

The PGM markets

Outlook and price forecasts



Edison themes

13 December 2021

Each of the six platinum group metals (PGMs, platinum, palladium, rhodium, iridium, ruthenium and osmium (unstable at room temperature)) contribute enormously to a clean environment by converting deleterious exhaust gases from internal combustion engines (ICEs) through their catalytic properties to benign gases in a more efficient way than any other known catalyst. Platinum has been used for decades as a catalyst in chemistry, petroleum refining, hydrogen production and the use of its catalytic properties in fuel cells and as a die in fibreglass manufacturing. It is also used in the manufacture of gorilla glass, high-capacity solid state e-storage of data and cancer treatment drugs, as well as in investment instruments such as ETFs and to create bars and coins. Palladium and rhodium are more efficient in converting emissions from gasoline engines and, as such, more than 90% of these metals are used in this application.

Vehicle sales are a key driver

Vehicle sales are a key driver for demand for palladium and rhodium for ICEs. Palladium and rhodium are more exposed to gasoline car sales, while platinum is exposed to diesel. Both gasoline and diesel will be gradually replaced with electric vehicles (EVs). Unlike palladium and rhodium, platinum is also used in fuel cell EVs (FCEVs) and could therefore benefit from the likely increase in hydrogen adoption. Gasoline powered cars currently make up around 75% of sales, but this is expected to decline meaningfully as new green vehicle sales such as battery EVs (BEVs), hybrid cars (with both a battery motor and an ICE) and FCEVs take away market share mainly from the gasoline ICEs and diesel to a lesser extent. Hybrids and FCEVs will likely see PGM demand equal to or greater than current ICE usage because FCEVs currently use more platinum than ICEs and use no palladium.

Outlook remains firmly positive

With the expected recovery in chip supply in mid-2022, we forecast a positive outlook for PGM prices except for palladium, which is likely to suffer from loss of market share because it is used mainly in gasoline ICEs and in diesel to a lesser extent. However, this decline in sales could in part be offset by higher PGM loadings due to stricter emissions regulations, which are likely to be tightened further. The outlook for platinum, iridium and ruthenium over the next two decades is positive. These have exclusive catalytic properties in the generation of hydrogen within the fuel cell battery. We see a balanced market for platinum in the short term followed by large deficits from the late 2020s onwards due to growing demand from the developing hydrogen economy. For palladium, we see growing surpluses and for rhodium large deficits to 2028 followed by surpluses thereafter. The basket price of the metals for South African producers is forecast to average \$2,520/oz between 2022 and 2030, 2.5x the prices achieved before 2019.

Winners: South African PGM producers like Sibanye Stillwater, Sylvania Platinum and Tharisa.

Losers: Northern Hemisphere PGM producers like Nornikel, Stillwater mine and Impala Canada.

The winners and losers shown above do not translate into buys and sells as other themes (and valuation parameters) may conflict with this one.

From the street

This report analyses the future demand and supply of PGMs taking into consideration vehicle, industrial, jewellery and investment demands, which differ for each metal. The supply of PGMs from South Africa, Russia and North America also differ in the percentage of each metal produced from their ore mined. The resultant market balance of either surplus or deficit for each metal is then considered when arriving at a forecast price. The forecast depends mainly on this market balance and global growth prospects.

Edison themes

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Introduction

Vehicle sales: Key driver of PGM prices

Auto catalyst emissions control is responsible for around 90% of global palladium and rhodium demand and 36% of platinum demand. After two years of steep price rises in all six PGMs, 2021 saw a sharp correction mainly because of the global computer chip shortage and the resulting drop in production and sales of motor vehicles. Compared to the 96m vehicles sold globally in 2019, a normal pre-COVID-19 year, just 78m were sold in 2020 and an estimated 80m will be sold in 2021 (source: LMC Automotive, JD Power), of which the majority are powered by gasoline. Gasoline cars use only palladium (c 4.2 grams per autocatalytic converter (autocat) on average) and rhodium (0.7 grams); hence, these metals are likely to be most affected in the longer term by falling demand for ICE vehicles.

Platinum, iridium and ruthenium are needed to produce hydrogen, which will increasingly be used as lower carbon emission strategies are implemented globally. Platinum has other uses due to its catalytic properties in the chemical, petroleum, electrical, bio-medical and investment sectors and is largely protected from the expected demand pressures in the auto sector. By mid-2022, it is likely that the chip supply issues will be resolved, and we see moderate demand for palladium and rhodium until around 2025, when we expect BEVs to start taking significant market share from gasoline and diesel-powered vehicles (source: Worldwide car sales by fuel technology 2030|Statista). By 2030, we see sales of around 36m BEVs (see our April 2021 report [EV outlook #1](#)). As a result, we expect palladium and rhodium demand to decline as they are the two metals that are used almost exclusively in gasoline engines, which engines are likely to lose most market share due to their predominance of sales currently. Our long-term price forecasts are for palladium prices to approach \$1,500/oz and rhodium to fall to \$5,000/oz.

Outlook

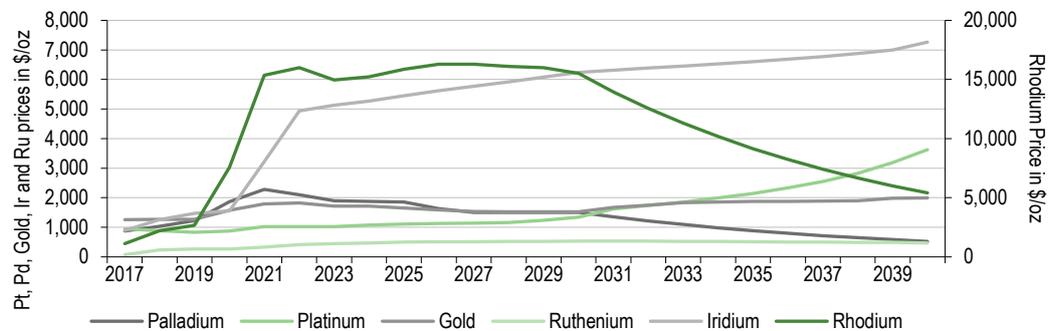
Even though the hydrogen economy is at a very early stage of development, platinum demand is forecast to rise as this economy gains momentum and prices are expected to firm as above-ground stocks of platinum are consumed; prices are forecast to rise steadily thereafter. Demand for palladium and rhodium is set to remain firm until around 2025, when gasoline car sales are likely to begin losing market share to EV sales, and prices for these two metals will start to fall. Platinum may see some reduced demand for diesel engine catalytic converters as diesel ICEs lose market share, but diesel sales are already small (we estimate c 18% of global vehicle sales in 2021) compared to gasoline (c 70% of sales in 2021) and diesel engines have special applications in trucks, construction and mining vehicles that electric trucks will have difficulty competing with due to the weight of the batteries and the length of time it takes to charge or replace them. (Fuel cell trucks are far better suited to high torque applications and their performance is very similar to diesel trucks.)

Iridium and ruthenium prices are likely to remain strong as hydrogen production increases. However, significant increases in PGM production (iridium and ruthenium cannot be mined individually as they come in a basket of metals unique to each mine) are unlikely given the widespread view that BEV and FCEV will take market share from gasoline cars over the next 20 years, making producers reluctant to expand production as an oversupply of metal will result in a fall in prices. Platinum will also be used in heavier transport in FCEVs (which average 30 grams per vehicle and can contain up to 80 grams of platinum per vehicle versus diesel's 5–15 grams per vehicle), as these perform as well as diesels in terms of torque, range and refilling times compared to BEV trucks whose batteries weigh 1.3–2.0t and take time to replace or recharge. The outlook for rhodium is positive as increased loadings in gasoline and diesel autocats is scheduled continuously

through to 2027 with demand firm despite falling gasoline car sales. China 6 and Euro 6 emissions regulations have been implemented since 2020 and 2015 and will continue to be implemented until early 2027, when China 7 and Euro 7 regulations are likely to be imposed (Johnson Matthey Pgm market report, May 2021).

Our forecasts for PGM prices are based on our outlook for the various drivers (such as emissions regulations, PGM loadings in gasoline and diesel vehicles, loading of platinum and its thrifting in fuel cells, BEV targets put out by various governments and car companies, EV sales, etc) and which are summarised in Exhibits 1 and 2 below. It is worth noting that we forecast the South African basket price of the metals that it mines, namely 55% platinum, 25% palladium, 8% rhodium, 8% ruthenium, 2.5% iridium and 1.5% gold, to average \$2,520/oz between 2022 and 2030. This is 2.5x the price achieved before 2019 and puts the South African producers in a very good cash flow-generating position for the foreseeable future if they do not increase supply or the ZAR versus the US\$ does not strengthen.

Exhibit 1: PGM price forecasts (average annual prices to 2040)



Source: Edison Investment Research, Refinitiv

Exhibit 2: PGM price forecasts (average annual prices to 2030)

\$/oz	2019	2020	2021	2022e	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Platinum	827	875	1,018	1,025	1,025	1,075	1,111	1,125	1,137	1,162	1,237	1,343
Palladium	1,230	1,865	2,286	2,100	1,900	1,877	1,857	1,630	1,500	1,500	1,500	1,500
Rhodium	2,664	7,564	15,363	16,000	14,964	15,215	15,853	16,301	16,300	16,100	15,992	15,506
Gold	1,263	1,582	1,786	1,819	1,714	1,715	1,649	1,585	1,539	1,524	1,524	1,524
Ruthenium	264	262	333	417	442	471	495	506	514	520	526	530
Iridium	1,466	1,555	3,215	4,937	5,131	5,268	5,445	5,618	5,770	5,919	6,077	6,239
SA basket	1,052	1,636	2,494	2,553	2,425	2,473	2,544	2,535	2,513	2,515	2,552	2,575

Source: Edison Investment Research, Refinitiv

Demand and supply to 2040

Platinum

We estimate total demand for platinum at 7.6Moz in 2021. Demand for platinum currently is around one-third for autocats for diesel engines, one-fifth for jewellery and the balance for the industrial sector. This includes chemicals, petroleum refining, fibre glass manufacturing, electrical solid state high-capacity storage and processing capability external drives and high-capacity data storage cards and cancer treatment drugs in the form of cisplatin. Investment demand includes instruments such as exchange traded funds (ETFs) and platinum bars and coins.

Demand for platinum in autocats is expected to stabilise at around 3Moz pa to the late 2020s as heavy-duty diesel vehicles in mining, construction and long-distance haulage will be difficult to match by heavy duty BEVs (HDBEVs) for efficiency. HDBEVs will have enormously heavy batteries to carry and long charging times making them uneconomical versus diesel trucks. FCEV heavy duty

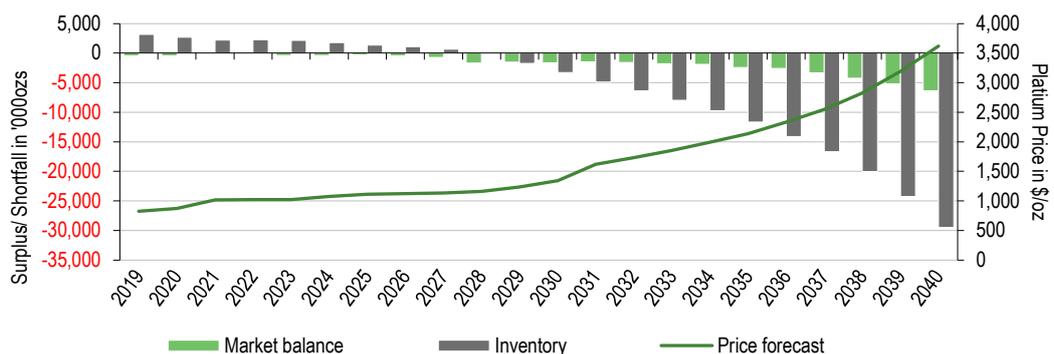
trucks are likely to be more attractive than HDBEVs as their range and refueling times are equal and better than heavy duty diesel-powered vehicles.

We see jewellery demand declining to 1.7Moz pa and stabilising at this level going forward if platinum prices remain below gold prices. Other demand sectors for platinum are forecast to stabilise at pre-2020 pandemic levels then growing in line with global GDP rates, with electronics and glass manufacturing slightly higher than this due to the swiftly growing demand for electronics hardware including cell phones, tablets, computer and TV screens and 5G towers made from fibreglass, as well as wind turbines and other fibreglass applications. Investment demand for platinum bars and coins and ETF products remains strong even post 2020 when uncertainty due to the pandemic was at its highest.

Based on our calculations for platinum demand to produce hydrogen, the use of hydrogen in fuel cell-driven passenger vehicles, heavy and light duty trucks, non-road vehicles, ships and railway locomotives is estimated at 7Moz spread over the next 10 years and back-end loaded.

The supply of platinum is dominated by South African producers, 4.0Moz pa of the 5.7Moz pa total primary supply. Secondary recovery from autocats, industrial and jewellery scrap is estimated at 1.9Moz, which results in a balanced market for 2021. We estimate above-ground stocks of platinum to be 2.8Moz at the end of 2021.

Exhibit 3: Platinum price, market balance and inventory forecasts



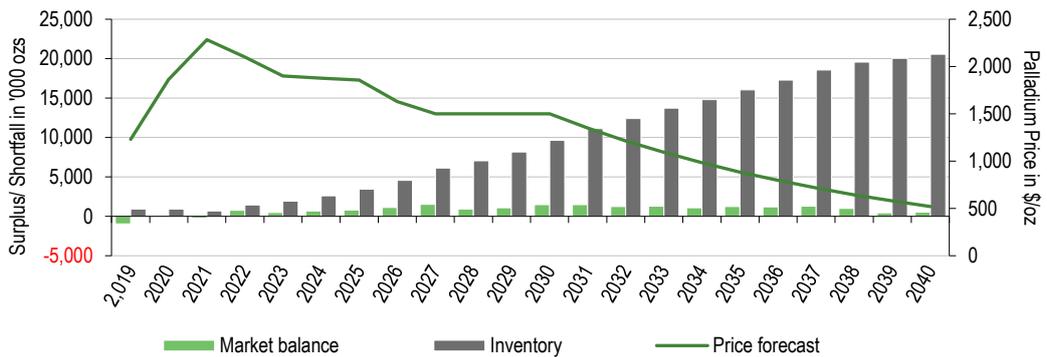
Source: Edison Investment Research, Johnson Matthey Pgm market report May 2021. Note: Market balance excludes inventories.

We expect a virtually balanced market until the end of 2029 (Exhibit 3), after which we forecast demand for hydrogen production and consumption in fuel cells to accelerate, while increases in the supply of platinum are muted and above-ground stocks are depleted by 2027. Secondary supply is estimated to drop off as the recovery of spent autocats declines sharply from 2028 (assuming an eight-year average life of a car) because of the 2020 pandemic and low car sales persisting for the rest of 2021 and into 2022 due to the worldwide computer chip shortage. Combined, this results in the demand supply equation shown in Exhibits 3 and 4 with the resultant longer-term effect on platinum and palladium prices.

Palladium

We estimate palladium demand to be 9.9Moz in 2021. Demand for palladium is dominated by autocats, with 83% currently used for emission control of gasoline engines. A further 7% is used in electronics, 5% in chemicals and the balance is used in dental, jewellery and other applications.

Exhibit 4: Palladium price, market balance and inventory forecasts



Source: Edison Investment Research, Johnson Matthey Pgm market report, May 2021. Note: Market balance excludes inventories.

Palladium has the important property of being able to withstand high temperatures without a drop in performance in its catalytic conversion properties and is therefore well suited to the high operating temperatures of a gasoline engine. The outlook for the gasoline engine is positive for the next few years with constantly tightening emissions control regulations. Currently, Europe and China are at level 6; the United States at tier 3 is at a broadly equivalent level. These three regions are the biggest in terms of car sales and are therefore important to recognise in any demand projections. The next stage for China and Europe, China 7 and Euro 7, is set for 2027 (source: Johnson Matthey Pgm market report, May 2021). Typically, governments set tighter emission standards every four years. However, we see the BEV starting to take significant market share from mainly gasoline vehicles, which currently represent 75% of all vehicles sold, by 2025. This is because BEVs are likely to make significant inroads into vehicle market share (in Europe, they represented 50% of sales in Q321 and 9.8% in China) with the resultant drop in demand for the metal over the coming years.

Supply of palladium is dominated by Russia and South Africa, which contribute around 77% of total supply, with secondary recovery estimated at 3.0Moz pa. The resultant longer-term effect of the demand and supply balance on palladium prices is shown in Exhibit 4.

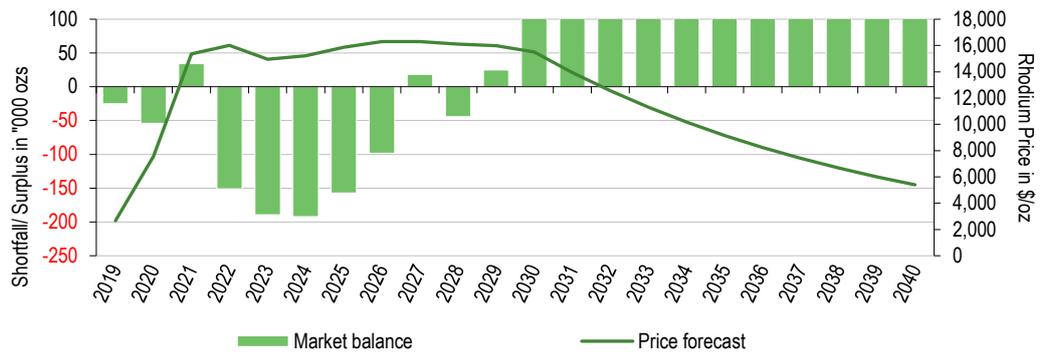
Rhodium

We estimate rhodium demand to be just over 1Moz in 2021.

Demand for rhodium is dominated by autocats, which use 86% of metal produced for emissions control of gasoline engines, 8% for chemical applications, 3% for fibreglass and glass manufacturing and the balance for jewellery, investment and other.

Rhodium has the exceptional quality of being 7x more efficient in converting the Nitrous Oxide emissions to benign gases in a gasoline engine. Hence, in a perfect world it should be priced 7x more than palladium (which, cannily, it currently is). Rhodium suffers from the same slackening demand outlook as palladium, with gasoline-powered cars losing market share to BEVs from 2025.

Exhibit 5: Rhodium price, market balance (no inventory) forecasts



Source: Edison Investment Research, Johnson Matthey Pgm market report, May 2021

We estimate that South Africa is responsible for 82% of total rhodium supply in 2021 as the by-product of the platinum-dominated basket of PGMs that it produces. Secondary recovery of an estimated 344koz with around 700koz of supply results in a small surplus of 38koz in 2021. The resultant longer-term effect of the demand and supply balance on rhodium prices is shown in Exhibit 5.

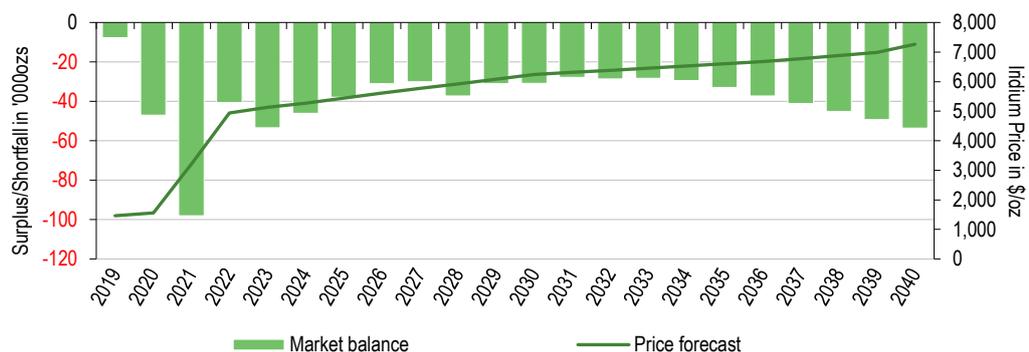
Iridium

We estimate iridium demand to be 320koz in 2021.

Half of the demand for iridium is for fuel cell electrical and electrochemical applications. In the anode of the fuel cell it is more efficient than platinum, while platinum is more efficient in the cathode. Iridium is a far smaller market than platinum, 267koz versus 7.4Moz for platinum. Other uses are in chemical and electrochemical applications and future demand for the metal is tied to the outlook for the fuel cell market and hydrogen production.

Supply of iridium is again dominated by South Africa which we estimate will supply 122koz of the total 200koz in 2021. The resultant longer-term effect of the demand and supply balance on iridium prices is shown in Exhibit 6.

Exhibit 6: Iridium price, market balance (no inventory) forecasts



Source: Edison Investment Research

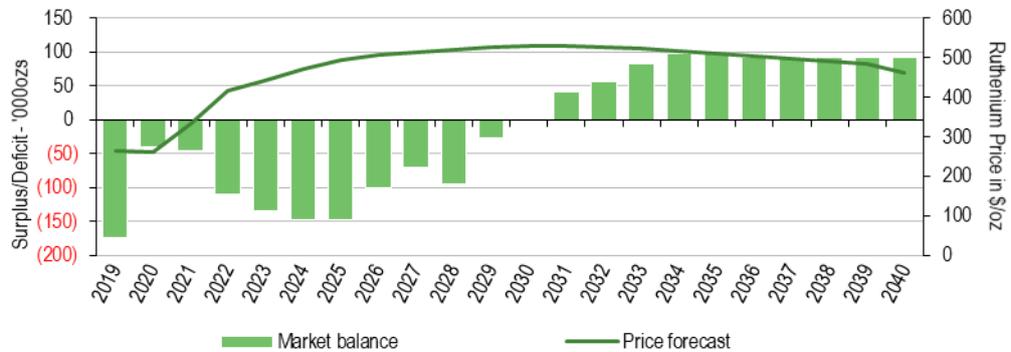
Ruthenium

We estimate ruthenium demand to be 1.2Moz in 2021.

Almost half of all ruthenium demand is from chemical applications with around a third from electrical applications including hard disk drives, semiconductors, and cloud storage. Around 10% of demand

is estimated for fuel cell applications. Ruthenium works just as well as platinum on the cathode (the hydrogen side) of the fuel cell. Forward demand for the metal is tied somewhat to the outlook for the fuel cell market and hydrogen production, though the metal is not as efficient as platinum and iridium in this application.

Exhibit 7: Ruthenium price, market balance (no inventory) forecasts



Source: Edison Investment Research

The supply of ruthenium is again dominated by South Africa which we estimate will supply 816koz of the total 1.1Moz in 2021. The resultant longer-term effect of the demand and supply balance on ruthenium prices is shown in Exhibit 7.

Likely winners and losers

Rhodium- and platinum-heavy producers will be the likely winners

- At current prices rhodium contributes 40% of the revenue of South African producers and is likely to benefit from tightening emissions regulations, while platinum contributes around 20% and is likely to benefit from the hydrogen economy. Hence, producers of these two metals should benefit if prices increase as we expect.
- Winners could include South African producers with a high rhodium content in their basket, for example Sylvania Platinum, Sibanye Stillwater and Tharisa.
- Of the northern hemisphere producers, palladium makes up 75% of revenue, rhodium 16% and platinum 11%. Palladium will likely see falling demand in the medium to longer term. As such, producers with high palladium production relative to rhodium and platinum will see less benefit from our forecast prices as we think gasoline cars, which use mostly palladium, will be the biggest losers of market share to new energy vehicles in the long run, though not in the short term due to tightening emissions regulations.
- Losers in the medium to longer term could include high palladium, low rhodium producers such as Nornikel and North American mines like Stillwater and Impala Canada.

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