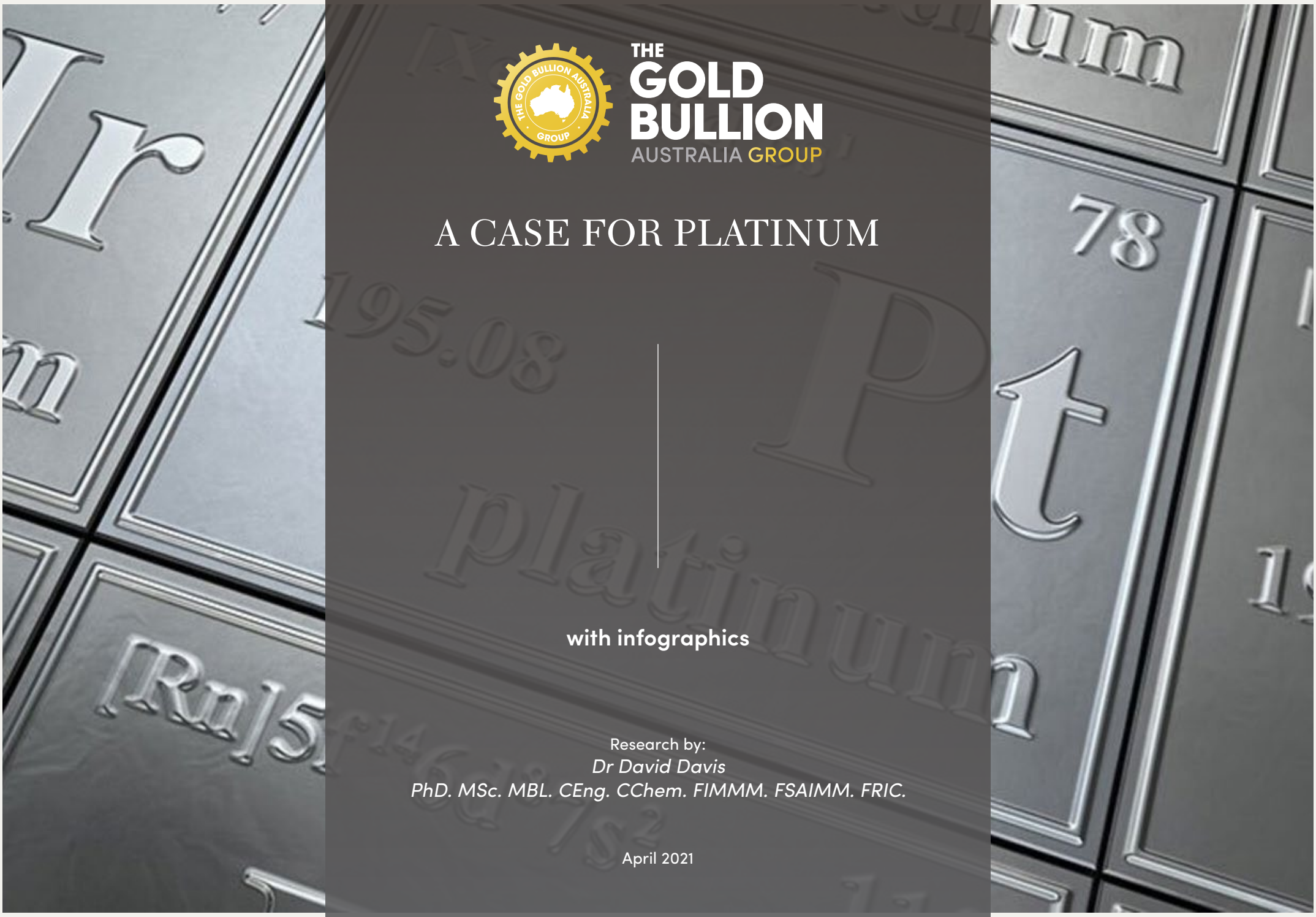

THE GOLD BULLION AUSTRALIA GROUP

A CASE FOR PLATINUM

with infographics

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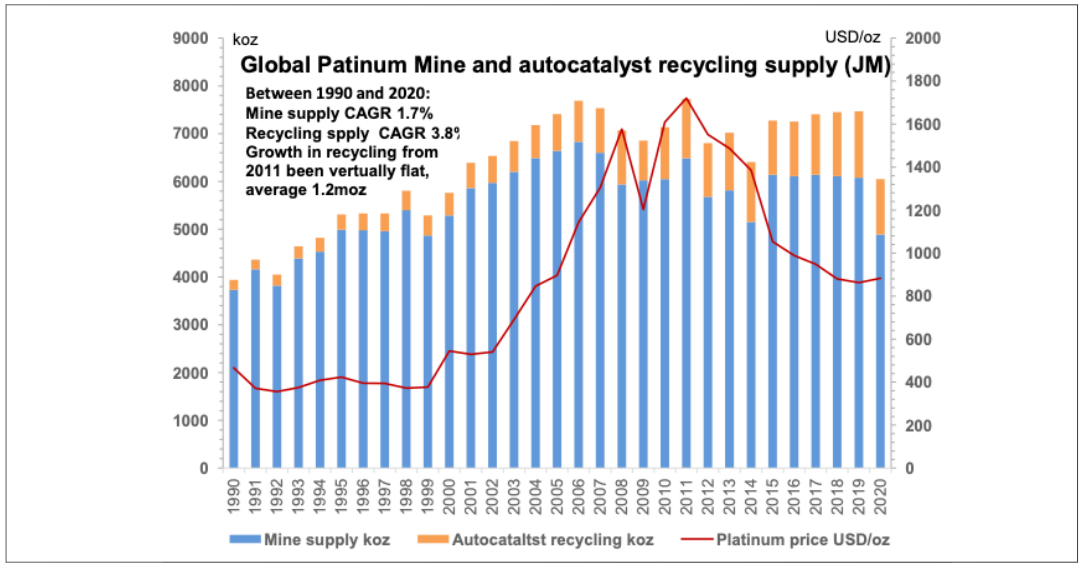
A CASE FOR PLATINUM

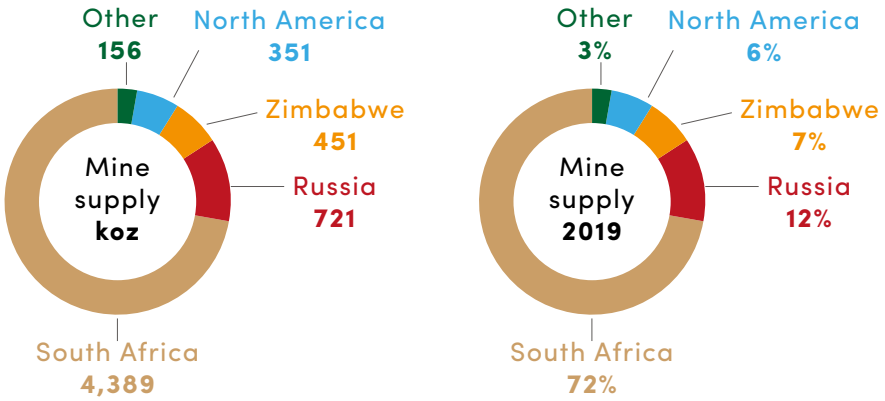
Platinum is one of the rarest and heaviest of the precious metals. The chemical symbol for the element platinum is Pt. It has an atomic mass of 195.08 and its atomic number is 78. Platinum is 30 times rarer than gold. It has been said that if all the platinum ever mined were melted and poured into an Olympic-sized pool, the platinum would barely reach your ankles. Gold, however, would fill three pools. Platinum concentrate is smelted at 1,500°C prior to refining, to separate it from waste products. The term 'precious metals' is taken to include silver, gold and the six platinum group metals (PGMs) - platinum, palladium, ruthenium, rhodium, osmium and iridium. Platinum has special characteristic properties which play a critical role in the reduction of global warming, and essential roles in a wide-range of industrial and medical applications.

Furthermore, a significant amount of the metal is used in the manufacture of upmarket jewellery. The rarity of platinum combined with supply and demand market balance trends and an unstable financial environment spur investment opportunities. Particularly, in an environment of stagnant supply and ever-increasing demand. In this regard, upward pressure on the price of platinum will be supported by the combination of a number of market indicators characterised by strong consumer demand and tight physical availability.

Global mine supply of platinum has grown by a CAGR of some 1.7% between 1990 and 2020. In 2019, global mine supply was some 6.1moz (JM). Mine supply is not, however, without risk,



as mine supply **depends heavily** on the **South African PGM mining industry, which supplies about 72% of global platinum**. Russia, North America and Zimbabwe supply around 12%, 6% and 7% respectively (JM 2019). Global mine supply between 2006 and 2019 declined by a CAGR of -1.0%, South African platinum supply declined by a CAGR of -1.4%. The gradual decline in the supply of platinum is attributed mainly to the historical evolution of the mining mix ratio of the PGM reefs in South Africa.



The PGM mining industry has also been starved of expansion and ore reserve replacement capital for a number of years. Miners are, however, beginning to invest in reserve replacement (2021). This quantum of investment is unlikely to stave off the decline in platinum supply. Both mine and recycling supplies have exhibited volatility at times, due mainly to the economic environment and labour unrest across the South African mines. Growth in platinum recycling from 2011 to 2020 has been virtually flat (average 1.2moz). The quantum of platinum autocatalysts recovered by recycling is not expected to grow going forward (2025) as platinum loadings are historically lower in light vehicles about to be scrapped, given the average age of light-duty vehicles is around 12 years. In comparison, the quantum of palladium autocatalysts recovered by recycling is expected to climb to over 4moz by 2025 from around 2moz (JM, Amplats).

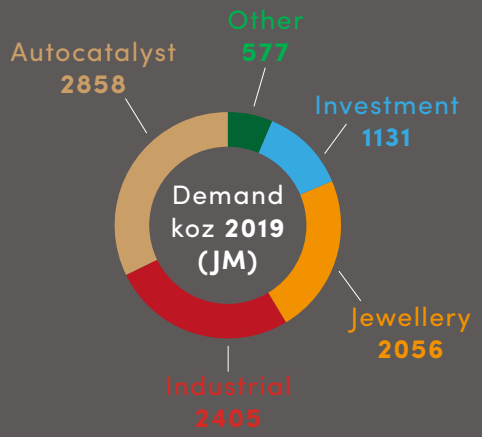
This observation is important as platinum secondary recycling supply will not likely support the expected decline in primary mine supply, thereby tightening platinum supply in a climate of ever-increasing demand.

Global demand for platinum hinges on its unique combination of physical and chemical properties. Historically, the use of platinum has been split into four segments, namely: industrial, jewellery, autocatalyst and investment demand.

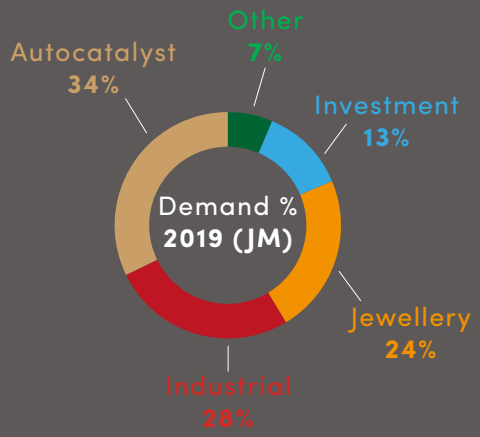
industrial | jewellery | autocatalyst | investment | hydrogen fuel cell & green tech

A fifth and new segment is beginning to evolve, the hydrogen fuel cell and green technology segment which will drive platinum demand significantly. In this regard, platinum will play a critical role in the reduction of global warming. In my view, the advent of fuel cell technology has changed this historical description. There are now two types of proton exchange membrane (PEM) hydrogen fuel cells, which will ultimately increase platinum demand: The first application surrounds the PEM fuel cell drivetrains of electric vehicles, particularly the drivetrains of heavy-duty vehicles. All of which meet the zero-emission standard. The second type of hydrogen fuel cells are called PEM electrolysers, which are used in the production of green hydrogen from solar power, wind power and hydro power.

Platinum demand by segment is represented by the pie charts depicted below, by the quantum of platinum koz and percentage distribution (JM 2019).



Total **Pt** demand **8450 koz**

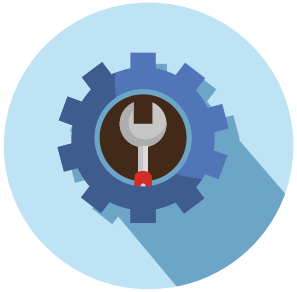


Total **Pt** demand % **dist.**

Demand in 2019 amounted to c. 8,450koz of which autocatalyst, jewellery, industrial, investment and other represented 34%, 24%, 28% 13% and other 7% of total demand respectively. Growth in the platinum demand segment listed as "other" is largely driven by ever-tightening emissions legislation and the drive to meet zero-emission standards.

This, in turn, drives the increasing use of platinum in the fuel cell sector, in both stationary devices and across parts of the transport industry, particularly in the application of fuel cell technology in the drivetrains of heavy-duty trucks. The ever-tightening emissions standard has have also resulted in additional technologies which have been developed to aid in the efficient control of vehicle emission systems. These include platinum contained in spark plugs and the use of specialised sensors.

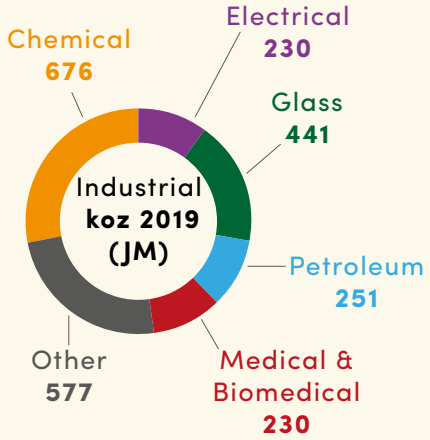
Industrial Segment

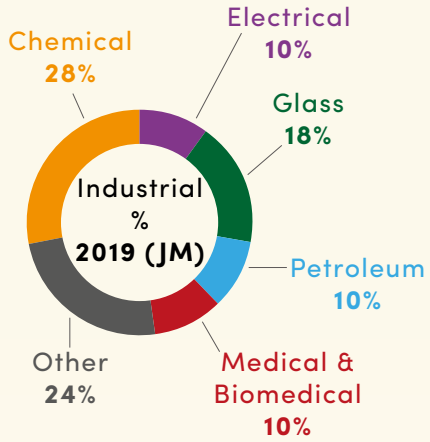


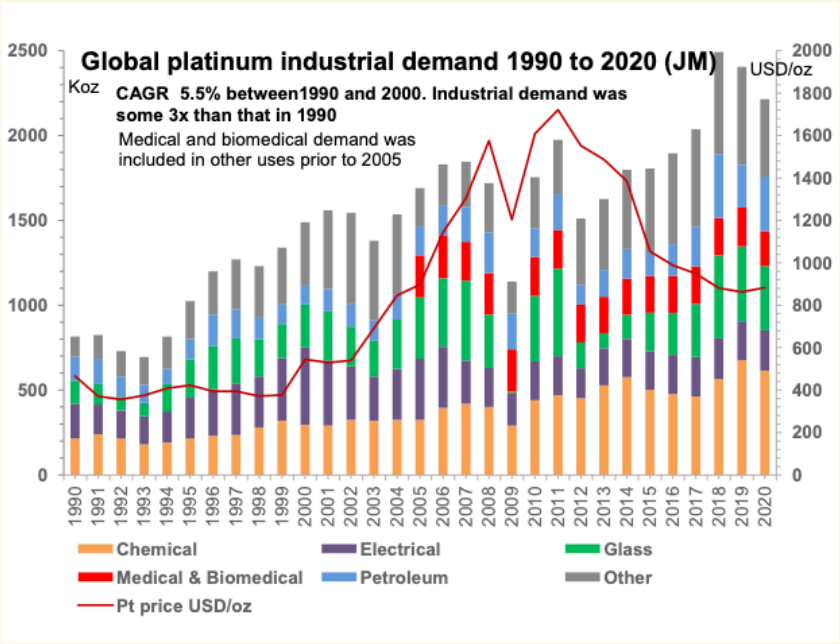
Between 1990 and 2020 growth in industrial demand has increased by a CAGR of 5.5%. By 2019, demand in the industrial sector represented around 2,405koz or 28% of global platinum demand (JM). This segment has six sectors, namely: chemical, glass, petroleum, electrical, medical & biomedical and other.

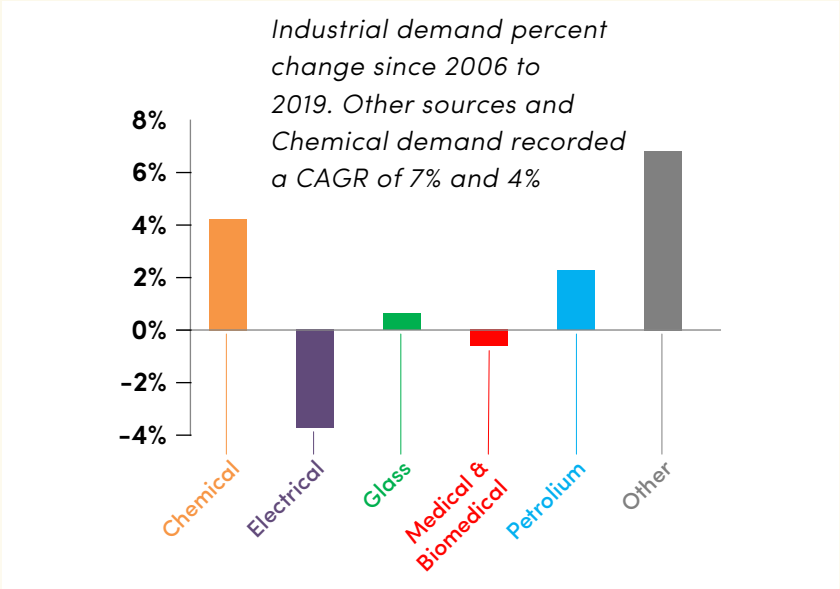
The 'other' and chemical sectors recorded heathy growth between 2006 and 2020, recording a CAGR of 7% and 4% respectively. This growth was mainly due to robust growth in fuel cell demand, particularly in Japan the US and China. Chemical demand in China has continued to grow with the expansion of its plant capacities.

It is clear from these observations that a fifth sector, described above, is growing rapidly: **Hydrogen, fuel cell and green technology**. **As indicated, this sector will drive platinum demand significantly**.









Chemical sector

Chemical sector demand of 676koz represents around 8% of global demand and 28% of the industrial segment (JM 2019). The main uses in the chemical sector are listed below.

Nitric acid and fertilizer

Platinum catalysts are vital to making nitric acid, 90% of which went to producing around 160 million tonnes of fertilizer nutrients (nitrogen) used in 2020.

Note that the global capacity for the production of nitrogen is around 190 million tonnes. The first stage of making nitric acid means oxidising ammonia gas with air to form nitric oxide. To achieve conversion efficiencies above 95%, this is normally carried out at pressure over precious-metal catalyst gauzes made of platinum with one-tenth rhodium.

The International Fertilizer Association (IFA, 2018) indicates that government policies are increasingly affecting fertilizer demand and supply on a global level, there are increasing calls to improve fertilizer use efficiency and nutrient recycling and mitigate the impact of N and P losses to the environment (UN Environment, FAO, OECD). Under these circumstances, nitrogen demand is likely to grow marginally at 1.2% p.a. (IFA). The current nitrogen surplus will likely be impacted by capacity reduction in China, driven by environmental policies. In this regard, the demand for platinum is likely to be muted going forward.

Plastics / silicone

Platinum compounds are frequently used as a catalyst in the curative process of manufacturing silicone rubber, especially in the manufacturing of speciality silicones, where performance characteristics such as high purity, tear resistance, transparency and low toxicity are important, for example, in bakeware (WPIC).

Platinum compounds are also used in everything from sealants to electrical wire insulation and lubricants (JM).

Glass and Fibreglass sector

Glass sector demand of 441koz represents around 5% of global demand and 18% of the industrial segment (JM). The main uses in the chemical sector are listed below.

Glass and fibreglass

Platinum's high melting point and resistance to abrasion and corrosion makes it ideal for handling very hot substances, most notably molten glass. Platinum tools are used both to channel the liquid and to create the hair-like strands for making fibreglass, which is used for everything from printed circuit boards to kayaks, home insulation to water-pipes in sewerage systems. "Fiberisation" is the term for extruding molten glass from a "bushing" – a platinum alloy container with tiny holes or jets for drawing out the fibres. Bushings are recycled once they are worn or have lost sufficient platinum to require replacement (JM).

The renewable energy sector relies on high-quality glass components for photovoltaic solar panels and high-quality fibre. Furthermore, glass fibre-based materials are being introduced in the automotive industry. This strong, but lightweight material is being adopted to reduce vehicle weight, helping vehicle manufacturers to meet fuel economy and emission standards (WPIC).

Liquid crystal displays (LCD)

LCD glass, used in applications such as digital watches and laptop computers, is the most intensive user of platinum and rhodium per unit of glass produced. This is due to the harsh conditions under which the raw materials for the glass are melted (usually at 1,650°C) and the quality of glass required, which can be as little as half a millimetre thick with zero defects (JM).

There is, however, a global shortage of glass substrates and LCD driver ICs, which has become severe due to the Covid pandemic and recent power outages hitting plants at NEG and UMC, according to Innolux president James Yang. These shortages will put upward pressure on LCD prices and in turn will likely have a marginal effect on platinum demand.

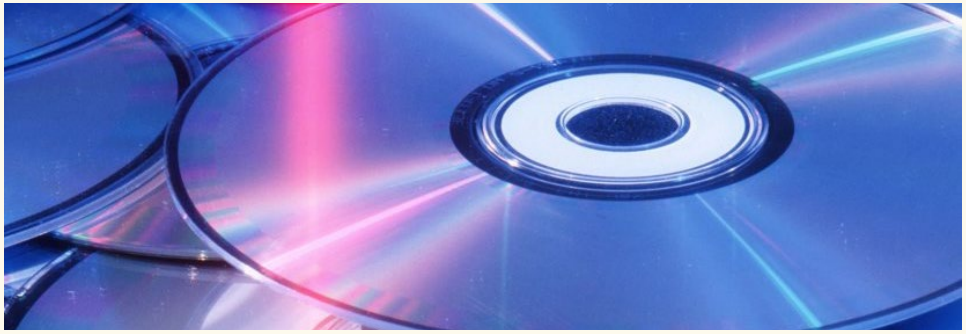
Electrical sector

The Electrical sector demand of 230koz represents around 3% of global demand and 10% of the industrial segment (JM 2019). The main uses in the electrical sector are listed below.

Hard disc drive - (HDD) storage capacity

Platinum and ruthenium play a vital role in hard disk drive storage capacity. Constantly improving technology has enabled hard disk manufacturers to pack more storage capacity than ever, at a cost per gigabyte that still makes hard drives the best bang for buck.

Notwithstanding, HDDs are facing competition with the increasing growth in market share of solid-state drives (SSDs), which are more expensive than HDDs.



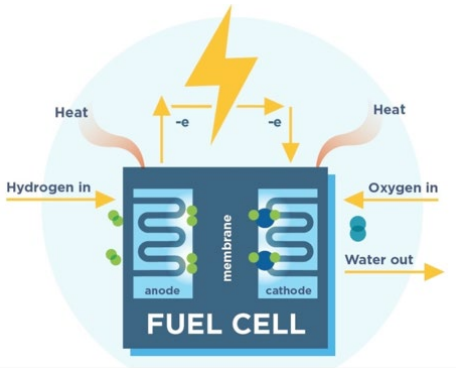
Circuit fabrication

Platinum is used in integrated circuit fabrication as an intermediate layer between an interconnecting gold layer and a protective silicon nitride layer. The platinum prevents the diffusion of gold into the silicon nitride and subsequently into the silicon layer. In addition, a thin (0.05 micron) platinum layer is initially sputtered on the silicon wafer and reacted to form a platinum silicide layer on the terminal ends of the wafer.

This platinum silicide forms a good low-resistance ohmic contact to the silicon.

Electronic technology and fuel cells

More importantly, platinum is *the catalyst used in fuel cells which converts hydrogen and oxygen to heat, water and electricity. The production of energy from fuel cells* ***will play a critical role*** *in the reduction of global warming. The application of fuel cells is discussed in the* ***Hydrogen, fuel cell and green technology segment****.*



Petroleum sector

The petroleum sector demand of 251koz represents around 3% of global demand and 10% of the industrial segment (JM 2019). The main uses in the Petroleum sector are listed below.

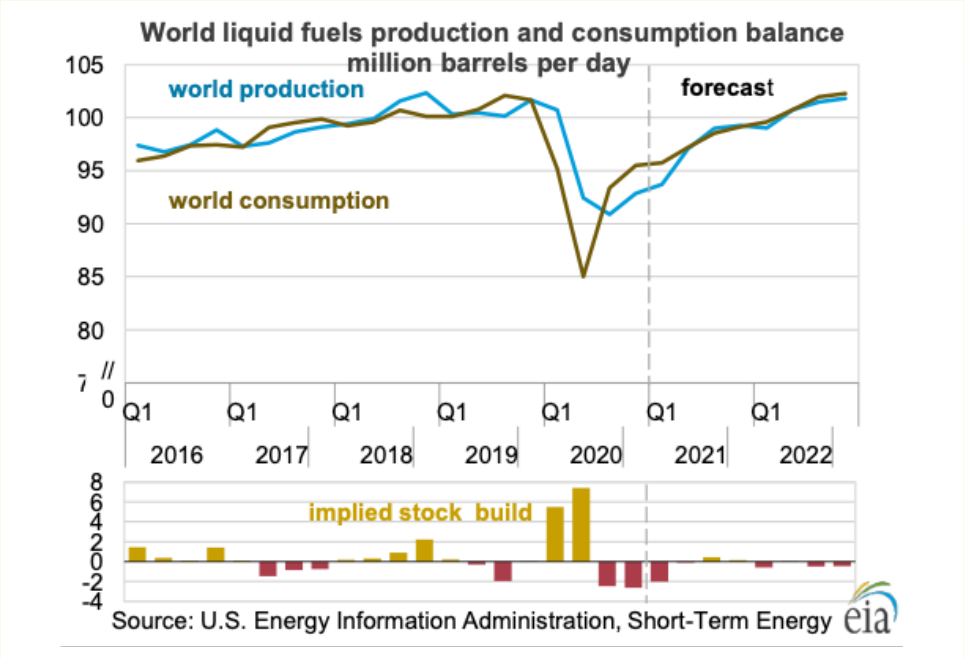
Petroleum

Higher octane fuels and chemicals

Finely divided platinum on the surface of small aluminum oxide pellets is used as a catalyst to convert heavy oils containing large-hydrocarbon molecules into smaller molecules at high temperatures (370° to 475°C). This process is known as cat-cracking. Some of these are branched or cyclic hydrocarbons that are used to raise the octane of petrol, diesel, gasoil and jet-engine fuel, while others are alkenes that are used as building

blocks to make other chemicals. In this process, the platinum aluminum oxide pellets are recycled through a reactivation process.

The EIA forecasts that world liquid fuel production will return to the 2019 level of around 100 million barrels a day by 2022. Statista (2021) forecasts a gradual increase in world liquid fuel production to around 109 million barrels a day by 2045. This observation would imply that the growth in petroleum products is likely to be marginal to 2045 and is in line with the advance of zero-emission vehicle strategies.



Medical and Biomedical sector

The Medical and Biomedical sector demand of 230koz represents around 3% of global demand for platinum and 10% of the industrial segment (JM 2019).

The chemical, physical and mechanical biocompatibility properties of platinum and its alloys make them uniquely suitable for a variety of medical applications. For example, platinum is used in surgical instrumentation (arthroscopic tools), electro-medical implants, interventional surgery and orthopedics. The main uses in the sector are listed below.

Surgical instrumentation

Arthroscopic tools

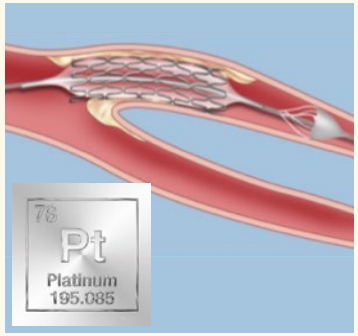
Arthroscopy instruments are designed to ease cutting and trimming due to their ergonomic designs and balanced weight. They are used in procedures such as hand, hip, knee, shoulder and other small joint procedures.

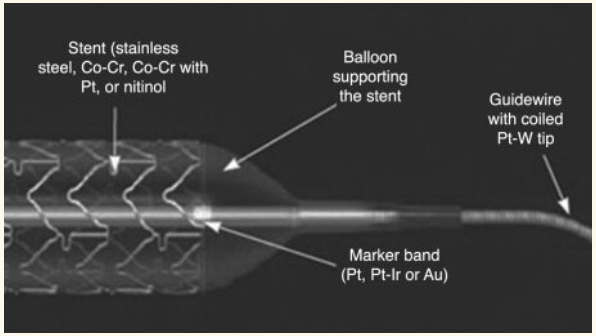
Electro-medical implants

Pacemakers, defibrillators, hearing assist devices and heart pumps.

Interventional surgery

A stent is a metal or plastic tube inserted into the lumen of an anatomic vessel or duct to keep the passageway open, and stenting is the placement of a stent. A wide variety of stents are used for different purposes, from expandable coronary and vascular to biliary stents. Many stents incorporate a unique platinum chromium (PtCr) alloy, designed specifically for coronary stenting and is intended to improve the acute performance of coronary stent implantation in the treatment of coronary artery disease.

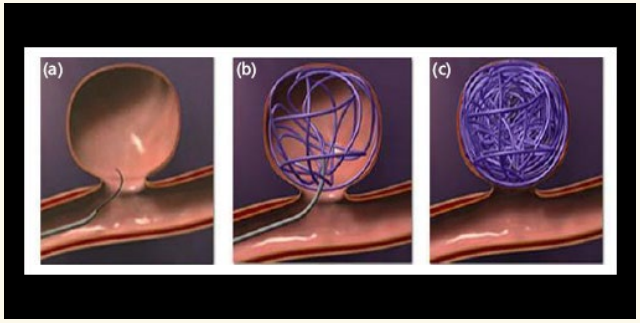


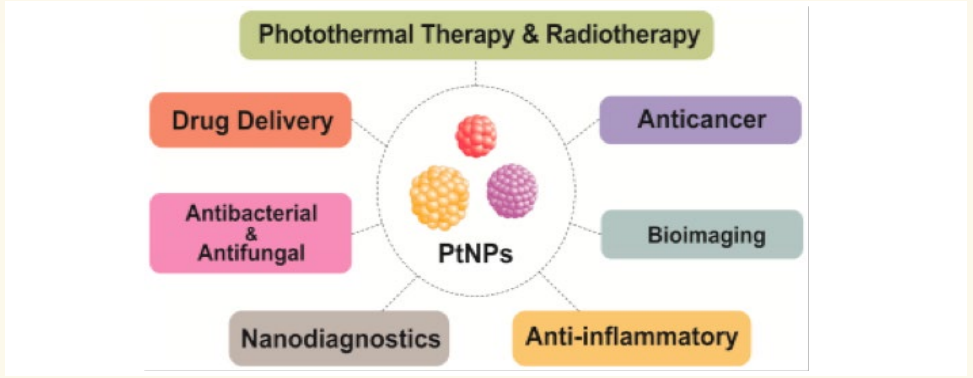


Endovascular treatment of aneurysms

Some aneurysms are treated with fine platinum wire. The goal of this treatment is to prevent blood flow into the aneurysm sac by filling the aneurysm with

coils of platinum wire, which have been guided into the aneurysm by a small catheter and thrombus. The coils of wire conform to the often-irregular shape of an aneurysm to prevent bleeding or re-bleeding.





Biomedical nanoparticles

Nanotechnology has provided the opportunity to get direct access to cancerous cells selectively with increased drug localisation and cellular uptake. Nanoparticles can be programmed to recognise the cancerous cells to enable selective and accurate drug delivery avoiding interaction with the healthy cells. Platinum nanoparticles (PtNPs). therapy is currently used for the treatment of specific cancers, including testicular, ovarian, lung, bladder, and head and neck cancers. Cisplatin, carboplatin and oxaliplatin are platinum therapies currently in use.

Recently, PtNPs have garnered steadily growing interest for different biomedical applications such as antimicrobial agents, anticancer agents, targeted drug delivery, hyperthermia, photoablation therapy, bioimaging and biosensing. Bimetallic NPs such as iron platinum (Fe–Pt) NPs possess unique chemical and magnetic properties such as chemical stability, super paramagnetisation, high Curie temperature, high saturation magnetisation and high X-ray absorption. These unique properties provide the potential for their application in hyperthermia treatment, as MRI contrast agents, in drug delivery, and as biosensors.

Other Uses sector

The Other uses sector demand of 577koz represents around 7% of global demand and 10% of the industrial segment (JM 2019).

As indicated above, growth in the platinum demand segment listed as "other" is largely driven by ever-tightening emissions legislation and the drive to meet zero-emission standards. This, in turn, drives the increasing use of platinum in the fuel cell sector, in both stationary devices and across parts of the transportation industry; in particular, in the application of fuel cell technology in the drivetrains of heavy-duty trucks. The ever-tightening emissions standards have also resulted in additional technologies, which have been developed to aid the efficient control of vehicle emission systems. These include platinum contained in spark plugs and in the use of specialised sensors. The main uses in the Other sector are listed below.

Spark plugs

Platinum spark plugs come in two varieties - single and double platinum. A single platinum plug is much like a copper spark plug with a platinum disc welded to the centre electrode; a double platinum spark plug has a platinum disc on both the centre and side electrodes. There are a number of advantages of using platinum-tipped electrodes. Longevity is a key advantage of platinum spark plugs. Another advantage of platinum spark plug is that they run a little hotter, which burns deposits off the spark plugs better and helps to prevent fouling. Platinum also handles high heat, enabling the spark plug to wear better and aids efficient emission control.

Sensors

By monitoring oxygen levels in exhaust gases in a catalyst-equipped vehicle, sensors provide essential feedback to the electronic engine management system which controls the air-to-fuel ratio. The oxygen sensor contains a ceramic body with a platinum tip, which is a central component of the engine control system. The function of the tip is to detect tiny changes in oxygen levels within the exhaust gas stream. Oxygen sensors are also used to check vehicle emissions as part of vehicle inspection and maintenance systems. This type of sensor is also known as lambda or an exhaust gas oxygen (EGO) sensor.

Sensors that detect the presence of oxides of nitrogen (NOx) in exhaust emissions contain both platinum and rhodium and work on a similar principle to the basic oxygen sensor. They are used in conjunction with specialised autocatalysts to control levels of NOx from lean-burn petrol and diesel engines. Air bags contain an initiator sensor, which uses a fine platinum wire coated with explosive material to facilitate release of the air bag (JM).

Medical sensors

Platinum sensors are used to measure the amount of oxygen dissolved in a solution and to control the addition of oxygen into a biological effluent system. This is particularly important in the analysis of blood gases (JM).

Jet turbines

The variety of uses includes coating turbine blades with platinum to increase their longevity in the harsh operating environment of a gas turbine (jet) engine; and platinum-clad anodes for the cathodic protection of nautical vessels (JM).

Jewellery Segment

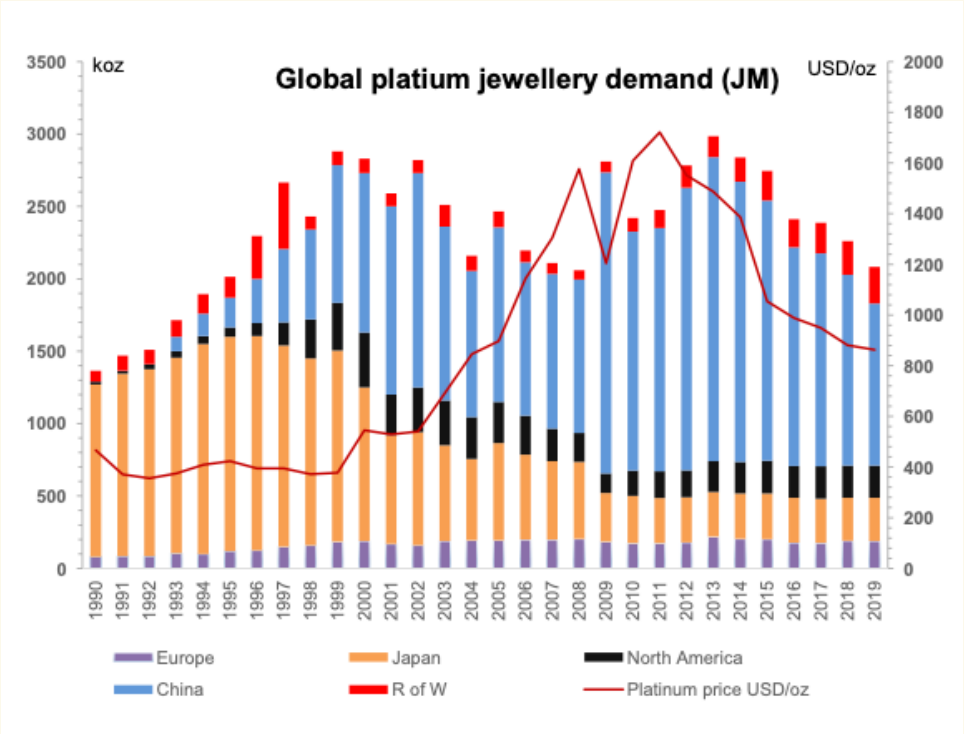
Platinum jewellery represents the third highest demand segment at 2,056 koz after industrial and autocatalyst, which amounts to some 24% of total demand (JM 2019).

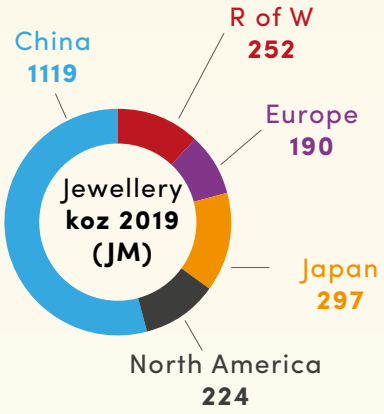
Why platinum jewellery?

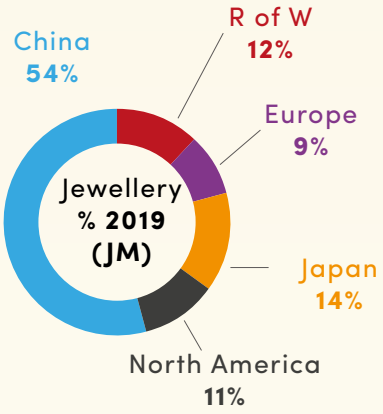
The rarity, precious metal special status, durability, strength, tarnish resistance and colour are drivers of platinum jewellery demand.

According to Johnson Matthey, platinum demand growth restarted in Japan in the 1960s. Platinum gained special status in Japan, which rapidly became the world's principal platinum jewellery market in the 1990s, reaching a high of 1,480koz in 1995. The Japanese economy suffered a prolonged recession following the collapse of the fabled economic bubble of the 1980s. This stretch of economic stagnation, the "lost decade", finally ended in 2002; it had taken more than 10 years, punctuated with occasional "false dawns" (Brookings).

Given the dire circumstances of the Japanese economy the demand for luxury goods fell away, as did demand for jewellery. This decline in demand was compounded by a sharp rise in the price of platinum from USD377/oz to USD1,721/oz between 1999 and 2011 respectively. Since 2012, Japanese jewellery demand has been muted at an average annual rate of 307koz.







Conversely, the demand for platinum jewellery in China has surged since 1995, especially among young urban women seeking the modern style that platinum jewellery represents. China is now easily the largest single market for platinum jewellery. Notwithstanding, between 2012 and 2019 the demand for platinum jewellery in China declined by a CAGR of -7.6%. Over the same period, China's GDP declined by around 22%. This, given a sharp decline in the platinum price.

As a result of the Covid pandemic, Chinese jewellery demand slumped to a 20-year low in 2020 (JM).

Industry analysts indicate that in the last decade demand has begun to grow in India. The WPIC reports that Indian jewellery fabrication is expected to improve in 2021, driven by a strong recovery in economic growth and the recent 2.5% cut in the import duty on platinum.

Given the potential growth in the jewellery segment, demand is likely to be muted by the market balance deficit and higher platinum prices.

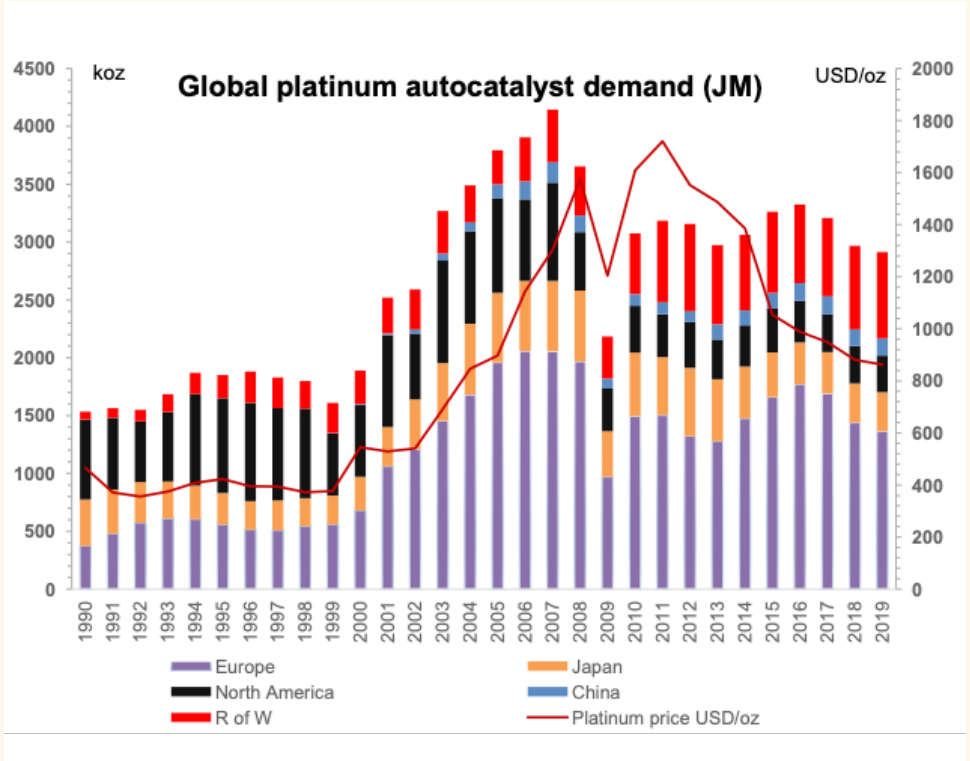
Autocatalyst Segment

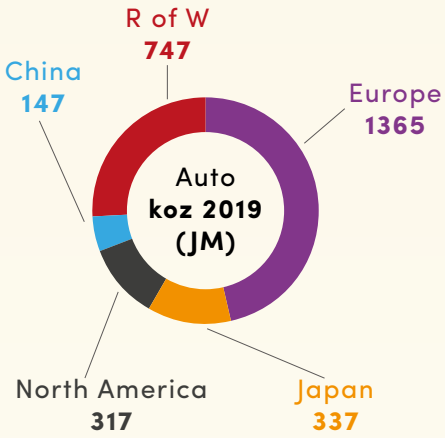
The platinum autocatalyst segment represents the highest demand at 2,858koz, which amounts to some 34% of total platinum demand. The strong demand for PGMs is inextricably linked to the introduction of vehicle regulations and standards for controlling the tailpipe emission of harmful gases (US Clean Air Act of 1970).

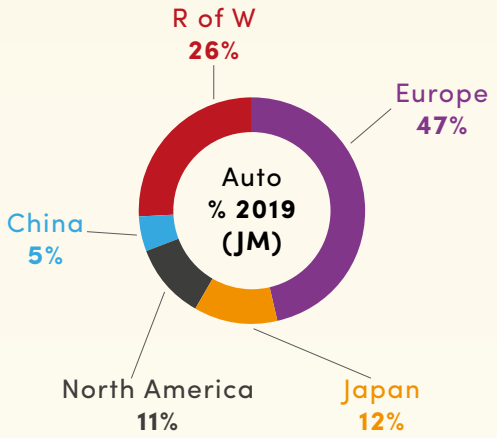
Vehicle manufacturers introduced catalytic conversion technology to meet these standards by using platinum, palladium and rhodium (PGMs) in various ratios to catalyse (neutralise) harmful gases such as carbon monoxide and the oxides of nitrogen. Vehicle emission standards have been progressively tightened through regulation worldwide since 1970.

The demand for PGMs has taken a step change upward with the adoption of new mandatory UK and EU CO2 emissions targets which came into effect from 1 January 2021. Between 2019 and 2030, due to tighter emissions legislation, Anglo American Platinum expects light-duty vehicle (LDV) petrol loadings will have increased by around 17% in China and Europe, and LDV diesel loadings will have increased by around 10% from already high levels. Heavy-duty diesel (HDD) loadings are expected to increase by around 60% between 2019 and 2025 as China and India adopt tougher emissions standards.

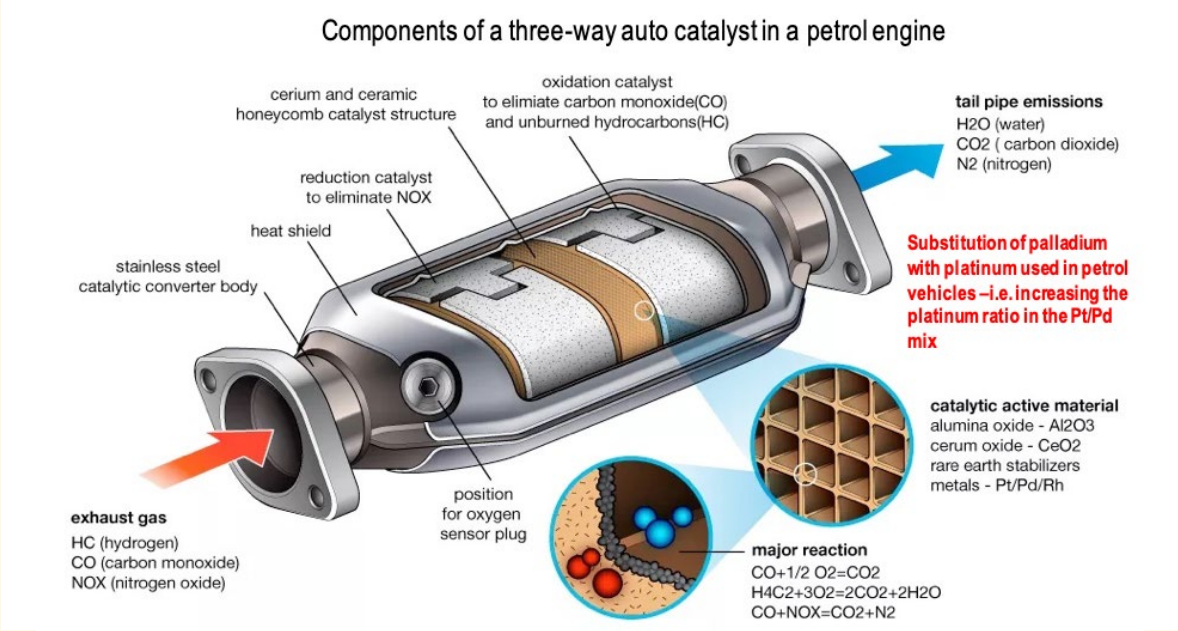
The additional quantum of PGM autocatalyst loadings is significant despite the expected increase in battery electric (BE) vehicles. Under these circumstances, the





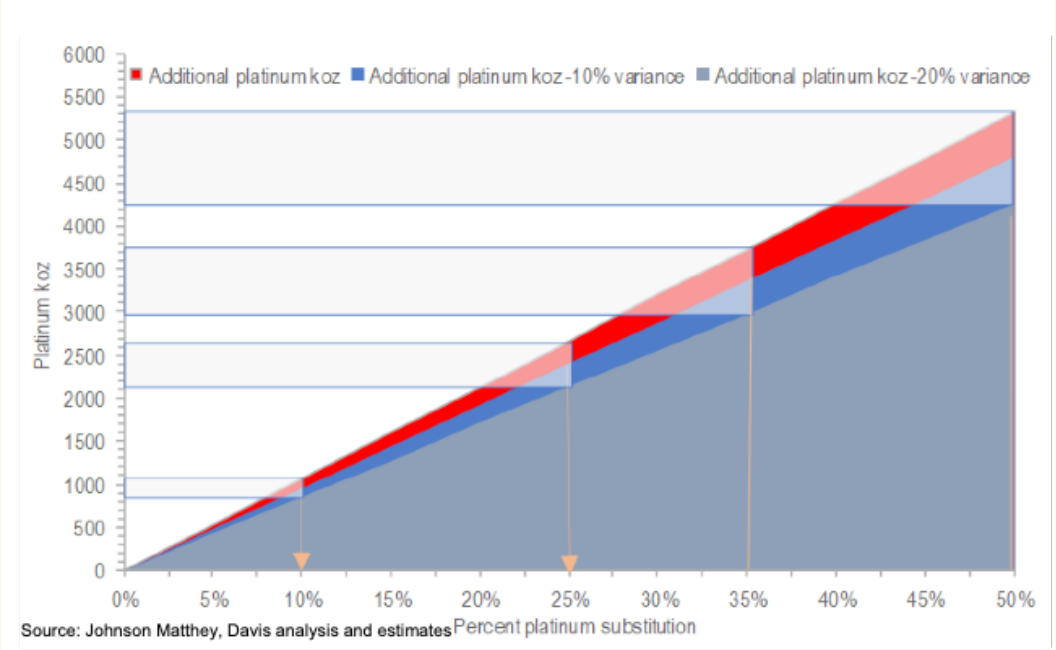


market balance deficit will likely deepen, thereby forcing upward pressure on PGM prices. This scenario will also be supported by the introduction of hydrogen fuel cell and green hydrogen technologies. Particularly in the case of platinum demand.



Substitution

Substitution of platinum for palladium and vice versa in petrol autocatalyst converters is not new to vehicle manufacturers. All the changes made over time in the converter PGM ratios were mainly driven by platinum and palladium price differentials, emission legislation and improved fuel standards. It is important to recognise that substitution does not only depend on the respective prices of platinum and palladium but also on the value of the respective platinum and palladium ratios in a catalytic converter.



Calculations imply that assuming a 1:1 Pt:Pd ratio, a global substitution rate of 10% and 25% of platinum for palladium in a petrol three-way auto catalyst converter, the quantum of additional platinum demand is significant, and amounts to approximately 1.0moz and 2.7moz respectively, at an average catalytic converter palladium loading. In this regard, the demand for platinum will increase significantly which, in turn, will likely put upward pressure on the platinum price.

The rate of platinum substitution will obviously play an important role in the platinum demand side of the equation. The World Platinum Investment Council (WPIC) believes substitution will happen faster than the industry first expected. They forecast that by 2025 the additional annual demand could be between 200koz and 700koz. This quantum would put the penetration rate between approximately 2% and 6%.

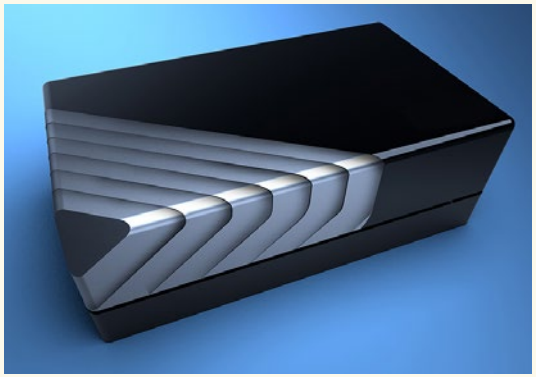
It is noted that in time, the industry will face a conundrum as ***substitution in petrol autocatalyst converters will effectively compete with platinum PEM FCEV and green hydrogen demand****. Furthermore, Russia's Nornickel is targeting brownfields production growth of between 45% and 50% for PGMs by the early 2030s, from 2020 levels, to ensure supply availability. I note that the PGM mix ratio from Nornickel's growth target is highly skewed towards palladium at 80% or around 1,400koz, 18% or 313koz platinum and 2% or 32koz rhodium.*

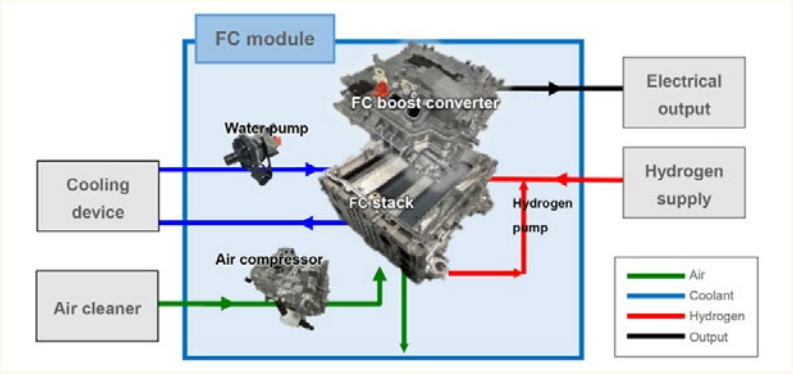
Hydrogen Fuel Cell And Green Technology Segment

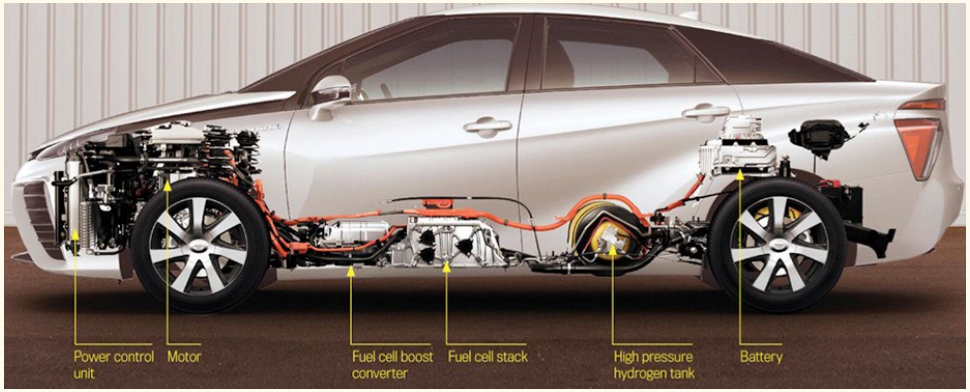
"A fifth and new segment is beginning to evolve, which will drive platinum demand significantly. In this regard, platinum will play a critical role in the reduction of global warming."

The drive for zero-emissions in the transport sector and future trends

Growth in the platinum demand segment listed as "other" has been mainly attributed to hydrogen fuel cell and green technology. This sector is now finally being driven at pace by ever-tightening emissions legislation and the drive to meet zero-emission standards, which in turn drive the increasing use of platinum in the PEM fuel cell sector, in both stationary devices and across parts of the transportation industry; particularly in the application of PEM fuel cell technology in the drivetrains of heavy-duty trucks. Hydrogen PEM fuel cells directly convert the chemical energy in hydrogen to electricity and release water and useful heat as by-products. PEM fuel cells dominate the transportation fuel cell market with platinum the catalyst material used for both anode and cathode electrodes.

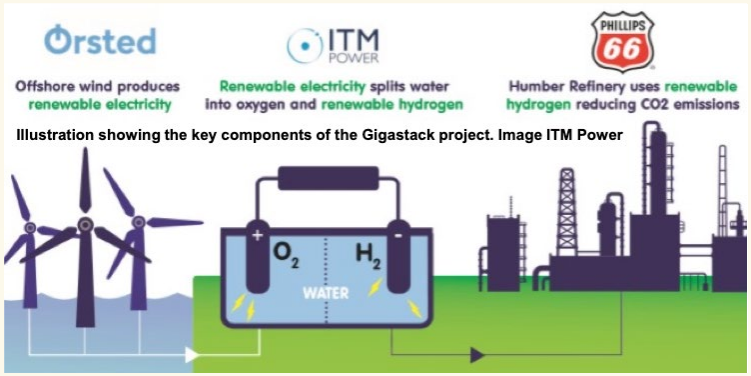






Green hydrogen

A road map for reducing the EU economy's carbon emissions through a hydrogen ecosystem was among the initiatives under the European Green Deal. The EU released its Hydrogen Strategy in July 2020. In this regard, a strategic objective to install at least 40GW of hydrogen electrolysers by 2030 with annual production of up to 10 million tonnes of 'green' hydrogen across the region was agreed upon.

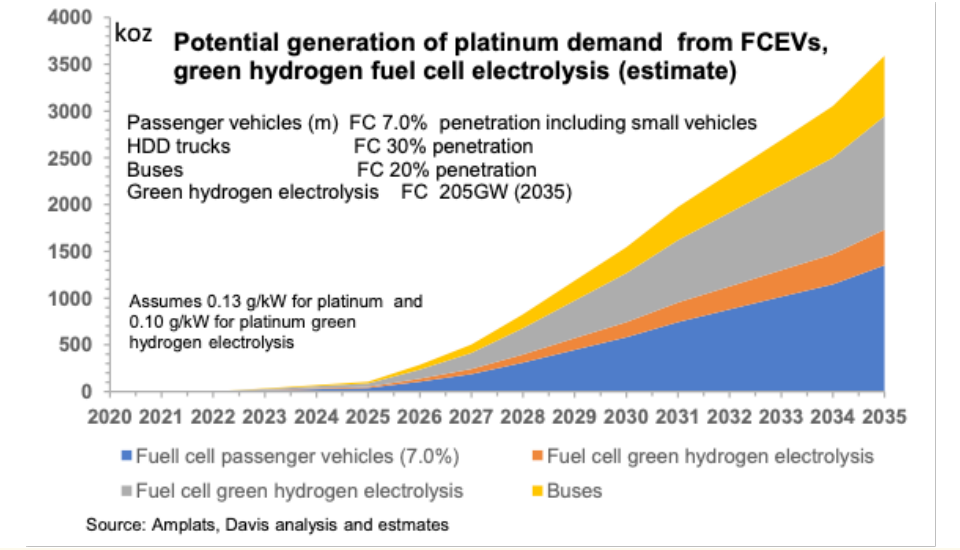


PEM electrolysers are currently seen as the most cost-efficient way to produce green hydrogen from renewable power as they are able to withstand the intermittency of renewable generation*. The WPIC indicated that the generation of green hydrogen capacity targets "alone" in the EU and China would require, cumulatively, between 300koz and 600koz of additional platinum by 2030. It is important to note that the additional platinum demand only considers the EU and China. What about the additional platinum demand required to produce green hydrogen in Japan and the US, etc.? These figures may therefore be considered as conservative. For example, Anglo American Platinum reports that global capacities could be as high as 126W by 2030. Under these circumstances, the cumulative generation of green hydrogen capacity would require around 1.0moz (based on 60% PEM electrolysers, 90% Heraeus loadings reduction with 0.45gPt/kw). Platinum thrifting and improved technology will likely reduce platinum loadings.*

Future estimates of platinum required to drive zero-emissions

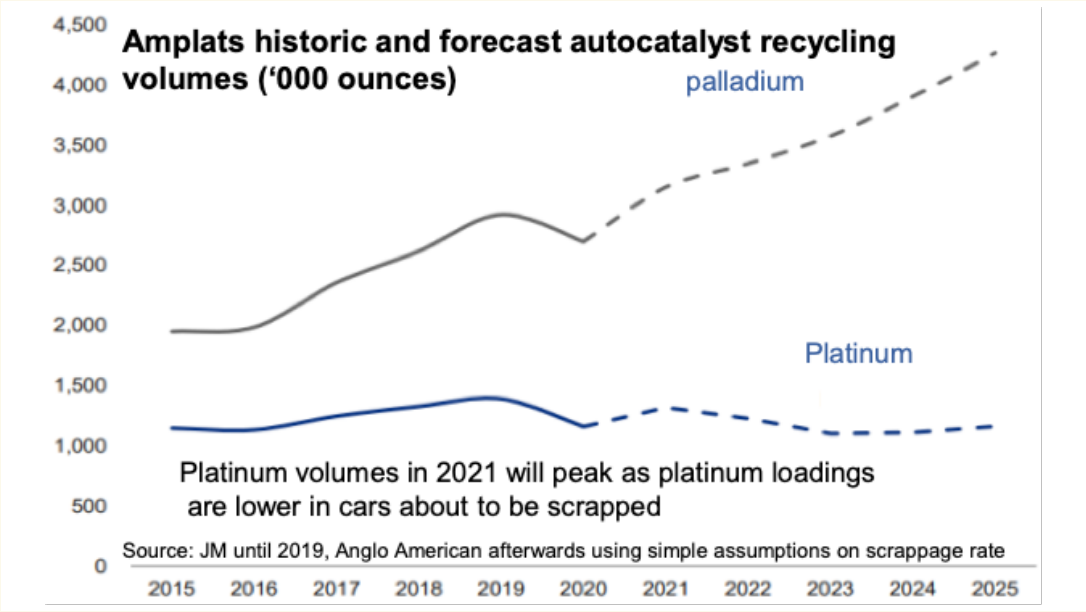
It is important to gain a "sense" of the quantum of the ***possible platinum required to drive zero-emissions*** *by 2050. Amplats (22 February 2021) presented a strategic scenario of what the hydrogen economy could mean for platinum demand to 2035. This presentation was based on the percentage penetration of FCEVs and hydrogen electrolysis at optimal thrifting levels for passenger*

vehicles of 15%, heavy-duty trucks 50%, buses 25% and small passenger vehicles 5%. Under these circumstances, Amplats indicated that these levels of FCEV penetration could generate annual demand of around 6moz by 2035. Obviously, there are numerous combinations of scenarios that may be applied to the Amplats model, which would result in alternative annual demand rates. It is important to note that the quantum of platinum supply is likely to be stagnant when compared to demand over this period.



Furthermore, Amplats' figures only apply to vehicle demand. The global supply of platinum amounted to some 8.45moz in 2019. This comparison begs the question: Are the Amplats figures for FCEV penetration realistic? In this regard, Amplats' model was used as a "base case" to generate an alternative scenario analysis which has much reduced penetration rates by 2035 these are: passenger and small vehicles 7%, heavy-duty trucks 30% and buses 20%.

Under these conditions, FCEV levels could generate annual demand of around 3moz by 2035. This scenario is illustrated (left). The alternative scenario implies that FCEV penetration rates are still likely to be too high. The penetration of green hydrogen electrolysis could generate annual demand of around 380koz by 2035.

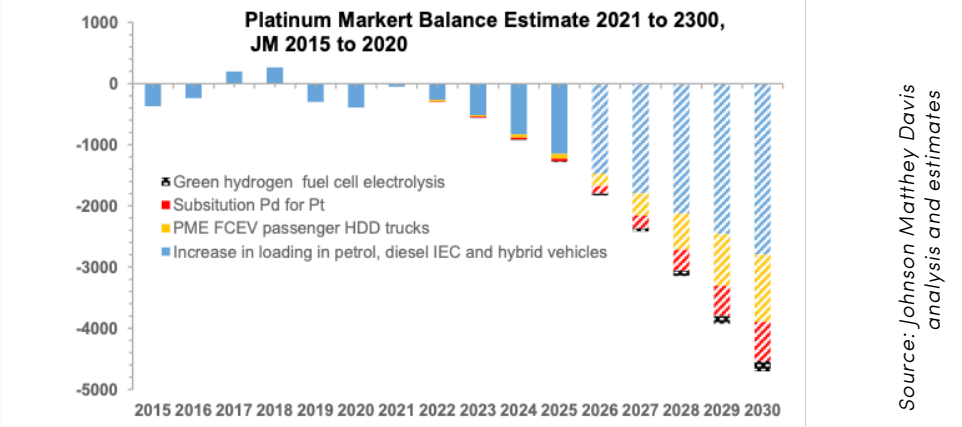


What do these figures mean with regard to platinum supply, are they sustainable, are they realistic?

In 2019, global primary mine supply was some 6.1moz (JM) and, as indicated, is likely to be stagnant going forward. Growth in the secondary supply of platinum (recycling) from 2011 to 2020 has been virtually flat (average 1.2moz). The quantum of platinum autocatalyst recovered by recycling is not expected to grow going forward (2025) as platinum loadings are historically lower in light vehicles about to be scrapped, given the average age of light-duty vehicles is around 12 years. In comparison, the quantum palladium autocatalyst recovered by recycling is expected to climb to over 4moz by 2025 from around 2moz (JM, Amplats). In this regard, secondary recycling of platinum will not likely bolster platinum supply for at least 5 to 10 years.

Market balance estimates looking forward to 2030

The estimated impact of the additional demand for platinum emanating from higher autocatalyst loadings in LDVs and heavy-duty trucks, the introduction of FCEV and the production of green hydrogen on the platinum market balance is illustrated in the chart (right). The market balance moves into a continuous deficit.



Supply

- *Global primary supply is expected to decline by around 950koz by 2030, CAGR -1.8%. Due mainly to the historical evolution of the mining mix ratio of the PGM reefs in South Africa, and to the fact that the PGM mining industry in South Africa has been starved of expansion and ore reserve replacement capital for a number of years.*

- *Global secondary supply (recycling) is not expected to grow at a pace as platinum loadings are historically lower in light vehicles about to be scrapped, given the average age of light-duty vehicles is around 12 years.*

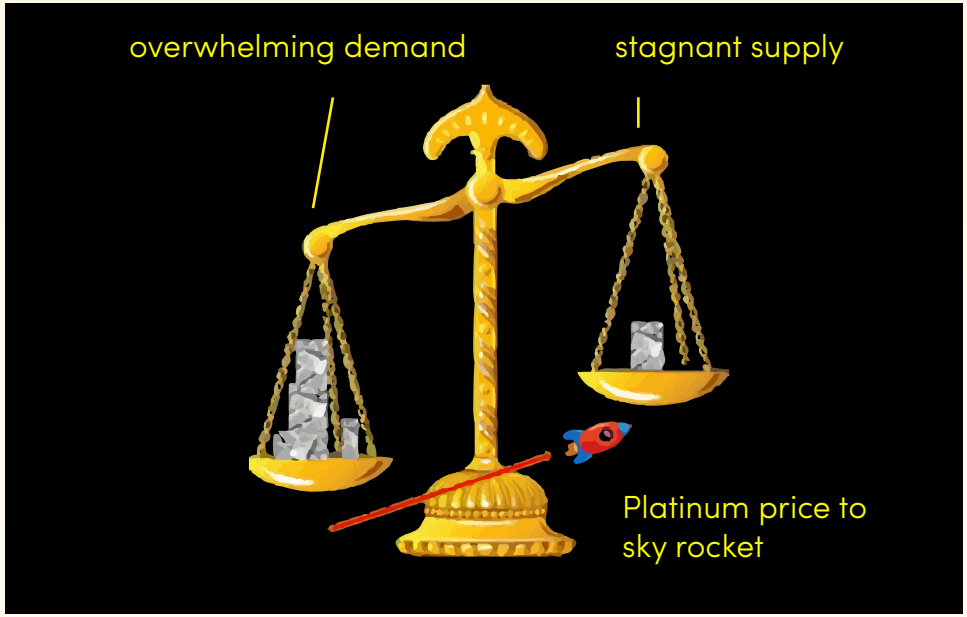
Demand

- *Increase in platinum demand will mainly come from the substitution of palladium for platinum in petrol vehicles (estimated at around 650koz by 2030).*

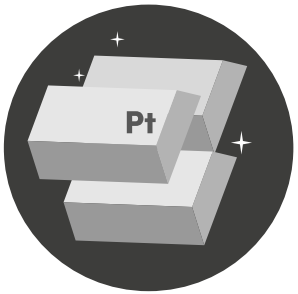
- *The introduction of FCEV passenger and fuel cell heavy duty vehicles will likely contribute around 500koz to demand by 2030.*

- *Platinum loadings of petrol and diesel ICEs and hybrid vehicles will likely contribute around 2,800koz by 2030.*

What then is the future of platinum given the scenario described above? The market balance for palladium has been in deficit for at least nine years and rhodium is about to follow suit. In both cases, the supply imbalance has been the main driver of the sky-rocketing price. In my view, platinum will be next to board the price rocket.



Investment Segment

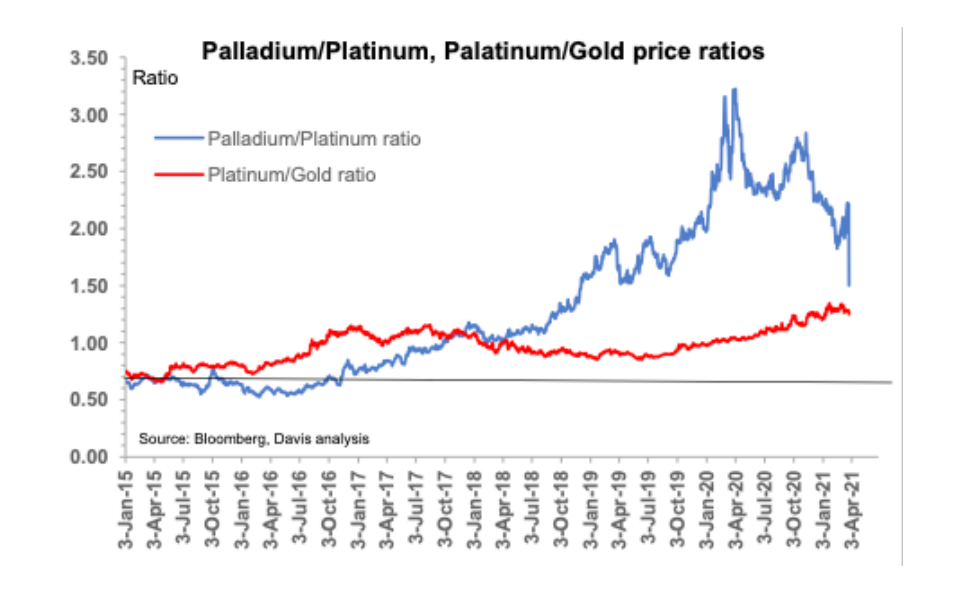


It is important to recognise that there is a significant difference between the sectors and the quantum of demand associated with the application of platinum and palladium. For platinum, autocatalysts, jewellery and investment at c.34%, 24% and 13% respectively, are the main drivers of demand. For palladium, autocatalysts and electronics at 84% and 6%

respectively, are the main drivers of demand. It is clear that platinum demand is also influenced by jewellery demand and is therefore subject to the vagaries of choice and societal economic factors. It is also clear for similar reasons that platinum investment demand for bars, coins and ETPs can be considerable and, as such, cannot "merely" be regarded as a swing factor at play when considering the complexities of the make-up of supply and demand fundamentals. ***It is, in fact, part of the DNA of platinum investment demand and a highly regarded rare precious metal***.

There are a number of market indicators which when combined are likely to propel the price of platinum. These indicators are a deteriorating global financial environment and tight physical availability coupled with a continuous supply and demand market balance deficit. Furthermore, PGM demand is inextricably linked to the introduction of vehicle regulation and standards for controlling the tailpipe emission of harmful gases (US Clean Air Act of 1970). Demand for PGMs is all about climate change and the drive for net zero emissions by 2050. In this regard, the auto industry has introduced new types of drivetrains for vehicles, with a move from ICE to BEVs, HEVs and FCEVs in order to meet new emission standards.

These new standards mean higher autocatalyst PGM loadings. The new emission standards also mean accelerated demand for FCEVs that contain platinum.



Of note is that the first petrol catalytic converters initially used platinum as the primary metal in the mix and over time platinum was substituted with palladium. Platinum is the predominant PGM in the metal mix in diesel autocatalysts. The move to almost 100% palladium used in petrol catalytic converters together with a partial displacement of platinum in diesel catalytic converters boosted palladium demand significantly, at the expense of platinum. Dieselgate precipitated a backlash against diesel, which brought about a downturn in diesel vehicle sales that were initially replaced by petrol rather than battery or hybrid vehicles, supporting palladium demand, again at the expense of platinum.

The increase in palladium demand moved the market balance into a deficit, a condition that spurred investment demand. The market balance has a deficit, which has lasted nine years. The price of palladium as of 26 March 2021 was USD2,676.10 per ounce.

In contrast, the platinum price has been a laggard with regard to price movement due mainly to the lack of demand. Between 2018 and 2020 the price has varied

from a high of USD1,078 to a low of USD596/oz. The tables, however, have "turned" for precious metal investors as the current environment is led by climate change and the drive for net zero emissions by 2050. This drive favours platinum-based applications, particularly FCEV passenger and HDD vehicles with higher PGM autocatalyst loadings, PEM fuel cell electrolysis and numerous other applications, including stationary applications.

In this regard, and given the rarity of platinum, combined with a decline in supply and overwhelming demand is a formula for a build-up of a "perfect storm". This, in my view, will lead to significant upward pressure on the price of platinum. Investors have already started to react to these signals.

About Dr David Davis PhD. MSc. MBL. CEng. CChem. FIMMM. FSAIMM. FRIC.

David has been associated with the South African mining industry and mining investment industry for the past 44 years (mainly PGM, gold and uranium). At present, David is working as an independent precious metal consultant. David's PhD involved: "Studies in the catalytic reduction and decomposition of nitric oxide 1976".

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