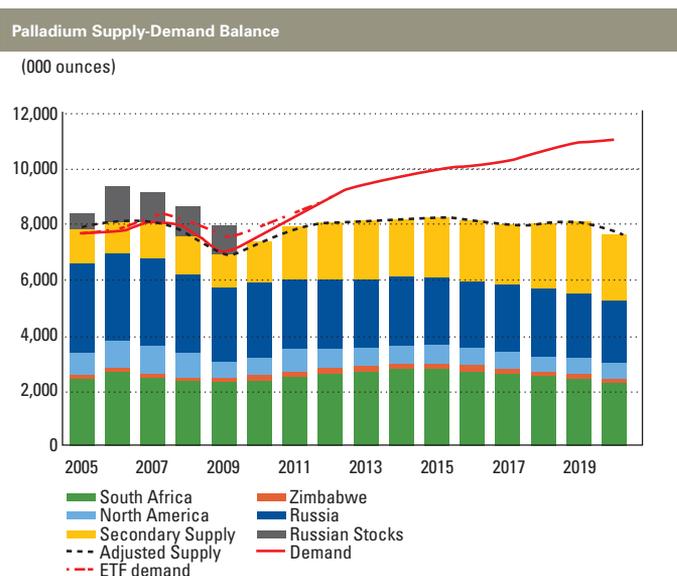
The Big Story Lies Ahead

Headlines Blare

- Platinum and palladium remain scarce, expensive commodities
- South African PGM producers, who face severe operating constraints, are key to global supply
- Car build is surging in the emerging economies, while recovering in the developed world
- Catalytic converter loading requirements are expanding in emerging economies
- Stable to robust demand continues for palladium's other end-uses – jewelry, electronics, dental, chemical
- Growing PGM investment demand now includes U.S. platinum and palladium ETFs

- Fundamental market deficit ahead leaves palladium supply potentially reliant on sales of Swiss stocks
- Secondary supply (recycling), although projected to double, will not offset market deficit
- Remaining Russian palladium inventory, if any, will likely have little future market impact
- The 4 to 1 price differential between platinum and palladium is not sustainable
- New price equilibrium between platinum and palladium may already be emerging
- Platinum and palladium price equilibrium could test 2 to 1 – perhaps even 1.3 to 1 (50% - 75%)
- Platinum price to remain above palladium – driven by South Africa's PGM market basket

These factors (the above headlines) are now converging and will have an increasingly dramatic effect on the demand for palladium. A fundamental palladium market deficit potentially lies directly ahead which will leave incremental palladium supply reliant on existing stocks, recycling supply, and still short of meeting demand. During the next ten years projections show the supply-demand picture moving from being closely balanced into severe deficit as auto sector demand recovers and auto production surges in the developing economies. Annual supply deficits, excluding ETF activity and above ground stock purchases and sales, are forecasted to grow to over one million ounces by 2014.



The following treatise examines the critical segments of the big story that lies ahead.

Scarcity of PGM Resources

Two Key Countries Account for 90% of Primary PGM Production

20 Year totals: South Africa 57% – Russia 33% of total

Platinum, palladium and rhodium (PGMs) are scarce metals found in only a few, mostly isolated, regions in the world. They are both precious metals in demand for jewelry and investment purposes, and industrial metals vital to certain catalytic applications where no good alternatives exist.

Geological formations containing commercial grades of PGMs are limited for the most part to South Africa and Zimbabwe; Russia, above the Arctic Circle in Siberia; Canada, north of the great lakes in the greater Sudbury region; and United States, in the mountains of Montana north of Yellowstone Park.

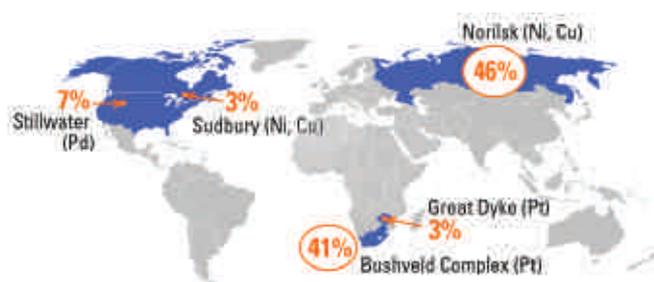
An understanding of the production originating in each region is key to appreciating the fundamentals governing PGM markets. Further, secondary production from recycling and above-ground stocks (inventories) also are critical to these fundamentals. Production and supply for 2009 were as follows:

2009 Primary Production (Ounces '000)	Palladium		Platinum		Rhodium		Total		Primary Metal
	Ounces	% of Production	Ounces	% of Production	Ounces	% of Production	Ounces	% of Production	
South Africa	2,380	41%	4,550	78%	650	84%	7,580	61%	Platinum
Zimbabwe	160	3%	220	4%	20	3%	400	3%	Platinum
Russia	2,680	46%	780	13%	80	10%	3,540	29%	Nickel
Canada	150	3%	140	2%	20	3%	310	3%	Nickel
Montana	410	7%	120	2%	0	0%	530	4%	Palladium
Total Primary Production	5,780	47%	5,810	47%	770	6%	12,360	100%	
Recycling Production	1,170	54%	820	38%	180	8%	2,170	100%	
Total Production	6,950	48%	6,630	46%	950	7%	14,530	100%	
Inventory Changes	(500)		(380)		-	-	(880)		
Total Supply	6,450	47%	6,250	46%	950	7%	13,650	100%	

By comparison to these metals, 2009 primary world production of the other two precious metals, gold and silver, was far greater, with gold at about 80 million ounces and silver at approximately 400 million ounces. Even when PGM production is combined, total annual PGM output at less than 13 million ounces is only 16% that of gold.

It is important to note from the chart above that production economics are driven by the primary metal being produced from each specific geological resource. In South Africa the primary product is platinum, and (at 2009 PGM prices) palladium only contributes about 7% of total value – except in the lower producing Eastern and Northern Limbs of the Bushveld Complex where its contribution generally is closer to 12%. In Russia, Norilsk Nickel's primary product is nickel, and palladium contributes about 10% of revenue.

Global palladium production by region (2009)



And a similar story applies to the limited production from Canada, where palladium generates roughly 8% of revenue. Only in the U.S. (Montana) are production economics driven primarily by palladium. The point being, because palladium only plays a supporting role in most mining operations, at current price levels the amount of mined palladium produced is fairly insensitive to changes in its price.

South African PGM production facing severe constraints – key to global supply

Primary Production of PGMs Limited

*Twenty Year Totals – Pt 104 m oz –
Pd 110 m oz – Rh 14m oz*

Perhaps there is nothing new to the challenges facing South Africa, the world's preeminent source of PGMs, which over the last 20 years has produced an estimated 57% of the world's combined total PGMs, including 76% of its platinum, 36% of its palladium and a huge 85% of its rhodium. But the number and the complexity of the challenges it faces today make the current situation seem especially difficult. As one commentator puts it – “the head winds faced by South African PGM producers are severe.” Challenges detailed include at least a dozen items.

1. Electricity – The failure of Eskom, the government-owned electric utility monopoly, to add necessary capacity to support the demands of South Africa's growing economy – this has and is expected to continue to result in periodic service interruptions, resulting in lost production and adding to cost.
2. Electric cost – Eskom recently won approval to increase electric rates to fund additional generating capacity – the rate increases of 25% per year for 3 years will double power costs for all producers in two years and are expected to add appreciably to production costs.
3. Mandatory mine safety shutdowns for fatality inspections – a civilized response that results in lost production – have been adding to cost.
4. The ever-deepening nature of the Bushveld resource – this translates into massive and increasing capital requirements just to maintain production rates.

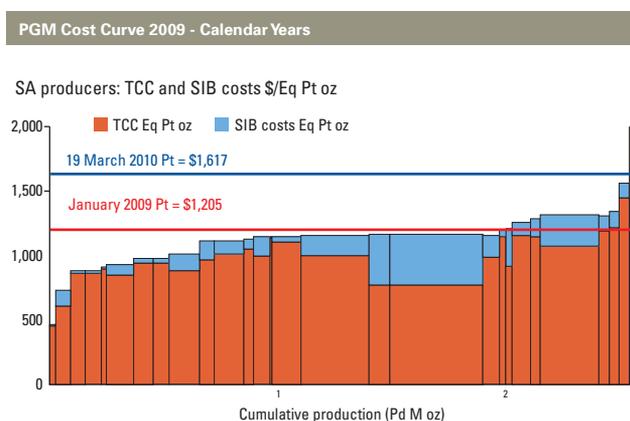
5. Ever-increasing power consumption – to operate in the deepening mine environment requires deep hoists, and refrigerated ventilation.
6. Deferral of capital spending – low prices in 2008 and 2009 led to scuttling previously projected production increases, resulting in a falling production rate since the 2006 peak – 2007 to 2010 average production (Pd+Pt+Rh) is down by about 12%.
7. Rand/dollar exchange rate – with higher PGM prices, increased revenue flows into South Africa strengthen the Rand, and thereby shrink the Rand-equivalent value of dollar-based revenues, narrowing margins (a perverse dynamic).
8. Skills shortages and wage demands – demand for qualified mining personnel exceeds supply, particularly for mining the Merensky, and outsized annual union wage demands of ~10% persist.
9. Mining emphasis, by default - shifting from higher platinum “Merensky ores” to UG2 ores with lower platinum grades and difficult-to-process chrome content.
10. New project mining permits - delays by government.
11. Competition for water - new projects compete with community demands, and so water is difficult to permit, source and transport.
12. Threats of government interference or takeovers – discourage investment decisions.

Regardless of these challenges, South African PGM production is essential to meeting increasing global requirements for these metals. Thus pricing will continue to be largely driven by the South African PGM 4E market basket (at an overall ratio of about Pt 2.0, Pd 1.0, Rh 0.2, Au 0.1) and heavily influenced by increasing cost pressures in South Africa, such pressures being driven by cost increments for higher production, given PGMs are in short supply.

Further on this point: the South African cost/price driver is quite obvious when the economic driver of Russian PGM production is taken into consideration. Russia's PGM production (33% of world total) is a by-product of nickel production and therefore is not affected very much by changes in PGM prices.

At March 19, 2010, with platinum at \$1,617 per ounce and palladium at \$476 per ounce, the South African 4E market basket price was \$1,317 per ounce, which puts the majority of South African mines back into profitable territory.

The chart below demonstrates the benefit of increased PGM prices to South African producers, expressing total cash costs (TCC) and reinvestment requirements (stay in business, or SIB costs) on a platinum - equivalent basis at the current exchange rate.



Car build rate surging – again

The Emerging Economies Surpass Critical Mass
World Car Build Growth 2-3% per year – To Top 100 million by 2020

The historically dominant automobile demand centers of Western Europe and North America were long ago trumped. For the last 20 years these two economic centers have averaged around a 15 million-car annual build rate each – with the lack of growth reflecting the maturity of these economies. The global car build rate was 73.7 million cars in 2007 falling to 60.2 million by 2009 as a result of the 2008 world economic collapse. Relative to 2007, the Western European and North American car build rates accounted for the majority of the 2009 drop (a 35.5% reduction or 9.8 million units) masking the robust nature of the “rest of the world” car build rate – particularly in China. In fact, from 2007 Chinese production soared an astonishing 33.3% to 11.9 million cars in 2009, stimulated by government incentives and surpassing the North American car build rate.

More importantly, while the car build rate is expected to recover quickly in Western Europe and the North America the real future surge in car build rate is in the emerging economies of China, India, Brazil, Eastern Europe and Russia. Once the world auto industry emerges fully from the current economic downturn, longer-term growth is projected at a rate of 2% to 3% per year over the next 10 years, with the car build rate worldwide expected to top an astonishing 100 million units per year by the end of 2020. The five economies mentioned have the economic wherewithal and growing discretionary income for their people to support this surge in growth.

Vehicle Production - All Vehicle Types														
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
United States	10,830	8,750	5,690	6,910	8,380	9,280	9,930	10,250	10,490	10,740	11,010	11,300	11,600	11,690
yoy%	-4.4%	-19.2%	-35.0%	21.4%	21.4%	10.7%	7.0%	3.3%	2.3%	2.4%	2.5%	2.6%	2.7%	0.8%
Western Europe	16,680	15,160	12,060	11,830	12,660	14,070	15,140	16,000	16,090	16,200	16,320	16,450	16,590	16,490
yoy%	2.7%	-9.1%	-20.5%	-1.9%	7.1%	11.1%	7.6%	5.7%	0.6%	0.7%	0.7%	0.8%	0.9%	-0.6%
Japan	11,430	11,330	8,420	9,080	10,040	10,430	10,650	10,810	10,960	11,110	11,260	11,410	11,570	11,530
yoy%	-0.3%	-0.8%	-25.7%	7.0%	10.5%	3.0%	2.1%	1.5%	1.4%	1.4%	1.4%	1.4%	1.4%	-0.3%
China	8,900	9,340	11,860	11,880	12,730	13,680	14,640	15,570	16,340	17,150	18,000	18,890	19,830	20,430
yoy%	21.1%	5.0%	26.9%	0.2%	7.1%	7.5%	7.0%	6.4%	4.9%	4.9%	5.0%	5.0%	5.0%	3.0%
Rest of World	25,860	26,190	22,220	24,360	29,020	31,540	33,380	34,980	35,910	36,890	37,900	38,960	40,050	41,070
yoy%	9.9%	1.3%	-15.1%	9.6%	19.1%	8.7%	5.8%	4.8%	2.7%	2.7%	2.7%	2.8%	2.8%	2.5%
WORLD	73,690	70,780	60,240	64,050	72,820	79,000	83,730	87,610	89,800	92,090	94,490	97,000	99,640	101,210
yoy%	5.5%	-4.0%	-14.9%	6.3%	13.7%	8.5%	6.0%	4.6%	2.5%	2.6%	2.6%	2.7%	2.7%	1.6%

Catalytic converter requirements surging, in particular in the emerging economies

Emerging Economies Stepping Up to Meet World Environmental Standards

Catalytic Converter regulations in China at Euro 4 – as of 2010

Many Western observers seem to believe that the Chinese economic phenomenon, now 30 years in the making, still lacks legitimacy. Some suggest the huge increase in car build rate in 2009 was fabricated, as gasoline consumption remained flat. Some suggest that the Chinese cars are not fitted with catalytic converters. To the contrary, such doubters are simply wrong – both Chinese economic strength and its surging growth and environmental focus are very real.

Reports from Western catalytic converter manufacturers for 2009 indicate that their catalytic converter plants in China were operating at peak capacity, and they needed to import foreign made catalytic converters into China to meet demand. Such reports validate the car build rates and the use of catalytic converters.

All of the large emerging economies of the world mandate catalytic converters on the automobiles they manufacture. And virtually all of the world's automotive growth is coming from these emerging economies. The chart below shows a selective cross-section of the increasingly stringent

requirements in different nations. Note that Chinese and Russian regulations require compliance with Euro 4 standards effective this year – 2010 – and India requires Euro 3 standards. The result of these tighter emission limits will inevitably be somewhat increased PGM loading requirements. Because gasoline engines predominate in new automobiles throughout most of the world, palladium demand will benefit disproportionately from these new regulations.

In the developed world, the largest remaining new application for catalytic converters is for diesel particulate filters (DPF), where a transition toward higher palladium loadings already is underway. In 2007 U.S. regulations requiring both catalytic converters and DPF to be installed on all newly built diesel cars and trucks from that time forward. Besides diesel applications, catalytic converters for off-road equipment, motorcycles, lawn mowers, and other incidental exhaust streams are either under way or soon to be. Legislation supporting the retrofit of catalytic converters on large vehicles manufactured before 2007 also is being considered.

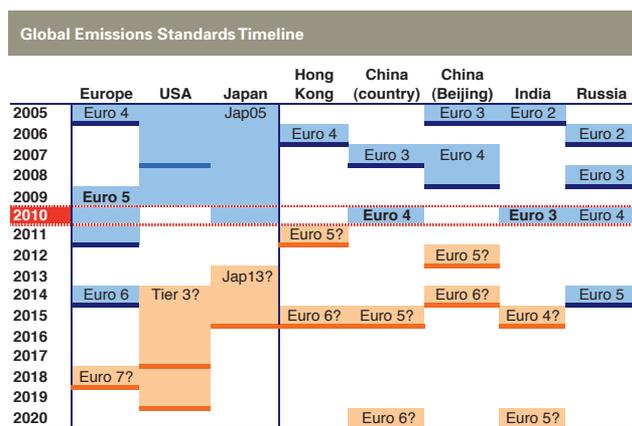
In Europe, where DPF filters were voluntarily installed by some high-end manufacturers for many years, legislation now requires new diesel platforms to install DPF filters beginning in September 2009 and all new diesel platforms to have them in place going forward from the end of 2010.

Gasoline engines to dominate new car build for next 20 years – favoring palladium

Electrics to Require Significant Advances in Technology Hybrids Require Equal or More Emission Control

Combustion engine and hybrid technologies most likely will continue to dominate the automotive market for the next 20-plus years, so auto catalysts still will be required to meet increasingly stringent emission legislation, suggesting a robust and growing demand for palladium.

Further, the trend toward downsized, high-efficiency gasoline engines for automobiles offers a compelling package of energy efficiency and good CO2 reduction



at only modest additional cost. It appears, looking at the trade-offs among economics, environmental concerns and performance, that this will be the strongest growth market over the next decade or two. Technological breakthroughs in battery technology or fuel cells not fully foreseen today could shift this somewhat over the longer term. But at present the outlook for reliance on palladium-based auto catalysts is strong.

Given the current state of technology and battery performance, it appears that the next generation of electric cars will be suitable only in niche markets and test fleets, not as mass market cars, and manufacturers will continue to make losses on electric cars for many years to come. Electric vehicle battery technology, as historically with gasoline combustion engine technology, probably will follow a path of evolution rather than revolution, requiring billions of dollars in auto company losses or government subsidies to perfect.

Diesel engines will continue to be favored for their efficiency in larger cars in Europe and will increasingly include palladium as loadings move rapidly up to the 50% now possible, with expectations beyond 50% as new technology emerges driven by the platinum palladium price/cost advantage. Diesel catalytic converters use twice the PGM loadings of gasoline converters for the now mandatory DPM conversion requirements on new European platforms and for all platforms by year end 2010. Diesel-powered vehicles, because of their added size and weight, are unlikely to take a major share of the auto market in China or emerging markets.

PGM supply from recycling projected to double

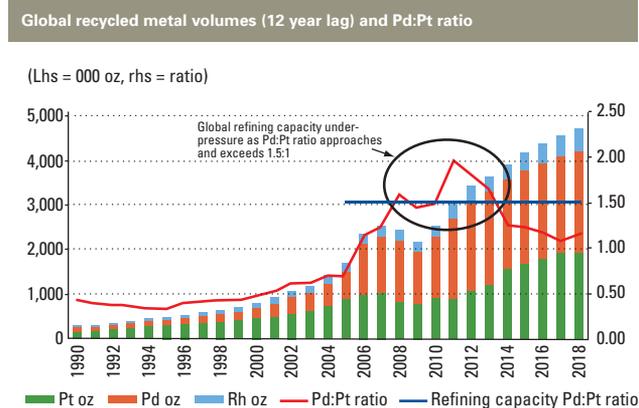
Recycling Recovery Rate at 50% to grow to 70% – Driven by Maturing Collection Structure and Price Recycling Growth will not Offset the Palladium Market Deficit

Automotive catalytic converter recycling constitutes the largest supply of PGMs from secondary sources. At present only about 50% of catalytic converters scrapped worldwide are recycled, and the average age of a catalytic converter recycled today dates to about 1998 – 12 years. With the

increased loadings in more recent automobiles and rising PGM prices factored in, the recovery rate is projected to increase to 70% over time.

Currently about 2.5 million ounces of PGMs are being recovered annually. The palladium-platinum ratio of the current recycling volumes is currently at 1.5 to 1 – that is, palladium constitutes about 60% of the total PGM content and platinum 40%. This ratio is expected to rise gradually to approximately 2 to 1 over the next few years, and then should fall back below 1.2 to 1 as the heavily platinum-loaded diesel catalytic converters in Europe begin to be scrapped out. Rhodium, the third (and scarcest) component metal, comprises about 5% of the total recycle PGM mix.

Annual recycling volumes are projected to grow to almost 5 million ounces over the next 10 years.



Growing investment demand now includes U.S.A.-based ETFs

U.S. Platinum and Palladium ETF trading initiated January 2010 – Complements European ETFs Palladium Trading on Shanghai Gold Exchange Expected in 2010

Palladium futures have traded on NYMEX since 1968 and on TOCOM since 1992; between the two markets new long positions reached 1.68 million ounces in December 2009. Trading volumes dipped briefly in April 2009 when

palladium prices retreated, but then increased rapidly throughout the second half of the year. There has been significant interest in palladium on the NYMEX, with large speculators holding positions totaling a record 1.4 million ounces in December of 2009.

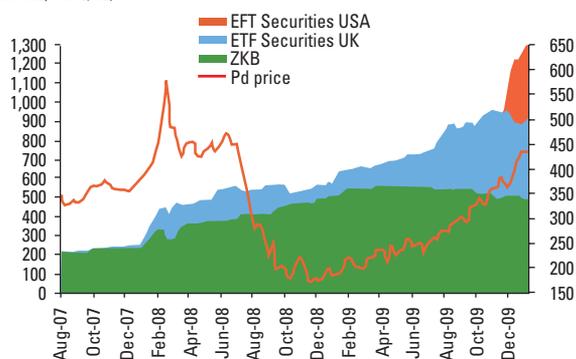
Exchange Traded Funds (ETFs) are a newer investment alternative for platinum and palladium. ETF shares represent a proportionate interest in physical metal held in a vault in London or Zurich. ETF Securities initiated platinum and palladium exchange-traded funds in 2007 in Europe.

In early January 2010 ETF Securities received SEC approval and listed platinum and palladium ETFs in the U.S. on the NYSE-Arca. The U.S. palladium ETF was immediately successful, accumulating 195,000 ounces in the first week of trading and selling out within weeks of its debut. Total worldwide palladium ETF holdings totaled about 1.5 million ounces at the end of January 2010.

Further, as seen from the following chart, it appears that ETF investors generally take a longer view of the metals, perhaps understanding the growth opportunities for industrial palladium and that the market is moving toward a fundamental deficit position. Consequently, as witnessed in the London and Swiss ETFs, a price correction (or even an economic downturn) doesn't necessarily mean a sell-off in palladium.

Palladium ETF holdings and price

(lhs koz; rhs \$/oz)



Other palladium demand stable to growing

The other uses for palladium are each driven by both economic and technological fundamentals. They include jewelry, electronics, dental and chemical applications.

China Dominates in Palladium

Jewelry – Platinum As Well

UK Initiates Palladium Hallmarking January 2010

Jewelry is the third-largest source of demand for palladium. It remains largely a China-based phenomenon that first emerged there about five years ago. Since then, palladium use for jewelry has spread to most parts of the world based upon affordability and growing customer awareness and acceptance. On average about one million ounces per year of palladium have been used for jewelry over this five-year period, a rate that is expected to continue, driven by the relative cost of precious metal alternatives, platinum and gold. China will remain the largest market for palladium as well as for platinum, with palladium proving particularly popular in second and third tier cities. Unlike platinum and gold, Chinese consumers do not yet see palladium jewelry as a store of value, which potentially limits its sales growth potential. This could change if and when the Shanghai Gold Exchange begins trading in palladium – possibly in 2010 as recently suggested by the exchange's Chairman. The UK hallmarking of palladium jewelry, mandated beginning in January 2010, will help to secure palladium's position as a precious metal and ensure greater worldwide consumer approval and demand.

Electronics – MLCC Demand Continues

Palladium MLCC Technology Critical to Surging HDTV

Palladium's use in electronics is based in part upon price and in part upon the need for high quality electronic components in the fast-growing high definition television, mobile phone, and other image technologies. Palladium-based MLCCs, or multi-layered ceramic capacitors, are expected to retain their 10-15% share of the MLCC market, particularly for higher specification products such as mobile phones, computers and their peripherals, digital audio-visual equipment, automobile electronics and, in particular, high definition television. The opportunities for growth in television are large as technology shifts from cathode ray tubes to flat-panel high definition television (HDTV). Though the palladium loading in each unit may be small, the growth in volume of MLCCs outweighs this – a standard 32" CRT contains approximately 250 MLCCs per unit, whereas a flat panel LCD or plasma display with an HDTV module will increase the content to 1,150 MLCCs for the same screen size in order to deliver its superior clarity.

Dental – Palladium Superior in Restorations

Growing Ageing Population Prefers

Restoration over Extraction

Dental demand is forecast to increase based partly on its lower price and partly on the superior alloy properties. Bonding of ceramic palladium alloys shares high temperature stability and expansion coefficients of dental porcelains. A high melting point is vital as the high firing temperatures of most porcelain requires the alloy used to have a higher melting point so it does not melt. Palladium's low expansion at high temperatures is key compared to silver, gold and platinum, and thus helpful when developing lightweight porcelain alloys compatible with currently used porcelains. However, despite its attractive properties, palladium is vulnerable to substitution if price rises above that of alternative metals.

Chemical – Another “Emerging Economy” Story

Palladium in Growing Nitric Acid Requirements

Chemical demand in nitric acid production will remain relatively flat in mature economies as little new capacity is planned and thus any metal used is simply for top up requirements. However, consumption is forecasted to expand significantly in the emerging economies as new nitric acid production capacity comes onstream; Chinese nitric acid output has been growing at around 10% per annum, concentrated around the Shandong Province in the eastern coastal region. Chinese demand alone for palladium catalysts is forecast to grow from 79,000 ounces in 2010 to 155,000 ounces in 2029.

Market Conclusions

4 to 1 price Differential between Platinum and Palladium Unsustainable

Law of Supply/Demand to prevail

Price disparities between products that compete for the same market are a curious thing. In the end, absent compelling product performance differences, such competition is settled by price. That is in principle just the law of supply and demand. For most of the catalytic converter market there is little compelling product difference now between palladium and platinum – except price. With about 50% of the demand for PGM metals today going into catalytic converters, price is the determining factor and has made palladium the metal of choice wherever feasible. With the technological shift toward palladium continuing, growth in the auto sector resuming, and the exhaustion of Russian stocks presumably nearing, the converging price trend between palladium and platinum that has emerged in recent months should continue. Determining the appropriate price equilibrium between the two apparently will become the new market riddle.

***Russian Palladium Inventory Resolved?
Market Strength Implies Any Remaining Russian
Inventory to Have Minimal Impact***

The massive 27 million to 30 million ounce Russian palladium inventory estimated to have existed in 1990, and which has overshadowed the palladium supply picture for 20 years, is nearly depleted, already fully liquidated or, given the broad, robust and relatively inelastic demand for palladium, is to the point that whatever is left of the inventory can only have a marginal impact on the market going forward.

***New Platinum, Palladium Price Equilibrium to Emerge
Platinum, Palladium Price ratio to
Test 2 to 1 – Perhaps Beyond***

So the key question – if the palladium price is now moving toward a new equilibrium relationship with the platinum price, where will it settle out? This question will be fiercely debated as the market tightness becomes apparent. Given the volatility of metal markets, it is not even clear that there is any single answer. But whatever the new equilibrium relationship turns out to be, it will have been most heavily influenced by new supply constraints in the face of demand that has continued to expand. In summary, those dynamics include the following cascade of factors –

- Demand growth for all PGMs will continue as auto build rates strengthen worldwide. The auto sector currently consumes about 50% of new PGM production. By 2020, the auto sector will require 3.2 million more ounces of palladium than in 2009.
- Worldwide emission control standards are continuing to tighten, requiring additional PGM loadings in each catalytic converter.

- Emission control demand is price-driven, and is shared among palladium, platinum and rhodium. Currently economics greatly favor the lower-priced palladium.
- However, without a platinum price strong enough to support South African production costs, over half of the world's PGM production is at risk. South African production is faced with rising costs on several fronts. This suggests the palladium price is likely to rise rather than the platinum price falling.
- The Russian strategic inventories of palladium, while perhaps not yet entirely liquidated, will be less and less of a contributor to palladium supply dynamics in the future and because of surging demand against the shrinking supply will have a less significant price impact. Swiss inventories are also a potential supply factor, but at least to date seem to be largely held in stable hands.
- Alternative vehicle technologies are still largely experimental and are unlikely to displace a significant share of the conventional auto market for the foreseeable future.
- As a consequence of all these factors, demand for palladium is likely to grow faster than supply, suggesting that the palladium price must rise.
- Palladium demand for other uses likely will be rationed as its price moves up, leaving additional metal available for automotive use.

Such is the case for palladium. It appears that the fundamentals are now in place for a significant upward price rereating against, or along with, platinum.

Source of charts and graphs SFA (Oxford)