Heraeus

HERAEUS PRECIOUS METALS

Setting the PGM agenda for the years ahead

The Platinum Standard 2020

Produced in collaboration with SFA Oxford

THE PLATINUM STANDARD

May 2020

Issue 12

Designed and typeset by Francesca Price

CONTENTS

TPS COLLECTION: AGENDA-SETTING COMMENTARY

The Platinum Standard was first launched in May 2014

One-half review, one-half preview, The Platinum Standard comprises analytical commentary on those issues we believe will set the PGM agenda for the year ahead

If you are interested in reading the collection, you can now download the editions via our new website

FOREWORD – BEYOND THE PANDEMIC

Foreword – Beyond the pandemic

The platinum market takes a hit from COVID-19

You are reading this at an exceptional time when the world is fighting the COVID-19 virus. Industrial operations are temporarily shut down and locked-down consumers are tightening their purse strings; supply and demand for platinum are both inevitably being seriously affected. As Dr. Ralph Grimble's review of the PGM markets in this edition of *The Platinum Standard* reveals, the hit is unprecedented on both sides of the market balance – a sharp contraction in consumer spending is suffocating demand for cars and jewellery, mining has been temporarily suspended, and platinum auto and jewellery recycling volumes are in a slump. The outcome is expected to be a second successive year of market surplus for platinum well in excess of a million ounces, and the weakest average platinum price since 2002.

This might be the best that it gets this year, as the numbers assume no further supply and demand destruction from new measures to contain local virus outbreaks, or, worse, a second wave of the pandemic. The recovery of demand going forward will inevitably depend on the shape of the economic recovery – will it be the 'V' that the SFA numbers reflect, or the flatter and more damaging 'U'- or 'L'-shaped curves?

The post-pandemic economy

The post-COVID-19 economy will certainly be different, argues George Magnus of the University of Oxford's China Centre, perhaps in some unexpected ways, possibly not all of them progressive. The triple impact of the simultaneous economic, demand and supply shocks delivered by the pandemic must have consequences, some of them potentially unpalatable.

In an insightful piece, George speculates that the outcome for us all on the other side of this crisis will be something unprecedented – at least in recent memory – with the possibility that government oversight will persist in the form of monetary controls, and a serious potential for inflation to develop. Perhaps the only good outcome for PGMs is George's prediction that in these circumstances, commodity prices are likely to rise.

Any platinum linings in this cloud?

There might be another upside for platinum. During the lockdowns that so many countries have been experiencing, no-one, especially in urban environments, has failed to notice the freshness of the air, the brightness of the sky, and the clarity of the birdsong. It is not difficult to identify the reason for this change: the volume of traffic on the roads has been decimated and the air is pollution-free, allowing us to breathe more easily – ask any asthma sufferer. Will this be something that after the eventual economic recovery we dismiss as a nice moment, as we get back to life as usual? Or will it stimulate greater public demand for cleaner air along with carbon emissions reduction which could reinforce an increasingly discernible commitment to the development of hydrogen-powered transport?

Green hydrogen - you know it makes sense

In their article on producing hydrogen from electrolysers, Dr. Philipp Walter and Dr. Christian Gebauer of Heraeus point out that hydrogen can be an important tool in mitigating global warming, but that it has to be 'green' to make sense – hydrogen produced from fossil fuels simply preserves the status quo. Using electrolyser technology to split water and make hydrogen for use in industrial applications and fuel cells, as well as for storing surplus energy generated from renewable sources, gets around the problem. Of several competing electrolyser technologies, platinum-based polymer electrolyte membrane (PEM) electrolysis has the high power density needed for energy storage and the transfer from conventional to 'green' hydrogen. This technology also uses iridium at intriguing potential levels of demand.

Decarbonisation means platinum demand

Dr. Jenny Watts of SFA writes about the development of an electrolyser network. The next ten years will be a critical period for establishing competitively priced clean hydrogen supply which will itself underpin expanding production of fuel cell vehicles. Electrolyser installations commercially producing hydrogen are ramping up fast in early markets, with installed capacity, currently below 100 MW, expected to reach around 1 GW by 2025. Government targets for the decarbonisation of transport have widened the opportunity for new platinum demand, so in this article Jenny reveals for the first time SFA's estimate of 2020 demand in the electrolyser and fuel cell markets, plus an indication of future offtake for electrolysers and transport and stationary applications as the 'green' hydrogen economy takes shape.

WHY THE POST-COVID-19 ECONOMY WILL BE DIFFERENT

Why the post-COVID-19 economy will be different

George Magnus, University of Oxford's China Centre & SOAS University of London

It is hard to imagine how the economy might look in the next two to three months, let alone over the next two to three years, as we scramble to regain our footing in the deepest and fastest economic contraction we have ever experienced.

Unlike past economic downturns triggered by tight monetary policy, over-leverage, or other business-cycle phenomena, this one is happening out of choice. We are suffering detrimental economic outcomes as we try to stop our health systems from being overwhelmed by bad epidemiological outcomes, which would then make the economy even worse. Until we have a vaccine, or at least more effective treatments and better control over infections, we may oscillate between different degrees of lockdown and restrictions. Eventually, though, we will move on, and one thing that is becoming clear is that the macroeconomic environment is going to be quite different from what we have come to regard as normal.

Freedom of movement will not return until it is safe

Triple shock

In the first instance we are experiencing a '*supply shock*'. People who cannot work at home, and who are not essential workers, cannot work. Economic activity on construction sites and in factories, offices and shops has stopped. Trade, travel and transportation are limited or suspended. Output and transactions are falling precipitously, and services which account for 80% of the economy in the UK have mostly ground to a halt.

Around 80% of the UK economy is stagnated

Owing to this, we also have a derived '*demand shock*' because even as governments try to provide people with income support and businesses with loans or grants, there is little appetite, capacity or opportunity to spend, borrow or invest as we do normally.

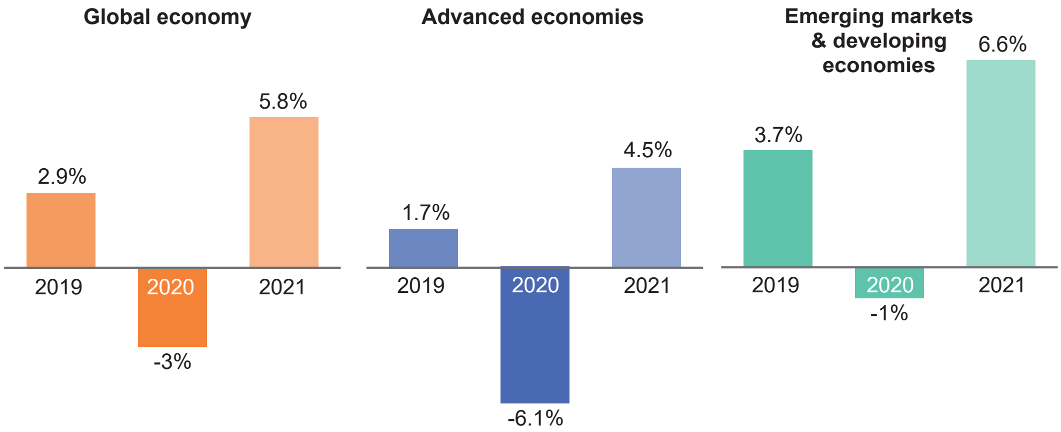
Limited opportunity to spend money despite government support

Combine the two, and you can see why we also get a '*financial shock*'. As cashflows, revenues and liquidity dry up, and balance sheets decay, firms fail and people become unemployed leading to a surge in bad debts, putting banks and other lenders at risk. Tumbling stock markets raise the cost of equity and impose hefty charges on company pension fund liabilities. Fortunately, banks are better capitalised, provisioned and more liquid than they were before the financial crisis of 2008-09, but there is plenty for regulators and supervisors to monitor.

We do not know how long this malaise will last. Many economists think we might get a 'V'-shaped recovery, and the IMF's recent central forecast provides for just such a scenario.

The IMF expects a 'V'-shaped recovery

Economic growth projections



Source: International Monetary Fund

Yet, the chances look slim. Lifting the lockdown completely is liable to lead to a new wave of infections and fatalities, and so we should expect an extended period of infection control measures and new intermittent or partial lockdowns. While governments and central banks have announced large-scale programmes to maintain income flows, to keep firms from failing and sustain liquidity in markets, it is better to think of this as 'disaster relief' rather than fiscal stimulus for the time being. People and firms will only spend and borrow again once confidence in public health and the future has returned.

Consumer confidence will remain very low until the virus is contained

Chinese lessons

We might learn something from looking at China, which is about six to eight weeks ahead of us in the unfolding pandemic, with the lockdown in Wuhan ending on 8 April. After a drop of nearly 10% in GDP in the first quarter, which is most likely a considerable underestimate, data for March and anecdotes for April suggest that production of steel and chemicals, and other parts of what is referred to as 'heavy industry' have bounced back, so that firms, mostly state enterprises, were producing roughly 80-90% of what they did in January.

There could be lessons to be learnt from China which has rebooted its economy swiftly

China Manufacturing Purchasing Managers' Index (PMI)

Source: SFA (Oxford), Bloomberg

Chinese PMI in March dropped lower than the financial crash of 2008-09

Yet, it has been easier to crank up output in large firms than boost demand. Places of work, shops and restaurants are opening again but significant parts of the leisure and entertainment sector remain closed. Not all of China's 280 million migrant workers have returned to work. Unemployment, which is poorly measured, has almost certainly shot up to perhaps 20%, and hundreds of thousands of small enterprises, the lifeblood of the economy and employment, have failed. Economic life and people's behaviour are slowly normalising but are very far from 'normal'.

Major Chinese enterprises have returned to work but challenges still exist for smaller companies and the leisure sector

The government has provided a considerable amount of bridge financing for firms, and tried to keep incomes and credit flowing and stimulate demand. In recent weeks, it has authorised the financing of a great deal of new infrastructure, offered cash vouchers to consumers to spend as they choose, and helped the auto sector by offering cash to auto buyers, extended subsidies to producers, and tax breaks for new energy vehicles. China's famed auto sector, where sales have been weak for two years already, has experienced an almost 50% fall in sales in the first quarter.

New government incentives provided to support China's auto industry

Whether these and other measures gain traction depends on stronger household income, which is about jobs, wages and, inevitably, more demand stimulus to come. Yet, the key to success is that people are confident there will not be a second wave of infections. At the current time, there are some new infections in north-eastern China, where Chinese people returning from Russia seem to be bringing COVID-19 home, but, reportedly, domestically sourced infections are under control. It is, though, early days.

Reinfection is a big risk for those countries which appear to have recovered

Uncertain future

In the UK and elsewhere in the Northern Hemisphere, the economic outlook in the next several months is uncertain and depends on how the coronavirus behaves as restrictions are eased. This, in turn, depends, until or unless we get a vaccine, on how we manage to control infections with testing and contact-tracing as alternatives to social distancing, and new social, business and customer management practices to keep people safe at work and leisure.

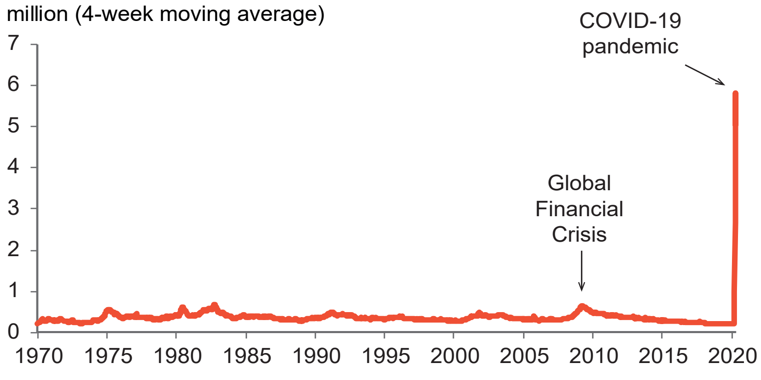
Test, track and trace systems can prevent a second wave of COVID-19

It is important to achieve a balance between restrictions, infection management, and the economy. If a second wave of the virus were to erupt, triggering a new total lockdown, economic decline would worsen. The longer people remain unemployed, the greater the likelihood that they will stay unemployed. That would curtail severely the outlook for income and consumption growth, and raise social cohesion risks.

Before the UK lockdown, for example, unemployment stood at 1.3 million or 3.9% of the workforce, but there are fears that a precipitous plunge in GDP in the April-June quarter could send unemployment up to over 3 million, or around 10%, the highest since the 1991-92 recession. In the US, over 33 million people have registered new claims for unemployment benefit since late March, offsetting all of the new jobs created since the 2008-09 recession.

Over 33 million people in the US have registered new unemployment claims

Initial unemployment claims in the US



Source: SFA (Oxford), Federal Reserve Bank of St Louis

If unemployment does not fall back down soon, governments may have to bolt on new programmes to the initiatives already announced, including extended periods of income support, help for small firms, and bail-ins instead of bail-outs so that the government would take equity in companies rather than provide loans or cash. Assistance for strategically important sectors, such as autos, could be given. In the UK, the auto industry accounts for close to 10% of GDP, and employs 4 million people directly, and many more in supply chains. Once people are back at work and happy to visit dealerships again, it would not be a surprise if the government were to introduce tax and other incentive schemes to encourage people to buy cars again, perhaps special deals to acquire electric vehicles.

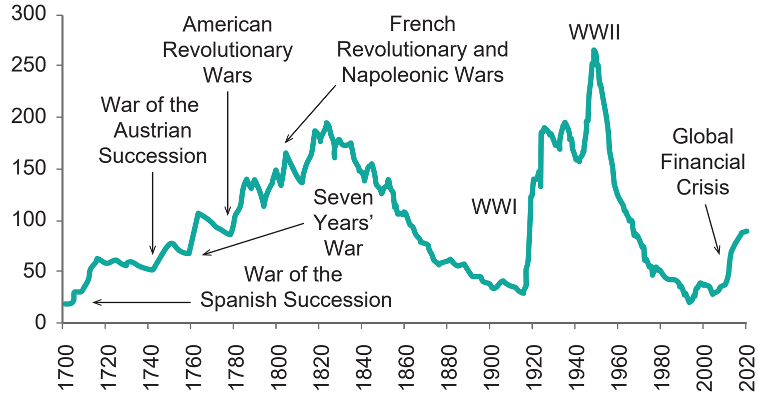
The UK auto sector is likely to receive government support

A different policy environment is likely to emerge

Yet, this sort of initiative, which could extend to housing or other sectors, is not new and it is possible that traction this time round will prove harder because of the unique, and very personal, nature of the crisis. In offering 'deals' to consumers or tax cuts and more public spending, the government is doing what all governments have done in every crisis since the 1980s, which is to borrow more. This money-tree is about to fall over because UK public debt as a share of GDP is on course to surge to over 100%, a level unseen since the Second World War.

UK debt is likely to surge to above 100% of GDP

History of UK debt as a % of GDP



Source: Deutsche Bank, Bank of England: A millennium of macroeconomic data for the UK

Higher UK inflation is to be expected

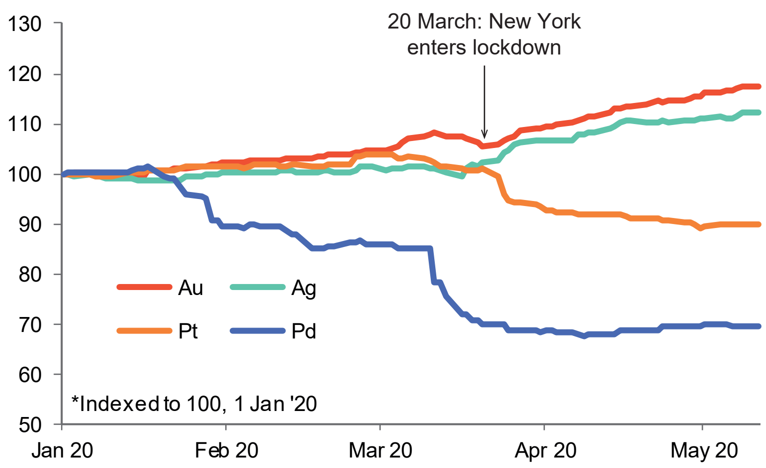
It is not that we cannot afford it, or that the country will become a failed state, but debt is now at a level that economists associate with a significant drag on economic growth in the future, and/or a new round of austerity as governments seek to bring it back down. Since we can assume that austerity is politically off the agenda, and default would be drastic and damaging, it seems increasingly likely that the way out of this economic crisis, with limits to new debt creation, will take the form of financial repression and higher inflation.

Real interest rates to stay negative

Financial repression is designed to keep the level of interest rates significantly below the rate of growth of nominal GDP, that is real economic growth plus inflation. In effect, central banks will be 'asked' to override their inflation targets or raise them. Financial repression, under which income redistribution is also likely, is, in effect, a tax on savings and on wealth, and a subsidy to borrowers, and people on middle to lower incomes who tend to save less. We would face an extended period in which rock-bottom interest rates would persist, and savers and financial institutions would be obliged to invest in government bonds. Since real interest rates would be negative, the temptation to gear up, for example in housing, would be strong, and so we might also witness the return of controls and macro-prudential regulations not seen since the post-war era.

Financial repression is also likely to be accompanied by slower, but at least some, growth and by policies that result in higher inflation. Higher inflation could result from direct monetary financing of public deficits by the central bank. In the UK, the Bank of England announced in April that some monetary financing would, in fact, take place via an expansion of the so-called Ways and Means facility, a government overdraft at the Bank. We may not call it monetisation, but that is what it is, and it is unlikely to be the only example.

Global ETF holdings*



Source: SFA (Oxford), Bloomberg

Gold investment surges on the prospect of slower growth and faster inflation

It is also likely to come about because of new constraints over supply. For the last 40 years, globalisation boosted the supply of everything from cheap labour to products and services. In a messier globalisation in future, there will be travel constraints, immigration limits, shorter or short supply chains, companies will replace ‘just-in-time’ production with ‘just-in-case’ production and stockpiling, there will be more government controls and regulations, and we will probably be more focused on security of supplies of not just health products, but food and energy too.

A refocus on security of supplies is now important

This is an important conclusion, for there probably has not been a period of higher inflation around much of the world that did not entail resurgent commodity prices. We have had only two major up-cycles in commodities since the end of the Second World War, in the 1970s and again in the 2000s, and three down-cycles, post-war, and following these two bull markets. Even if the China factor that drove commodity prices during the 2000s and early 2010s is now something of a spent force, higher inflation as a response to our economic plight seems more plausible now than the false alarm sounded following the financial crisis. This is likely to entail higher prices across the commodities complex, from food and agriculture to energy, industrials and precious metals.

At the time of writing, a dysfunctional oil market has been front-page news because of the slump in oil demand, and oversupply. For the first time, a near-term WTI futures contract was priced for negative prices. Doubtless, the rout in prices will take its toll on corporate earnings, capital spending and bankruptcies. Sovereign producers will experience mounting debts, stressed fiscal budgets and retarded development. While the damage to the industry in the immediate wake of the COVID-19 economic collapse is indisputable, commodity prices are likely to rise again in coming years in the very different sort of policy environment that is slowly taking shape.

Commodity prices will recover in the long term

George Magnus is a Research Associate at University of Oxford's China Centre and at SOAS, and was for over 20 years the Chief Economist at UBS. His latest book, Red Flags: Why Xi's China is in Jeopardy*, was published in paperback in 2019.*

GREEN HYDROGEN FROM ELECTROLYSERS: AN ALL-ROUNDER TO FIGHT CLIMATE CHANGE

Green hydrogen from electrolysers: An all-rounder to fight climate change

Dr. Philipp Walter & Dr. Christian Gebauer, Heraeus

Introduction

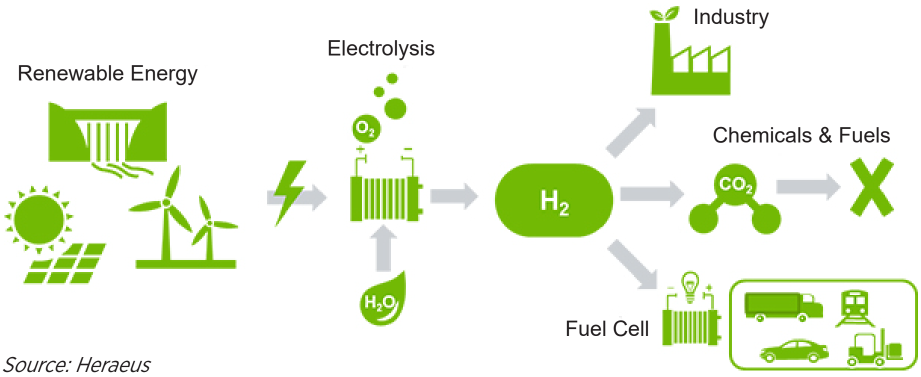
Global warming is real and carbon dioxide (CO_2) footprint reduction is a significant challenge for society and industry now and in the following decades, demanding alternatives to life based on fossil fuel resources. In this context, hydrogen (H_2) becomes increasingly important to fight climate change.

Climate change is generally attributed to higher levels of CO_2 in the atmosphere

The contribution of hydrogen to climate protection can be manifold, ranging from the replacement of conventionally produced hydrogen to future mobility and energy storage. Future mobility includes fuel cells and new synthetic fuels from CO_2 and hydrogen, seen in Figure 1.

New 'green' hydrogen-driven processes and applications can offset CO_2 emissions in many sectors

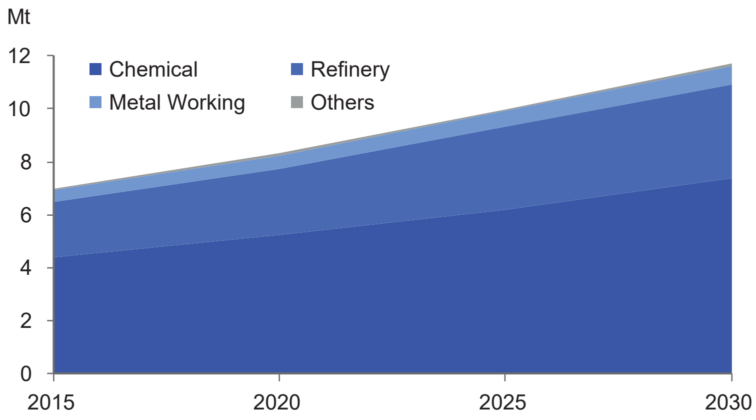
Green hydrogen generation and its applications (Figure 1)



Source: Heraeus

Already, hydrogen plays an important role in industry. With a yearly consumption of about 7 million tonnes (90%[1] of the yearly production of H_2), the use in a variety of industrial applications is significant and increasing.

Hydrogen consumption in Europe (Figure 2)



Source: Heraeus

Hydrogen consumption in Europe could rise 41%, from 8.3 mt in 2020 to 11.7 mt by 2030

Hydrogen from electrolysers using renewable energy sources is climate friendly

A positive impact of hydrogen on climate, however, is only possible with 'green' hydrogen. Whereas 90-95% of hydrogen is currently produced through methane steam reforming, where CO_2 is generated as a by-product, hydrogen should ideally be produced from water using electrolysis. In this electrolytic process, water (H_2O), a stable molecule, is split into its elements hydrogen (H_2) and oxygen (O_2). This cleavage requires energy and in order to be CO_2 friendly, the energy needs to come from renewable energy (REN) sources.

Hydrogen is the most reliable renewable energy source

Interestingly, the energy requirement for electrolysis represents on the one hand a burden and on the other hand the basis for the opportunity to use hydrogen in the energy sector for the storage and transport of REN. Supply of REN is fluctuating, as the amount of REN produced simply depends on the availability of natural resources such as sun and wind. To match the supply with the demand, storage and transport of REN are important for economically efficient operations. Hydrogen is highly capacitive[2] and can store energy long-term through stable chemical bonds in its molecules. Moreover, the transport of hydrogen does not depend on the power grid and can be included in already existing logistics and infrastructure. When going one step further, hydrogen can be transferred into valuable gases and chemicals or synthetic fuels, leading to sector coupling (Power-to-X = P2X).

[1]Fuel Cells and Hydrogen Joint Undertaking (FCH JU): CertifHy (2014-2016), Deliverable 2.1.

[2]Capacity - amount of energy storable, often in W/cm^3 (power per volume).

Hydrogen can also be used directly in the mobility sector as "fuel" for fuel cells, where hydrogen and oxygen react electrochemically and generate energy. Although battery electric vehicles (BEVs) are on a steep slope upwards currently, all experts agree that with a certain vehicle size (trains, ships and planes included) and range, fuel cell electric vehicles (FCEVs) become superior[3] to BEVs. It is clear from media reports that fuel cells are increasingly being introduced into the heavy-duty logistics and public transport sector. However, in general very little is reported about hydrogen generation through water electrolysis and what this could mean for the precious metal industry.

The use of platinum in fuel cells for heavy-duty vehicles is a growing market

Water electrolysis

Whereas the application of platinum-group metals (PGMs) in fuel cells is widely reported, the application of PGMs in water electrolysis is discussed less prominently.

Hydrogen from electrolysers and the use of PGMs is not widely known

In general, different technologies compete in the market when it comes to the electrolysis of water (see table below). Each technology has its distinct advantages and disadvantages[4]. The electrolysis market is dominated by the well-established alkaline water electrolysis (AEL) and by the so-called polymer electrolyte membrane electrolysis (PEM EL), recently gaining traction in the market. Furthermore, the high-temperature electrolysis (solid oxide electrolysis cell – SOEC) needs to be mentioned as a third technology for water electrolysis.

Comparison of different electrolyser techniques

Technique	Efficiency	Capacity	Power density	Flexibility	Industrialisation
AEL	++	++	+	+	+++
PEM EL	++	+++	+++	+++	++
SOEC	+++	-	+	-	-

Source: Heraeus

[3]Hydrogen Roadmap Europe (2019), p. 27 exhibit 10.

[4]Carmo et al. International Journal of Hydrogen Energy (2013).

PEM EL is the superior technique for high capacities and is suitable for renewables

The AEL is a reliable and well-understood technology which is based on non-precious metal electrocatalysts (e.g. nickel-based catalysts) and runs best on a base load without significant fluctuations. The overall efficiency is around 65% and hence in the same range as PEM EL, whereas its power density is only one-quarter of the latter. This makes AEL superior for capacity levels up to a maximum of 20 MW[5]. The disadvantage in power density leads to a significantly higher initial cost level (CAPEX) for higher capacities. For energy storage and the transfer from conventional to 'green' hydrogen, higher power densities are required, making PEM EL the more preferred option. Furthermore, the PEM EL has a very fast response time, from 0% to about a 150% load, which makes it suitable for an operation with wind and solar power.

Whereas AEL is based on non-precious metal electrocatalysts, PEM EL's heart, the catalyst coated membrane (CCM), contains electrocatalysts from precious metals such as platinum, ruthenium and iridium.

PEM EL cathode catalysts contain Pt and anode catalysts contain Ir and Ru

For the two reactions taking place in electrolytic water splitting, two different types of electrocatalyst are used: the catalyst at which hydrogen evolves (cathode), and the one at which oxygen is generated (anode). Anode catalysts are usually based on iridium and ruthenium, with iridium being the preferred component. However, iridium loadings of about 0.4 g Ir/kW_{el}[6] currently lead to rather high cost in a PEM EL. Non-precious metal-based alternatives, often discussed in scientific literature, are far away from industrial relevance. For the hydrogen evolution, platinum-based materials are used on the cathode side, with less than 0.1 g Pt/kW_{el}.

Being less industrialised so far, the high-temperature electrolysis (SOEC) is superior in efficiency (> 80%) since temperatures of about 800°C are applied at the ceramic electrodes. This advantage is at the same time a disadvantage for applications with high capacity, since maintaining such high temperatures for a larger ceramic electrode is rather difficult and hence expensive.

Realisation of water electrolysis for green hydrogen

Electrolyser capacities will scale up to 100+ MW in the future

Numerous initiatives within industry, countries and regions are ongoing with the aim of implementing water electrolysis as a technology for 'green' hydrogen. Looking at the distinct projects, it becomes apparent that the trend moves away from small-sized, project-based applications towards single electrolyser capacities in the 10 MW range and complete electrolyser capacities of up to 100 MW and larger (Figure 3a)[5].

[5]IEA Hydrogen Project Database (2019).

[6]Amount of active material (here: iridium) necessary to provide a certain power.

Lighthouse-type projects within the overall project landscape are projects funded by the German government dealing with a regional concept ("Real-Labore") in the 10 to 100 MW range as well as initiatives driven directly by the industry and, for example, making ports in the Netherlands nuclei for hydrogen distribution (wind on- and off-shore). The trend towards higher capacity set-ups is also emphasised by an initiative of the "Hydrogen for Climate Action"[7] conference from the European Union, where detailed figures of about 80 GW electrolyser capacity in the next 5 to 10 years are mentioned to avoid CO_2 from conventional hydrogen production. This is equivalent to an investment of about €20 billion to reduce 400,000 to 1,000,000 t of CO_2 per year.

Harnessing wind power to produce hydrogen could make the Netherlands a primary distribution hub

Australia (hydrogen as an export product), Canada and China as well as other countries are also tackling the GW range for hydrogen production in the upcoming years. Notably, this electrolyser capacity is not exclusively based on PEM EL, but a combination of AEL and PEM EL projects. However, assuming a 50:50 share between both technologies (a number often mentioned in the respective reports), it already results in a rather high amount of platinum and especially iridium needed.

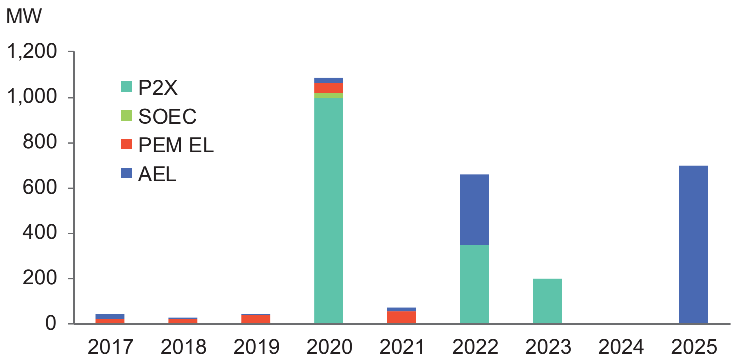
Existing hydrogen production uses both PEM EL and AEL technologies

Demand for platinum-group metals

Taking the above-mentioned 80 GW capacity and assuming that 50% will be PEM EL, this number can be transferred into an iridium demand of about 16 tonnes over 10 years (0.4 g Ir/kW). Figures 3a and 3b give a more realistic view based on recent projects and new announcements. The charts depict the electrolyser capacity (a) as well as the amounts of iridium and platinum needed (b) (PEM and 50% of P2X projects). Since these are mostly funded projects and, as mentioned above, regionally driven, a strong fluctuation in the yearly new electrolyser capacity is obvious while an increasing trend is expected.

Growth in PEM EL could increase Ir demand by 16 tonnes over the next 10 years

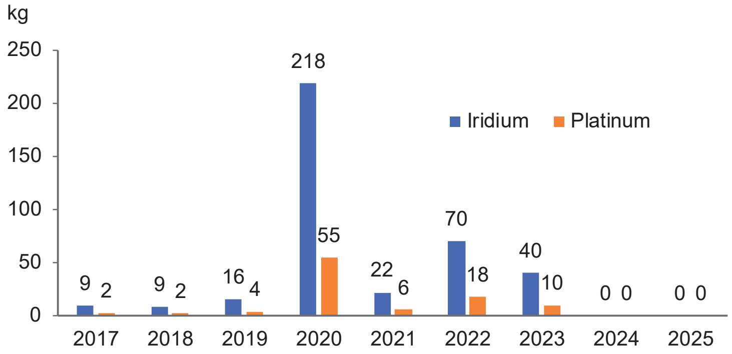
Capacity of different electrolyser techniques (Figure 3a)



Source: Heraeus

[7] *https://www.hydrogen4climateaction.eu/*

PGM demand for PEM EL (Figure 3b)



Source: Heraeus

Pt and Ir demand for existing PEM EL projects will peak in 2020

Having a more industrial view on this topic, and this is not depicted by this figure, a steady growth rate is assumed until sufficient capacity is installed (3% to 5% CAGR[8] for REN in Europe, based on the recent expansion of REN). This can be transferred into an increasing demand for iridium of about 2 tonnes in the first five years of industrialisation of water electrolysis. The focus for most of the projects, targeting the industrialisation of PEM EL, is currently material development, where all the single components (bipolar plate, membrane, etc.) and especially the iridium catalyst in the PEM EL are optimised. For example, the German government-funded Kopernikus P2X[9] project, a research cluster in which a significant contribution from Heraeus Deutschland GmbH & Co KG was included, was able to develop iridium-based catalysts with 10 times lower iridium loadings compared to the state-of-the-art catalysts at even higher activities. Only efforts and success stories such as the one mentioned will enable the breakthrough of PEM EL and thus the generation of 'green' hydrogen in sufficiently high volumes to fight climate change.

Lower volumes of PGMs will increase economies of scale

The technology for producing hydrogen via water electrolysis is ready. Hydrogen is an all-rounder for fighting climate change and precious metals are playing an important role for hydrogen.

[8] *CAGR = Compound Annual Growth Rate - average yearly growth rate.*

[9] *https://www.kopernikus-projekte.de/projekte/p2x*

THE HYDROGEN SOCIETY: DECARBONISATION DRIVES LONG-TERM PGM DEMAND GROWTH

The hydrogen society: Decarbonisation drives long-term PGM demand growth

Dr. Jenny Watts, SFA (Oxford) Ltd

Introduction

Interest in hydrogen as a source of clean energy is growing globally, with applications in land transport, heavy industry, stationary power, aviation, shipping, and beyond. Used as a fuel in a fuel cell system, the only by-products of the reaction are electricity, heat and water, so it can play a substantial part in improving local air quality and helping to avert global warming. To decarbonise these downstream end-uses, the carbon intensity of hydrogen production upstream must be cut substantially from today's levels.

Rising demand for hydrogen fuel cells

Using renewable electricity, such as from wind or solar, to power an electrolyser is one of the leading ways to achieve this. Electrolysis uses electricity to split water into hydrogen and oxygen. The hydrogen can then be stored and used to power a fuel cell vehicle, a stationary fuel cell system, or for power-to-other applications, such as power-to-heat, power-to-liquid fuels. Hydrogen shows great promise as a way of getting the most out of abundant but highly variable and intermittent renewable energy sources. Ever-closer integration of renewable energy and electrolysers is expected going forward.

Electrolysers powered by renewable electricity can help drive decarbonisation

Source: ITM Power

Emissions legislation will limit sales of ICE vehicles

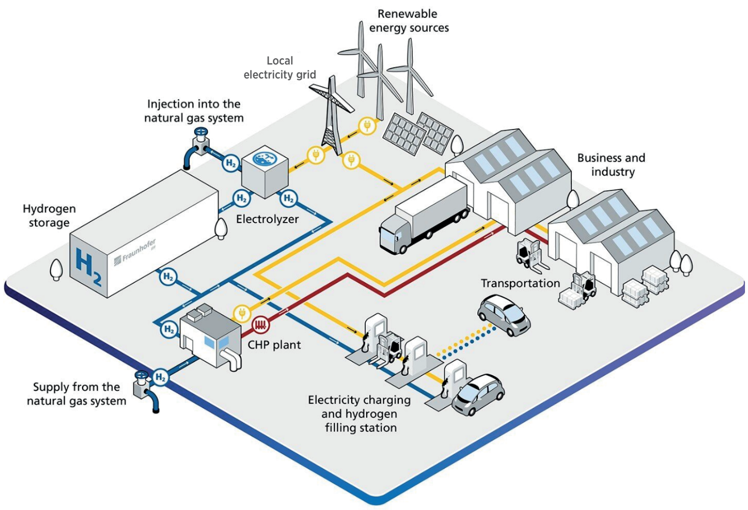
Fuel cell electric vehicles (FCEVs) are co-existing, not competing, with battery electric vehicles (BEVs). Uptake is driven by emissions legislation, covering greenhouse gases such as CO_2 and criteria pollutants such as NO_x. Within the next ten years, many countries and cities will enact legislation that bans, or at least severely limits, the sale or use of internal combustion engine (ICE) vehicles.

CO_2-neutral transport will only be realised through either BEVs or FCEVs using zero-carbon electricity and hydrogen produced via 'green' electricity. Both have advantages and disadvantages, depending on customer use patterns, distances travelled, loads carried, and access to fuelling infrastructure by region, and are expected to remain complementary to meet global transport needs.

Electrolyser capacity is essentially the enabling technology that needs to be in place – to provide green hydrogen fuel – before FCEV sales can grow significantly.

SFA now includes electrolyser demand modelling with other fuel cell applications, by taking a view of electrolyser capacity in place and under construction, along with estimates of the capacity needed to contribute to energy policy targets.

The graphic representation below gives an impression of the integrated, networked nature of the 'hydrogen society'.



Source: Fraunhofer IFF

This is the decade for establishing hydrogen technologies

Many countries and regions are setting targets for 2030, with correspondingly detailed action plans from numerous companies – production capacity build, investment from public and private sources – that aim to take advantage of the opportunities to deliver on these targets.

Many countries also have rather more ambitious, if less specific, plans to completely decarbonise by 2050, which provides the electrolyser and fuel cell industry with a long-term goal and supports ongoing government and private funding of development projects.

PGM demand in the hydrogen society is likely to be driven in the near term by the need to build electrolysers, some of which rely on PGM catalysts, to produce zero-carbon hydrogen, which can then be used as the fuel in PGM-catalysed fuel cells to power light- and heavy-duty vehicles, and in stationary and other industrial end-uses.

Long-term decarbonisation goals will support hydrogen technologies and PGM demand

Electrolysers (some technologies of which use PGMs) can be used to produce hydrogen for several industry sectors: transport (where there is already a strong PGM connection), industry (steel, chemical) and the gas supply grid (heating, commercial and domestic use).

Building the hydrogen fuelling infrastructure

The importance of this technology from a PGM perspective is expected to come initially from electrolysers, then increasingly from heavy-duty vehicles, and finally from rapid growth in the market for fuel cell light vehicles, once the fuelling infrastructure is in place. Current forecasts, even for heavy-duty vehicles where there is more near-term potential than there is for light-duty vehicles, suggest a very small market during the 2020s. For FCEVs to become credible, they must achieve the same fast fuelling and long range as fossil-fuelled vehicles and the same low emissions at the point of use as BEVs, all at a competitive cost. Automakers need a viable hydrogen fuelling infrastructure before they can fully resource the development of such competitive fuel cell vehicles.

The fuelling time and driving range of FCEVs need to be comparable to ICE vehicles to be competitive

PGMs are used as catalysts in some electrolysers and some fuel cells, for the same reason as in autocatalysts and industrial chemical processes, to ensure more efficient chemical reactions. As these technologies travel the long road from limited-scale prototypes to high-volume commercial production, their potential impact on PGM demand will be closely watched, along with any news of reduced PGM loadings, or even partial substitution, which will help to achieve cost-effectiveness.

Partial substitution and thrifting could impact PGM demand

Put simply, electrolysers are essentially the reverse operation of a fuel cell, whereby passing an electric current through water, a membrane and an electrolyte separates the water into hydrogen and oxygen. There are likely to be considerable economies of scale, certainly in the production of components that can be used in both electrolysers and fuel cells, and this may favour the adoption of the technologies that can be used in electrolysers and fuel cells, such as proton exchange membrane (PEM), which is the leading user of PGMs in this sector. Indeed, some of the promising technologies under development are reversible, increasing flexibility and lowering costs.

New fuel cell technologies are being developed to lower costs and increase flexibility

The highly dispersed fuelling infrastructure required for personal mobility in fuel cell light vehicles is very different to the much more concentrated infrastructure required to fuel heavy vehicles such as delivery wagons, buses and trains. These vehicles typically run on much more limited, defined routes and hence they can rely on far fewer, though perhaps larger, fuelling stations, initially tipping the cost and scale balance in hydrogen's favour for heavy-duty vehicles ahead of light-duty vehicles.

Light-duty fuel cell vehicles are currently cost-prohibitive

Longer term, automaker competitiveness may depend on the regional strategies around the hydrogen fuelling infrastructure. As automakers seek to establish a lead in technologies such as fuel cell powertrains that are currently emerging but with great future potential, they will locate R&D and production facilities where there is already some hydrogen production and a robust plan for expansion. At present, a very limited number of fuel cell light vehicles are being produced by automakers, and there is competition between some of the leading markets – Japan, Korea, Germany, the UK, California – for deliveries of these desirable vehicles.

Hydrogen as a fuel

Hydrogen contains more energy per unit of mass than natural gas or gasoline, so it is attractive as a transport fuel. However, hydrogen has a low energy density per unit volume (it is the lightest element), so compared with other fuels, higher volumes of hydrogen must be moved to satisfy the same energy demands. Fortunately, hydrogen can readily be compressed, liquefied, or transformed into practical hydrogen-based fuels that have a higher energy density.

Hydrogen can be compressed in order to increase its energy density

Hydrogen significantly extends our ability to make use of globally abundant wind and solar resources, which puts hydrogen in a strong position compared to other sustainable options such as energy conservation, electrification (non-hydrogen), the use of biomass and bio-based fuel sources, geothermal energy, and fossil fuels in combination with the re-use and storage of CO_2. New infrastructure and the adaptation of existing networks will be needed in parallel.

Green hydrogen – and all the other colours

Hydrogen, like electricity, is an energy carrier, rather than an energy source. While there are no harmful emissions at the point of use (if hydrogen is used to power a fuel cell), both hydrogen and electricity can come with a high CO_2 footprint from upstream if they are produced using fossil fuels – natural gas, coal or oil. These associated CO_2 emissions can only be mitigated by using renewable (e.g. solar, wind, tidal) or nuclear power, or fossil fuels with appropriate carbon capture, utilisation and storage (CCUS). A high proportion of the nuclear energy currently produced goes directly to electricity supply, but there is some interest in nuclear hydrogen production.

Hydrogen is only 'green' if it is produced from renewable electricity, but this is still generally the most expensive source at capacities less than 70 GW

Hydrogen produced from renewable electricity is often termed 'green', while production of hydrogen from fossil fuels with CO_2 emissions mitigated by using CCUS is termed 'blue'. 'Black', 'grey' or 'brown' are used to denote production of hydrogen from coal, natural gas and lignite, respectively, each with varying environmental footprints. At this stage, 'green' hydrogen is still generally the most expensive, but the Hydrogen Council states that once the installed capacity of water electrolysis exceeds 70 GW, estimated to be in the mid- to late 2020s, then 'green' hydrogen will be as cheap as 'brown' hydrogen.

Hydrogen society costs will fall rapidly with electrolyser capacity scale-up

Hydrogen can be more cost-competitive with fossil-based fuels if more financial value is given to environmental benefits, particularly to climate-change mitigation (source: IEA, 2017/2020). One of the key levers to unlocking the hydrogen economy is producing large-scale, low-carbon hydrogen at a reasonable cost.

Before hydrogen costs can come down, so must electrolyser equipment costs; electrolyser manufacturers are now gearing up fast to increase their production capacity. Electrolyser production costs have a high elasticity. Producing ten times the capacity is estimated to reduce the price to half, while producing 100 times the capacity will reduce the cost by 75% or more, according to estimates from Hydrogen for Climate Action (EU).

Electrolyser costs are price-elastic

Electrolyser installations, producing hydrogen commercially, are ramping up fast in early markets, with installed capacity sub-100 MW but expected to reach around 1 GW by 2025. The picture overleaf shows a typical PEM electrolyser in a modular format which can conveniently be scaled to meet end-users' needs.

Source: ITM Power

Most estimates of electrolyser capacity are ‘top-down’, based on national/sub-continent government studies attempting to forecast the electrolyser capacity required to meet decarbonisation targets and the cost at which this hydrogen must be produced to compete with incumbent fossil fuels. In such plans, there is generally little detail on the technological approach to achieve this. The energy input is not always detailed either; while some of the electrolyser capacity addition will come from zero-carbon renewables, much of it, certainly in the earlier years, is likely to involve carbon-capture activities to mitigate the CO_2 emissions from fossil fuels involved in the production of hydrogen. Hydrogen for Climate Action (EU) even describes its own 80 GW target as “an arbitrary, but very substantial figure”. Such numbers tend to come from modelled estimates of bringing the cost of green hydrogen down to a level competitive with other fuels, and modelled estimates of the cuts to CO_2 output required to reduce the threats of global warming.

There is limited guidance on how governments will reduce the cost of hydrogen production

Coming from a ‘bottom-up’ approach, individual company contract awards and installations are proudly announced, often with substantial investor involvement and frequently involving a consortium of companies providing production and market expertise. Some electrolyser companies are single-technology, while others are running multiple technologies, so announcements may sometimes be ambiguous on the technology to be deployed.

SFA's first platinum demand forecast in electrolyser and fuel cell market – growing fast in the late 2020s

Fuel cell platinum demand could reach 60 koz in 2020

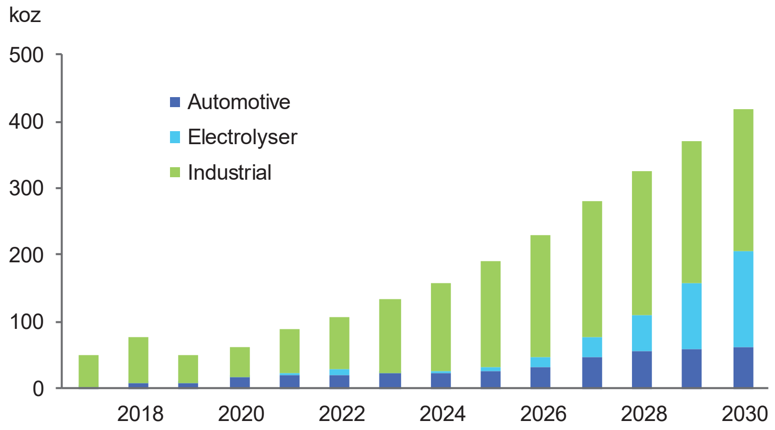
Over the next five years, we expect to see a steady building of the foundations for demand, leading to fast growth in the late 2020s. Overall platinum demand in all electrolyser and fuel cell technologies is estimated to be around 60 koz in 2020, but to reach significant levels, compared to other areas of industrial demand, approaching half-a-million ounces by 2030.

The chart below shows the estimated size of the fuel cell vehicle (on-road, light- and heavy-duty), electrolyser for hydrogen production and industrial (including non-road vehicles such as trains and materials-handling equipment, plus stationary) platinum demand over the next ten years.

The automotive estimate is based on vehicle production forecasts, fuel cell technology choices, currently known loadings, and expectations of substantial thrifting as vehicle production increases.

SFA's approach to electrolyser demand modelling is to look at 'bottom-up' installed capacity/order books and 'top-down' views from the energy policy world of the capacity needed to avert global warming. That gives a very wide range of possible demand and growth, with a middle way taken for this summary chart, to which an estimate of the PEM share of electrolyser is applied, and then estimates applied of the current platinum loadings and expected thrifting ahead.

Platinum demand: Fuel cells



Source: SFA (Oxford)

SFA (Oxford)'s Long-Term PGM Market Outlook report

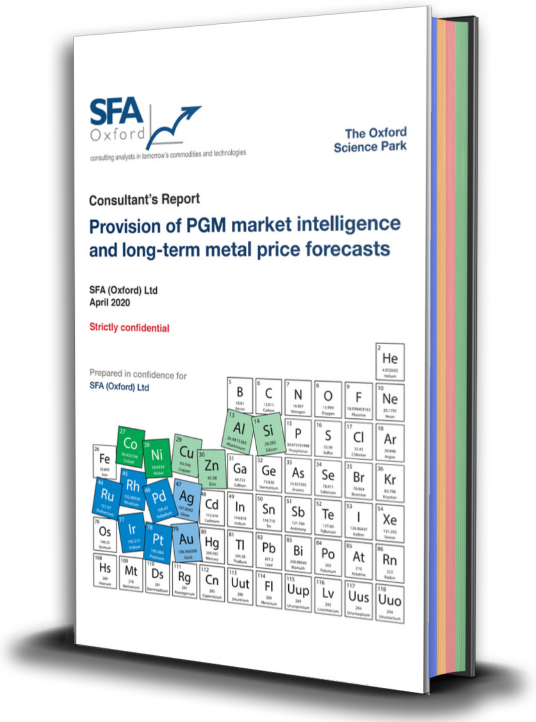
SFA (Oxford) unveils its latest in-depth *Long-Term PGM Market Outlook report*. This special edition is packed with all-inclusive analysis of the platinum, palladium and rhodium markets out to 2030.

For the first time as a new regular feature, the report includes SFA's first **projections and narrative on fuel cell demand in its supply-demand balances (covering autos, electrolysers and other industry uses).**

In addition, regular detailed ESG analytics is introduced, comprising the entire PGM food chain from suppliers to users, at the start of a long journey and strategic imperative for the PGM sector.

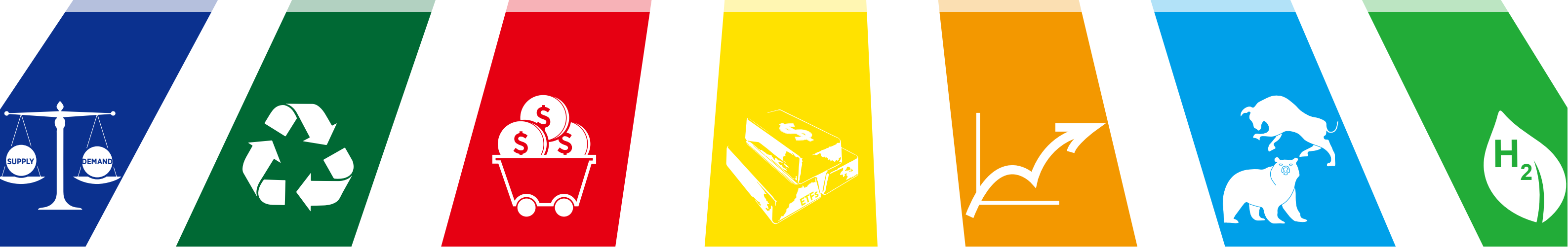
Also incorporated into this special edition is **an insightful one-off chapter, *Changes to the political system and Putin's future***, by eminent guest author and SFA Associate, Professor Paul Chaisty of St Antony's College, University of Oxford.

This report provides SFA's clientele with **well-reasoned, pre- and post-COVID-19 value-adding market intelligence, along with an array of carefully considered scenarios** impacting on the upstream and downstream chain-linkages of the PGM industry.



This report distils **21 reasons for PGM players and investors to adopt a new perspective on PGMs**, including:

- **Structural changes to our market view with price risk extrapolation.**
- **How COVID-19 affects inter-metal substitution.**
- **The impact of pre- and post-COVID-19 automotive trends plus emissions legislation.**
- **Decarbonising industry and transport; fuel cells and electrolysers as a new end-use.**
- **Movement of platinum bars as an investment stock.**
- **Recycling and primary supply scrutiny.**
- **Reserve depletion rates and mine economics, including cost-curve analytics.**
- **Impact of COVID-19 on PGM projects.**



To order your copy of the Long-Term PGM Market Outlook report please contact us via email at **info@sfa-oxford.com**

THE PGM MARKETS IN 2019/20

The PGM markets in 2019/20

Dr. Ralph Grimble, SFA (Oxford) Ltd

The platinum market

In 2019, mine supply held up at 6,145 koz and recycling grew modestly, lifting total supply by 1%. Both automotive and jewellery demand declined and industrial usage was little changed, so total consumption dipped by 5% and the surplus expanded to almost 1.3 moz.

COVID-19 has shaken up the PGM markets this year, causing both supply restrictions and demand destruction. While platinum mine supply has been cut by 16% and recycling is set to drop by 20%, gross demand is down 20% with automotive, jewellery and industrial uses all down sharply. The net impact reduces the estimated surplus for this year by just 100 koz, leaving it at 1.3 moz, which is marginally higher than in 2019.

COVID-19 severely impacts platinum supply and demand but a 1.3 moz industrial surplus is in prospect in 2020...

Last year, investment sucked up the surplus metal but this year ETFs have shed 350 koz in the first four months. This has been somewhat offset by coin and bar purchases which have been particularly strong in Japan, but that is very different from the 770 koz of investment demand in Q1'19 alone and 1.2 moz for 2019 as a whole.

...and investors are not buying ETFs this year

Mine supply

Primary platinum supply edged up 20 koz to 6,145 koz in 2019. Refined output in South Africa slipped just 40 koz (-1%) to 4,430 koz and Zimbabwe was down a marginal 5 koz, but gains in Russia, from a release of work-in-progress stock, North America, as the Blitz project ramped up, and other regions more than offset those losses.

The exceptionally strong palladium and rhodium price performances lifted the South African basket price by 53% over the course of the year, prompting some restarts of UG2 sections at RBP's BRPM South shaft and Anglo's Dishaba mine, and Impala kept Rustenburg's 1 shaft open which had previously been scheduled to close in H1'19.

A high basket price supported PGM output in 2019

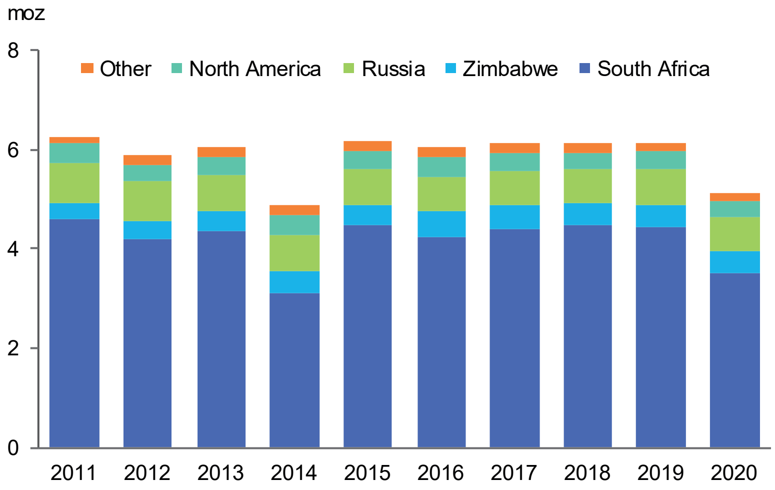
This year, a modest decline in primary supply was expected but the impact of COVID-19 has significantly changed the outlook. Global platinum output is now projected to contract by more than 1 moz (-16%) to 5,140 koz. This assumes no further halts to production from lockdowns or other measures to contain more local virus outbreaks in mining areas.

This year, platinum production could fall by more than 1 moz

In South Africa, a three-week stoppage of mining followed by a period of production at reduced capacity is estimated to cut platinum supply by 21% to 3.5 moz this year. Zimbabwe and North America have also experienced mine closures which have reduced output. Russian production is also expected to be down year-on-year, but that is due to processing of stock boosting the 2019 figure.

Mine closures set to cut South African supply by more than 20% this year

Primary platinum supply



Source: SFA (Oxford)

Recycling

Secondary platinum supply reached 2,005 koz last year as growth in autocatalyst recycling more than outweighed a small drop in jewellery recycling.

Last year, automotive PGM volumes were boosted by record palladium and rhodium prices which incentivised the flow of scrap catalytic converters and helped to offset the decline in scrap steel prices for scrapyards. The high metal prices were not entirely a boon as the increasing value of the catalysts' metal content meant companies had to allocate more working capital to their recycling businesses. Capacity constraints owing to a combination of permanent and temporary refinery closures also resulted in longer processing times and higher costs.

Platinum recycling is forecast to fall by 19% to 1,620 koz this year, as both jewellery and autocatalyst recycling are expected to decline. With consumers unable to purchase jewellery in stores and trade-in old pieces during lockdowns and the platinum price falling to the lowest level since the 1990s, jewellery recycling is forecast to shrink by 21%. Lockdowns are restricting the collection and movement of scrap, and lower new car sales will result in fewer old cars being scrapped, reducing automotive recycling.

Platinum recycling volumes likely to fall sharply this year

Demand

Total platinum demand (ex. investment) fell by 380 koz (-5%) to 6,865 koz in 2019. Automotive demand was hit by a further slide in diesel car sales in Western Europe and lower heavy-duty vehicle sales following a bumper year in 2018. Global jewellery demand slipped by 7% as the decline in demand in China continued and took jewellery purchases there below 1 moz for the first time since 2007. This more than offset gains in other regions. Industrial demand was mixed and dipped slightly overall as some sectors, such as electrical and petroleum, had lower requirements while others, such as chemical, used more metal.

Platinum demand to drop 20% to 5.5 moz in 2020

This year the impact of COVID-19 is predicted to reduce platinum demand across all end-uses and a 20% drop to 5,460 koz is anticipated. Automotive demand will be hit by lower sales of both diesel cars and commercial vehicles, resulting in platinum automotive requirements slumping by 24%. At the start of the year platinum jewellery demand was expected to decline in 2020 owing to the ongoing reduction in sales in China, but this has been exacerbated by the impact of lockdowns and weaker consumer spending, so globally a 25% drop is now anticipated. Industrial uses may suffer a comparatively modest 9% decline this year. China is the largest source of industrial demand for platinum and the economy there already appears to be recovering quite well.

Automotive demand

Platinum demand from the automotive industry fell by 7% to 2,870 koz last year. This was mainly due to a decline in Western Europe as diesel cars continued to lose market share, dropping to 30.5% from 35.9% in 2018. The rate of decline of diesel share slowed but demand still contracted by 14% (-170 koz) in Western Europe. There were also small declines in demand in India, Japan and the RoW, while heavy-duty demand helped to lift usage in North America and China modestly.

Fewer diesel car and commercial vehicle sales could reduce platinum automotive demand to just over 2 moz this year

This year automotive demand is predicted to fall by 24% to 2,170 koz, with all regions seeing lower metal requirements. The slump in car sales in Western Europe is impacting diesel as well as gasoline vehicles. Global commercial vehicle sales are also expected to be much lower than last year, cutting platinum demand in large heavy-duty truck markets such as China, the US and India, and contributing to the decline in Western Europe.

Jewellery demand

Jewellery demand in 2020 takes another leg down in China and sales suffer in other regions

In 2019, global platinum jewellery demand fell by 7% to 2,095 koz. Jewellery demand suffered a 14% contraction in China, for a fifth consecutive year of decline, which, as well as reductions of 2% in the US and 3% in Japan, more than offset moderate growth in India and small gains elsewhere.

Lockdowns, store closures and a reluctance by consumers to spend on luxury items in a more precarious economic environment will combine to limit jewellery sales this year, resulting in a 25% drop in demand to 1,565 koz. While the Chinese economy may be on a recovery trajectory, jewellery demand is expected to suffer a significant fall there this year, which, combined with the falls anticipated in all other regions, will result in a loss of more than 500 koz of jewellery demand.

Industrial demand

Industrial platinum requirements decreased marginally to 1,850 koz last year. The chemical sector saw the only gain in demand owing to increased use in a variety of chemical processes. Lower hard disk drive demand weakened electrical usage and fewer capacity expansions and a refinery closure reduced petroleum demand, while other sectors had little change in their requirements.

Industrial demand forecast to slip 7%

Industrial demand is not expected to suffer the same steep declines as automotive or jewellery demand this year. Nevertheless, the predicted broad contraction in economic growth is expected to reduce platinum consumption across all the major industrial uses and is estimated to lead to a 7% decline to 1,665 koz. Fuel cell demand is one small area that is still expected to grow this year, climbing to 60 koz.

Investment and movement of above-ground stocks

Record platinum ETF investment in 2019 but 350 koz in sales so far in 2020

Last year investors returned to platinum in a big way, particularly in the first quarter when the price was trading below $800/oz. ETF holdings rose by 995 koz, a record, and bar and coin sales were enough to take total investment to 1.2 moz. In the first quarter alone there was 770 koz of investment with 695 koz of net ETF purchases, the majority of which (418 koz) came from South African investors. Over the year as a whole UK investors increased their ETF holdings by the most (445 koz) as rand weakness led to some profit-taking in South Africa later in the year.

This year, investment has been mixed, with ETF holdings shrinking by 350 koz in the first four months of the year. The majority of the sales were from South African funds. However, in Japan investors have taken advantage of the slump in the platinum price to increase their purchases of platinum bars. Platinum coin sales have also been strong, with the US Mint increasing the mintage of platinum American Eagle bullion coins compared to recent years. The last time annual coin sales were higher was in 1999 when the price of platinum averaged less than $400/oz.

The palladium market

Demand to fall more than supply this year - palladium market close to balance

The palladium market ended 2019 with a deficit of 680 koz and the expectation was that ongoing tightening of emissions standards and growing vehicle sales would keep the market in deficit this year. Unfortunately, palladium demand is heavily reliant on the automotive industry and with measures to control COVID-19 shutting car plants and preventing consumers from buying cars, the collapse in demand is expected to be much larger than the supply interruptions, bringing the market into balance this year.

Last year, palladium production increased by 4% to 7,265 koz. Supply from South Africa rose by 60 koz to 2,565 koz owing to another year of record production at Mogalakwena and more UG2 mining. Output in Russia expanded by 200 koz (+8%) as Nornickel processed some stock, and North America also produced an extra 15 koz as the Blitz project continued to ramp up.

Palladium mine supply likely to drop 10% this year...

Palladium mine supply is the most diversified geographically of the PGMs but production is still expected to fall by 10% to 6,540 koz this year. Previously, palladium production was expected to be similar to last year. Stoppages in South Africa are estimated to cut 565 koz of palladium output, taking production to 2 moz. Declines elsewhere contribute an additional 165 koz reduction this year. Russian output is expected to dip 3% year-on-year in 2020 owing to a combination of stock being processed last year, which boosted refined production, and planned maintenance work at smelting operations this year temporarily reducing production.

Secondary palladium supply is predicted to fall by 19% to 2,110 koz this year. If scrap steel prices continue to decline this could hinder the collection of end-of-life vehicles, but a larger impact will result from the sharp contraction in gasoline vehicle sales which will lead to fewer old vehicles being scrapped in the first place. Waste electrical and electronic equipment (WEEE) and jewellery recycling are also expected to be lower than last year.

...while palladium demand could fall by 18%

Palladium demand is projected to fall by 18% this year to 8,680 koz. Automotive use is predicted to slump by 19% to 7,020 koz as light-vehicle production is significantly curtailed by the virus-induced lockdowns. While the impact is global, the greatest loss of demand is expected to be in North America, followed by Western Europe and then China where some recovery is anticipated. This year, industrial use of palladium is forecast to fall by 12% to 1,495 koz, partly owing to the impact of COVID-19 and partly to the ongoing decline in dental use. Dental demand has been on a long-term downtrend owing to a combination of cosmetic-based substitution and the high palladium price.

The rhodium market

Owing to its concentration of production in South Africa where mine stoppages have already been imposed as part of a COVID-19 lockdown, primary rhodium supply is expected to fall by 19% to 635 koz this year.

Last year, rhodium production edged up 1% to 785 koz. Rhodium output benefitted from the rise in the basket price which stimulated an expansion of UG2 mining and lifted South African supply by 1% to 635 koz. Russian output gained from processing stock that had built up in 2018.

Lower car sales, and hence fewer old vehicles being scrapped, are predicted to result in secondary rhodium supply falling by 17% to 290 koz this year. Low scrap steel prices might also inhibit end-of-life vehicle collection, but the lower PGM prices will at least reduce working capital requirements for recyclers.

Despite a COVID-19 induced reduction in car sales, the rhodium market remains in deficit in 2020

Rhodium demand, as with palladium, is dominated by the automotive industry and gasoline vehicle production. Tightening emissions standards and the focus on NO_x, in particular, lifted automotive rhodium requirements to more than 1 moz last year. However, with a collapse in light-vehicle production this year, automotive rhodium usage is forecast to drop by 17% to 835 koz.

Industrial rhodium demand is projected to fall by 18% to 140 koz in 2020 owing to the impact of weaker economic growth and thrifting in the glass industry.

The net result is that the rhodium market remains tight and is estimated to remain in deficit this year (-50 koz).

The price outlook for the next six months

Platinum $680/oz

Platinum has been the weakest PGM for years, as both jewellery and automotive demand have slowly been eroded, and this is reflected in its price. This year demand is dropping sharply and even with lower recycling and primary supply cuts, the market is still expected to have a surplus of 1.3 moz (ex. investment). Last year investors bought up the surplus, but ETFs are down 350 koz so far this year so a repeat performance is looking unlikely. If platinum is not being used for catalysts or jewellery and investment is drying up, then the platinum price could easily drop *below $600/oz* later this year.

Platinum is by far the weakest market and the price should reflect that

Palladium $1,675/oz

Palladium is more dependent than ever on the automotive sector. The impact of COVID-19 has resulted in dramatic reductions in car production forecasts for this year, cutting palladium demand and moving the market close to balance. That is not a situation that supports a $2,000/oz+ price.

A balanced market leaves palladium exposed to lower prices

China is recovering and may ultimately be the least-affected major auto market. The downside risks to auto demand look greater in Europe and, in particular, the US. With more than 30 million people losing their jobs in the US in less than two months, the fragility of consumer spending could constrain auto sales for quite some time.

Rhodium $5,250/oz

Demand for rhodium as an automotive metal is being hit by the sharp drop in auto production expected this year. Supply cuts in South Africa only partially offset this demand destruction, but this still leaves the market in deficit. The rhodium market is structurally tighter than that of palladium and, as such, the price could hold up better, particularly if the car market in China sees a strong recovery. However, as lockdowns are lifted, the availability of South African metal should become less of a problem, and while auto production is restarting it is less clear how soon consumer spending might recover. That suggests more price volatility ahead and further price downside in the near term.

Rhodium is the tightest market, but the price could weaken further as supply recovers faster than demand

The PGM Radar
Market Outlook Report – Q2'20

Stay up-to-date with the PGM market

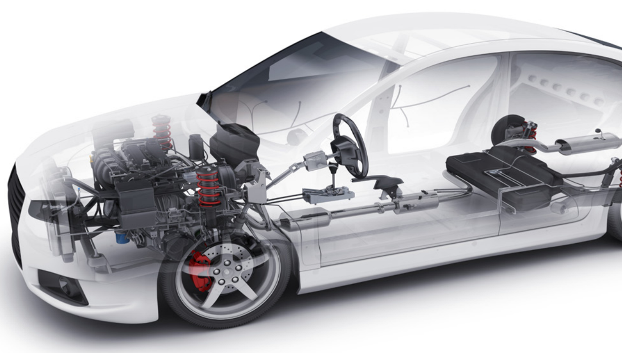
SFA (Oxford) is a world-renowned authority on platinum-group metals. Our understanding of the dynamics of the PGM industry is unrivalled and we have fostered relationships with the most significant PGM players across the globe, from mine sites to end-users.

Our unique quarterly PGM Market Outlook report will provide you with SFA's hands-on, forward-looking commentary and analysis on the events and trends currently impacting PGM supply, demand and pricing, and their market implications.

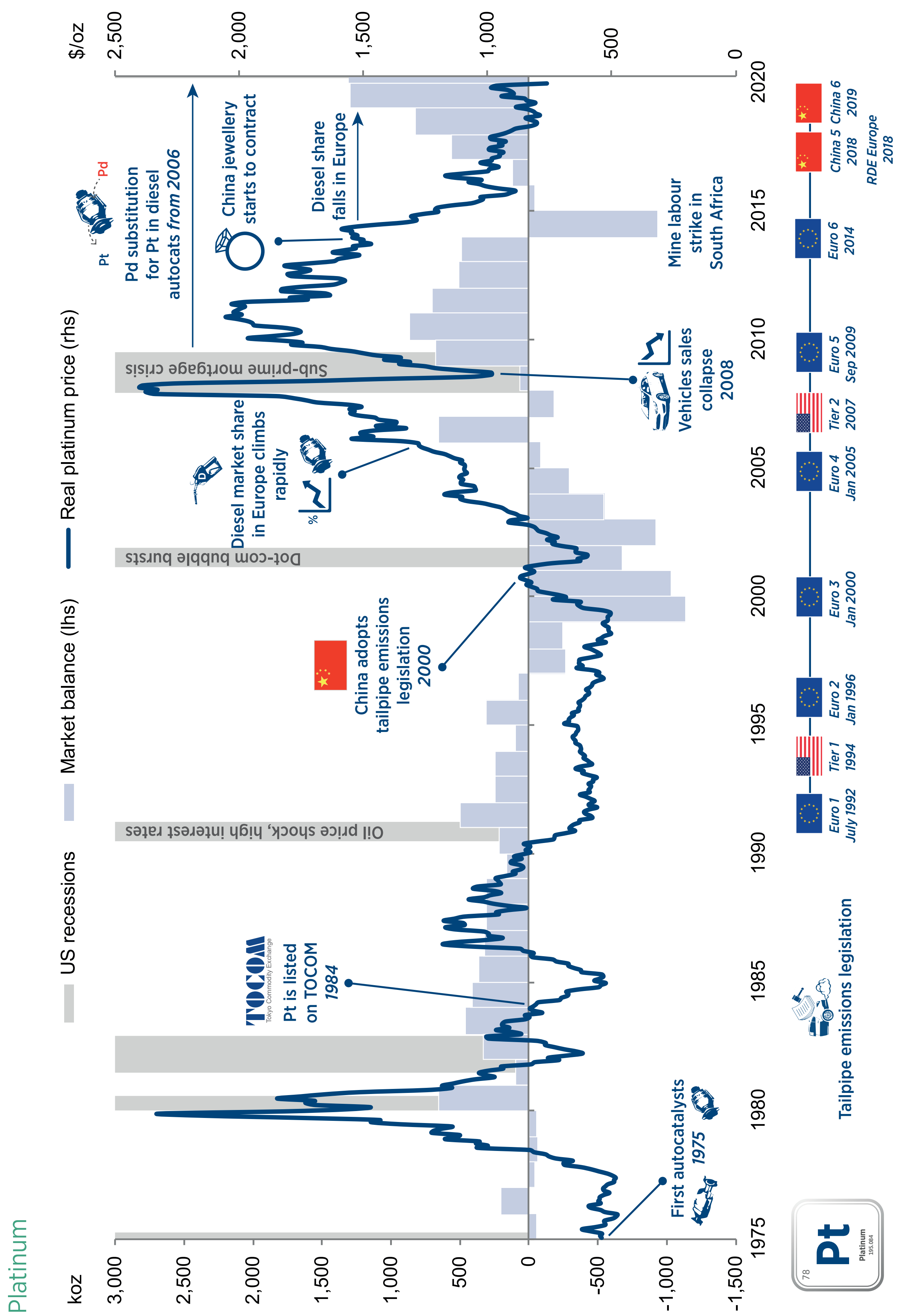
Specific content for each report varies according to market events and demand developments, but is tailored to incorporate the client's specific interests in the PGM industry.

Key report features:

- **Macroeconomic outlook and impact on supply and demand fundamentals and technology.**
- Updates on the **present and future stability and growth of primary PGM supply and demand.**
- Tracking and reporting **relevant processes and technology developments** in the market.
- **Legislative changes in all major regions affecting emissions and environmental issues.**
- Technology shifts and **automotive powertrain developments and their impact on PGM demand.**
- Future evolution and development of **industrial technologies**, both emerging and in decline.
- **Recycling forecast** supported by an extensive database of historical autocatalyst use.
- The social, demographic and marketing aspects of the **platinum jewellery business.**
- Commentary on the **political and socio-economic risks impacting primary supply.**
- Short- and medium-term **metal pricing outlook.**

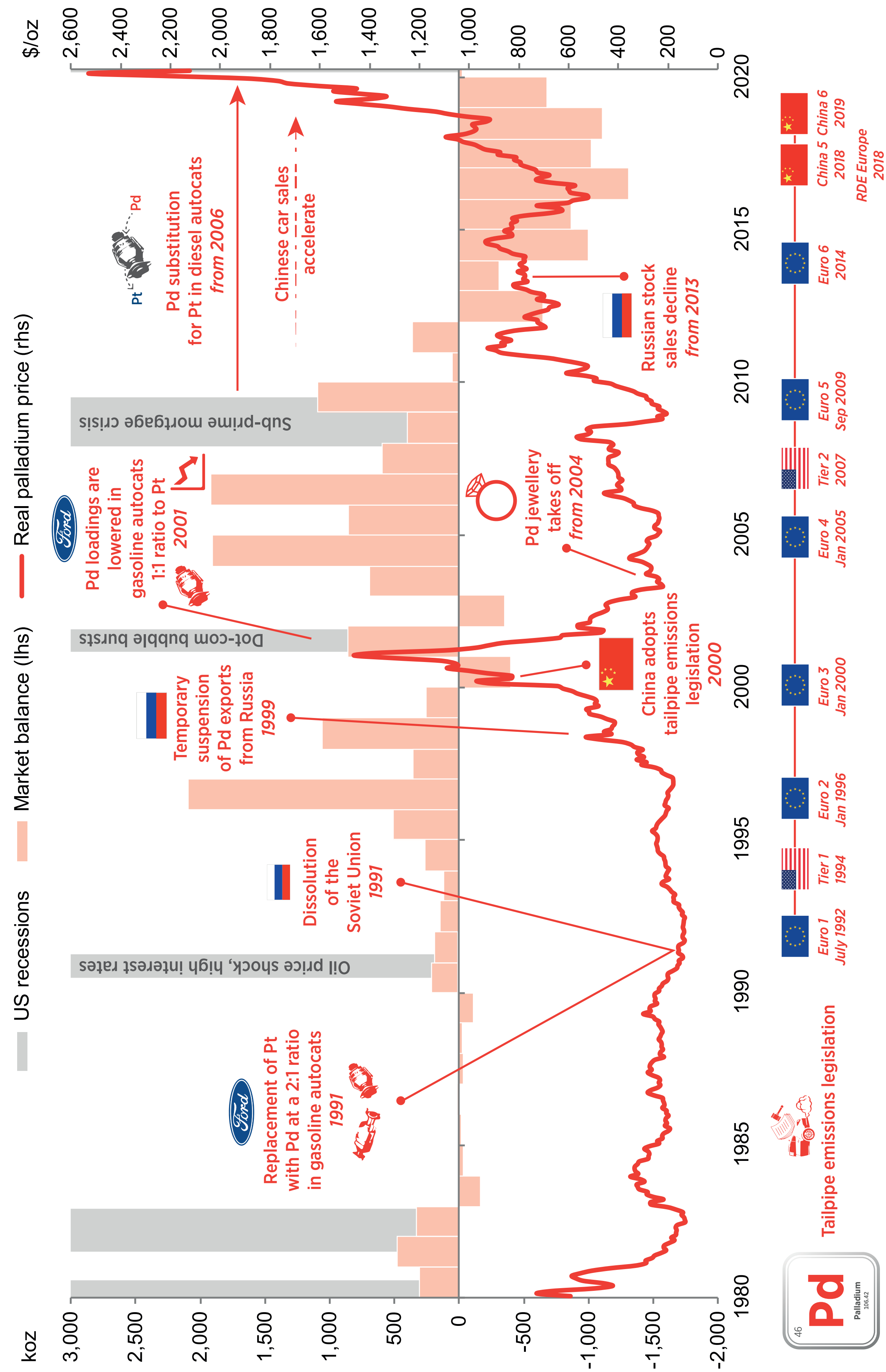


PGM PRICE HISTORY

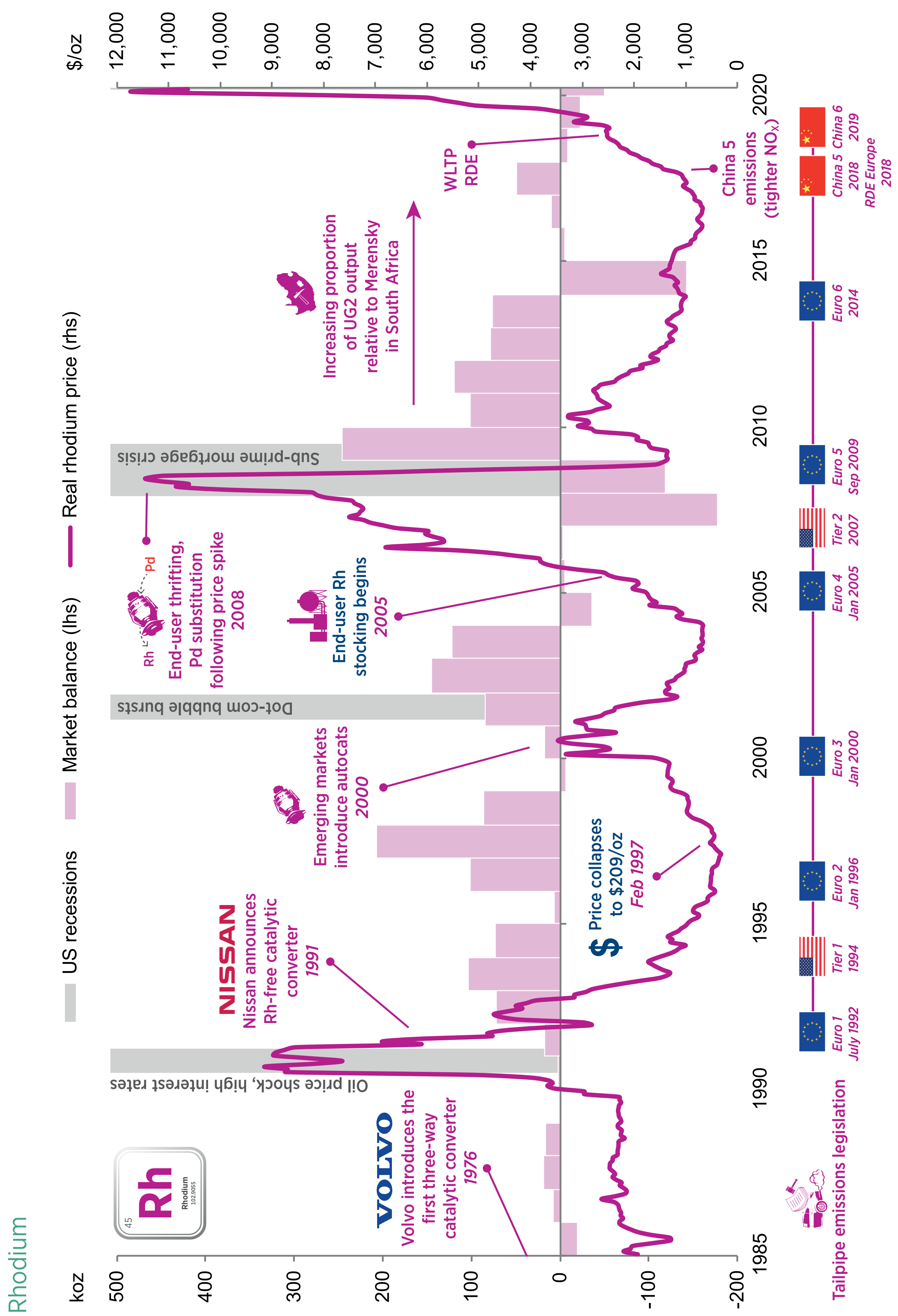


Source: SFA (Oxford), Bloomberg

Palladium

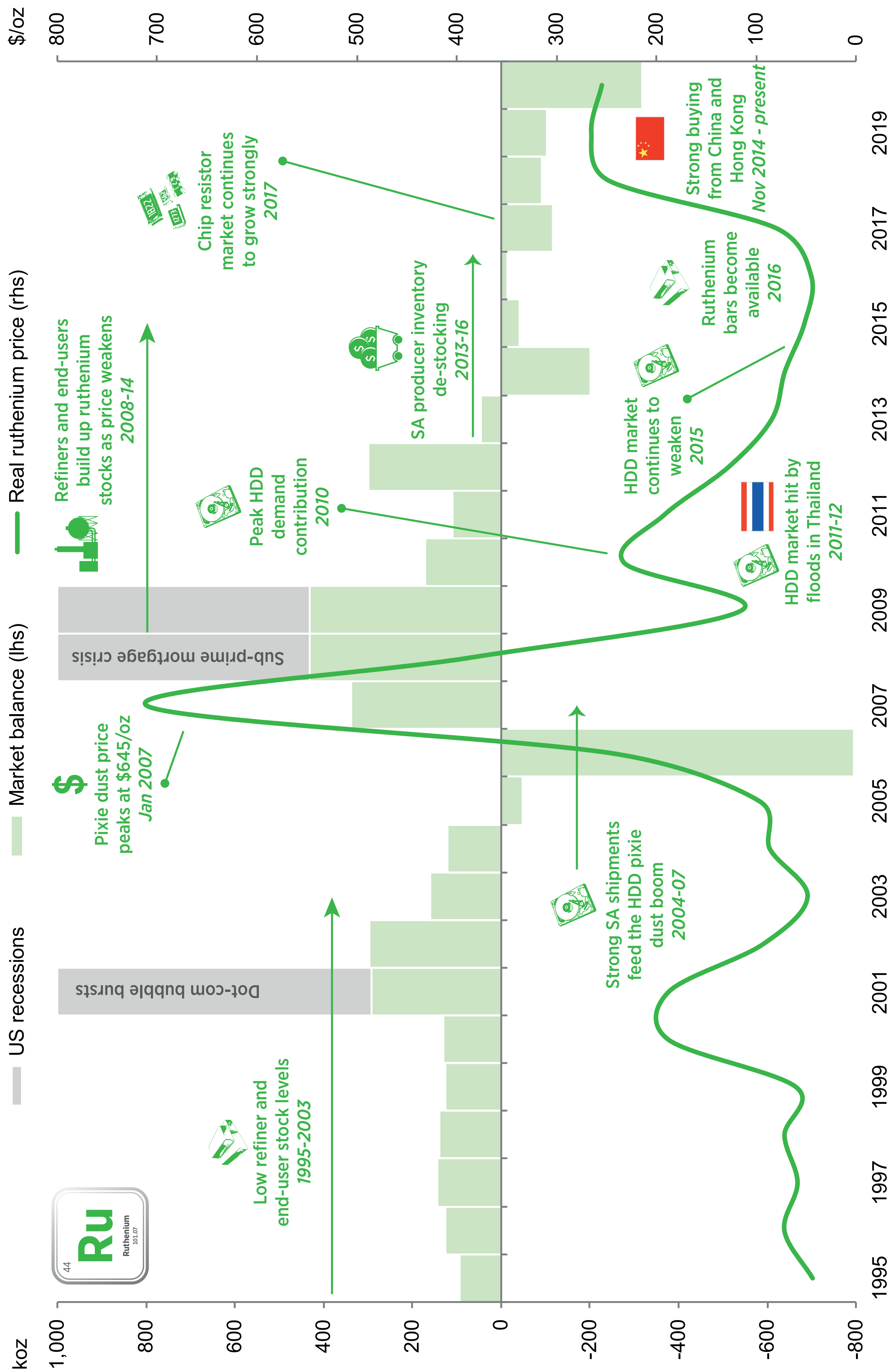


Source: SFA (Oxford), Bloomberg



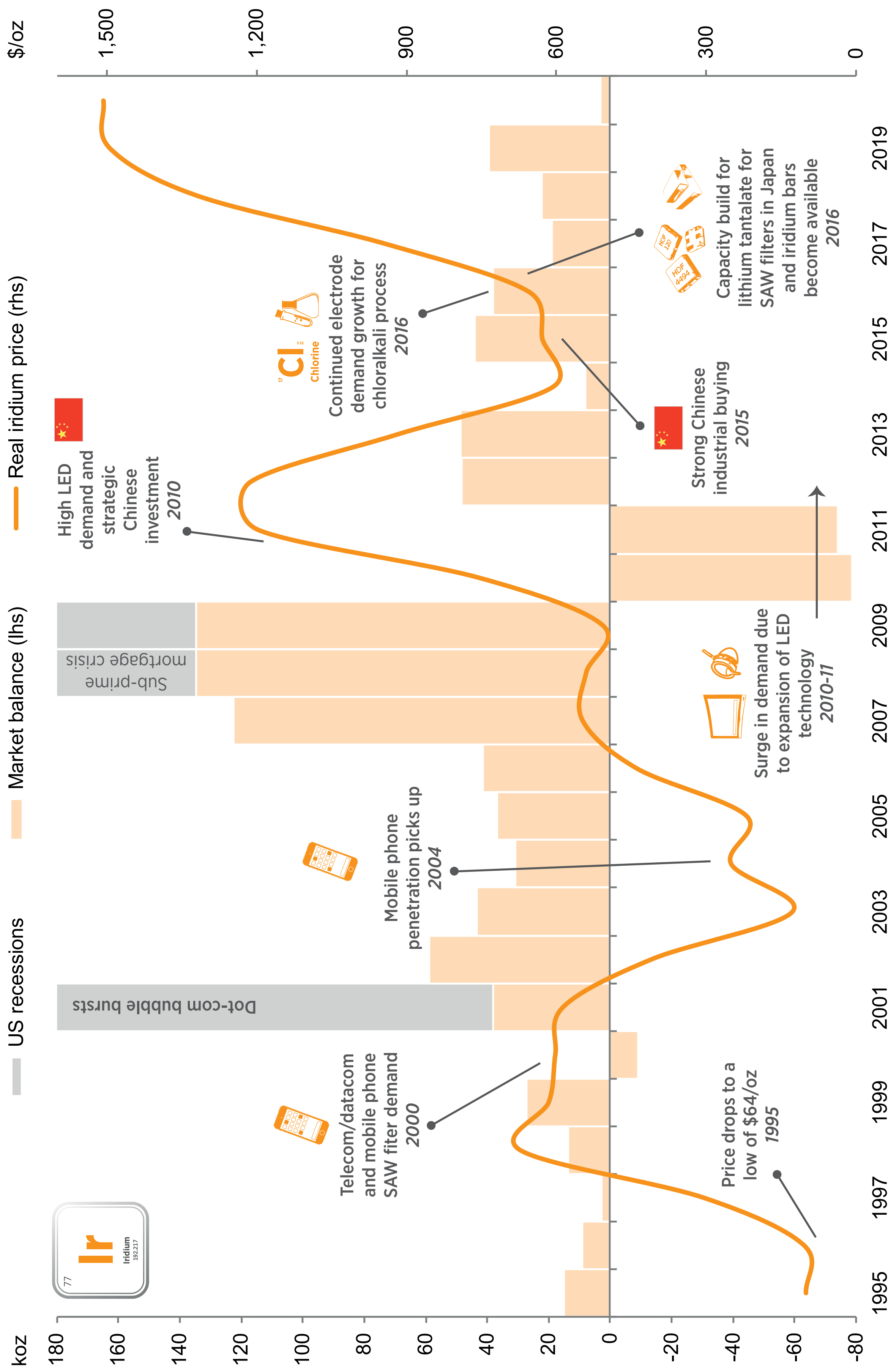
Source: SFA (Oxford), Bloomberg

Ruthenium



Source: SFA (Oxford), Bloomberg

Iridium



Source: SFA (Oxford), Bloomberg

Ruthenium & Iridium
Quarterly Core Analysis Package – Q2'20

Stay up-to-date with the market

SFA (Oxford) is the only company in the world that has derived ruthenium and iridium mine production and developed detailed demand modelling of all major end-uses to provide an authoritative view of the current and future ruthenium and iridium markets.

The Ruthenium and Iridium Quarterly Core Analysis Package looks at the current market and with analysis, charts and commentary provides a watching brief on the evolution of the market.

It utilises SFA's extensive knowledge and expertise in the ruthenium and iridium markets and provides an independent review. It gives an overview of the changing technological developments and highlights the underlying evolution of demand and end-use applications.

It offers insights, commercial knowledge, and estimates of stocks, including the working inventories and risk positions existing with producers and traders.

The Quarterly Core Analysis Package is a hands-on examination of events and trends currently impacting the ruthenium and iridium markets.

Key report features:

- **Market summary**
- **Price outlook and drivers to 2024**
- **Demand trends and stock estimates**
- **The only S-D market balance available**
- **Trade flow analysis**
- **Supply challenges and mine economics**

The **latest quarterly report** includes commentary and analysis on:

- **Sustainable drivers for demand recovery** post-COVID-19.
- Importance of Ru and Ir in **environmentally-tuned technologies.**
- Impact of near-term slowdown in **consumer electronics** and **automotive markets.**
- **COVID-19 impacts** on global Ru and Ir supplyin 2020.
- **Supply trends** and how they may be influenced by **short-term** and **longer-term changes to South African mining operations.**

SFA Oxford

To order your copy of The Ruthenium and Iridium Quarterly Core Analysis Package please contact us via email at **info@sfa-oxford.com**

APPENDIX

Platinum supply-demand balance

koz	2012	2013	2014	2015	2016	2017	2018	2019	2020f
Primary supply									
Regional									
South Africa	4,210	4,345	3,125	4,475	4,250	4,380	4,470	4,430	3,500
Russia	780	740	740	710	715	720	665	710	690
Zimbabwe	365	405	405	405	490	480	465	460	445
North America	345	355	395	365	390	360	345	360	340
Other	180	215	200	200	185	185	180	185	165
Total	**5,880**	**6,060**	**4,865**	**6,155**	**6,030**	**6,125**	**6,125**	**6,145**	**5,140**
Demand & recycling									
Autocatalyst									
Gross demand	3,100	3,120	3,250	3,370	3,445	3,320	3,095	2,870	2,170
Recycling	1,175	1,120	1,250	1,180	1,220	1,325	1,420	1,495	1,220
Net demand	1,925	2,000	2,000	2,190	2,225	1,995	1,675	1,375	950
Jewellery									
Gross demand	2,750	2,945	3,000	2,840	2,505	2,460	2,245	2,095	1,565
Recycling	840	855	775	510	625	560	500	500	390
Net demand	1,910	2,090	2,225	2,330	1,880	1,900	1,745	1,595	1,175
Industrial demand	**1,540**	**1,485**	**1,550**	**1,675**	**1,745**	**1,630**	**1,835**	**1,850**	**1,665**
Fuel cells	**5**	**5**	**25**	**25**	**45**	**50**	**70**	**50**	**60**
Other recycling	**5**	**5**	**5**	**5**	**5**	**10**	**10**	**10**	**10**
Gross demand	**7,395**	**7,555**	**7,825**	**7,910**	**7,740**	**7,460**	**7,245**	**6,865**	**5,460**
Recycling	**2,020**	**1,980**	**2,030**	**1,695**	**1,850**	**1,895**	**1,930**	**2,005**	**1,620**
Net demand	**5,375**	**5,575**	**5,795**	**6,215**	**5,890**	**5,565**	**5,315**	**4,860**	**3,840**
Market balance									
Balance (before ETFs)	505	485	-930	-60	140	560	810	1,285	1,300
ETFs (stock allocation)	195	905	215	-240	-10	105	-245	995	
Balance after ETFs	**310**	**-420**	**-1,145**	**180**	**150**	**455**	**1,055**	**290**	

Source: SFA (Oxford)

Platinum demand and recycling summary

koz	2012	2013	2014	2015	2016	2017	2018	2019	2020f
Gross demand									
Autocatalyst									
North America	425	420	465	505	460	425	430	435	290
Western Europe	1,315	1,350	1,400	1,550	1,705	1,555	1,295	1,125	850
Japan	600	580	590	510	450	440	430	410	320
China	115	130	125	125	160	190	180	205	185
India	200	165	170	175	170	175	195	145	115
RoW	445	475	500	505	500	535	565	550	410
Total	**3,100**	**3,120**	**3,250**	**3,370**	**3,445**	**3,320**	**3,095**	**2,870**	**2,170**

Platinum demand and recycling summary (continued)

koz	2012	2013	2014	2015	2016	2017	2018	2019	2020f
Gross demand									
Jewellery									
North America	185	200	230	250	265	280	280	275	225
Western Europe	175	220	220	235	240	250	255	260	200
Japan	325	335	335	340	335	340	345	330	260
China	1,915	1,990	1,975	1,765	1,450	1,340	1,095	945	675
India	95	140	175	180	145	175	195	210	145
RoW	55	60	65	70	70	75	75	75	60
Total	**2,750**	**2,945**	**3,000**	**2,840**	**2,505**	**2,460**	**2,245**	**2,095**	**1,565**
Industrial									
North America	320	320	315	245	380	330	335	285	310
Western Europe	260	190	240	290	265	265	305	295	250
Japan	90	90	25	85	70	30	90	95	75
China	370	515	445	525	575	535	480	530	515
RoW	500	370	525	530	455	470	625	645	515
Total	**1,540**	**1,485**	**1,550**	**1,675**	**1,745**	**1,630**	**1,835**	**1,850**	**1,665**
Fuel cells									
North America	0	5	10	5	15	15	15	10	10
Western Europe	5	0	0	0	5	0	0	0	0
Japan	0	0	5	15	20	30	30	15	25
China	0	0	0	0	0	0	5	5	10
RoW	0	0	10	5	5	5	20	20	15
Total	**5**	**5**	**25**	**25**	**45**	**50**	**70**	**50**	**60**
Total gross demand									
North America	930	945	1,020	1,005	1,120	1,050	1,060	1,005	835
Western Europe	1,755	1,760	1,860	2,075	2,215	2,070	1,855	1,680	1,300
Japan	1,015	1,005	955	950	875	840	895	850	680
China	2,400	2,635	2,545	2,415	2,185	2,065	1,760	1,685	1,385
RoW	1,295	1,210	1,445	1,465	1,345	1,435	1,675	1,645	1,260
Total	**7,395**	**7,555**	**7,825**	**7,910**	**7,740**	**7,460**	**7,245**	**6,865**	**5,460**
Recycling									
Autocatalyst									
North America	575	560	560	505	535	585	640	645	495
Western Europe	405	365	465	370	400	440	465	505	425
Japan	115	95	105	95	95	100	110	115	95
China	10	20	30	55	40	40	35	40	20
RoW	70	80	90	155	150	160	170	190	185
Total	**1,175**	**1,120**	**1,250**	**1,180**	**1,220**	**1,325**	**1,420**	**1,495**	**1,220**
Jewellery									
North America	0	0	0	5	5	5	5	5	5
Western Europe	0	0	5	5	5	5	5	5	5
Japan	285	250	235	160	150	160	145	140	110
China	555	600	530	335	460	385	340	340	260
RoW	0	5	5	5	5	5	5	10	10
Total	**840**	**855**	**775**	**510**	**625**	**560**	**500**	**500**	**390**
WEEE	**5**	**5**	**5**	**5**	**5**	**10**	**10**	**10**	**10**
Total recycling									
North America	575	560	560	510	540	590	645	650	500
Western Europe	405	365	470	375	405	445	470	510	430
Japan	400	345	340	255	245	260	255	255	205
China	565	620	560	390	500	430	380	385	285
RoW	75	90	100	165	160	170	180	205	200
Total	**2,020**	**1,980**	**2,030**	**1,695**	**1,850**	**1,895**	**1,930**	**2,005**	**1,620**

Source: SFA (Oxford)

78 **Pt** 195.08 **Platinum**

Palladium supply-demand balance

koz	2012	2013	2014	2015	2016	2017	2018	2019	2020f
Primary supply									
Regional									
South Africa	2,355	2,360	1,870	2,560	2,370	2,530	2,505	2,565	2,000
Russia	2,630	2,580	2,690	2,605	2,555	2,740	2,670	2,870	2,775
Zimbabwe	280	315	330	325	395	395	380	385	355
North America	895	975	1,055	995	1,065	985	1,035	1,050	1,045
Other	445	450	460	455	420	415	395	395	365
Total	**6,605**	**6,680**	**6,405**	**6,940**	**6,805**	**7,065**	**6,985**	**7,265**	**6,540**
Demand & recycling									
Autocatalyst									
Gross demand	6,650	7,085	7,460	7,730	8,080	8,325	8,530	8,635	7,020
Recycling	1,485	1,645	1,720	1,610	1,710	1,920	2,040	2,170	1,720
Net demand	5,165	5,440	5,740	6,120	6,370	6,405	6,490	6,465	5,300
Jewellery									
Gross demand	545	350	295	240	240	225	220	215	165
Recycling	130	145	120	80	80	70	60	55	45
Net demand	415	205	175	160	160	155	160	160	120
Industrial demand	**2,325**	**1,990**	**1,915**	**1,945**	**1,905**	**1,830**	**1,775**	**1,695**	**1,495**
Other recycling	**375**	**410**	**430**	**435**	**385**	**380**	**375**	**375**	**345**
Gross demand	**9,520**	**9,425**	**9,670**	**9,915**	**10,225**	**10,380**	**10,525**	**10,545**	**8,680**
Recycling	**1,990**	**2,200**	**2,270**	**2,125**	**2,175**	**2,370**	**2,475**	**2,600**	**2,110**
Net demand	**7,530**	**7,225**	**7,400**	**7,790**	**8,050**	**8,010**	**8,050**	**7,945**	**6,570**
Market balance									
Balance (before ETFs)	-925	-545	-995	-850	-1,245	-945	-1,065	-680	-30
ETFs (stock allocation)	285	-5	940	-665	-645	-375	-560	-90	
Balance after ETFs	**-1,210**	**-540**	**-1,935**	**-185**	**-600**	**-570**	**-505**	**-590**	

Source: SFA (Oxford)

46 Pd 106.42 Palladium

Palladium demand and recycling summary

koz	2012	2013	2014	2015	2016	2017	2018	2019	2020f
Gross demand									
Autocatalyst									
North America	1,745	1,815	1,925	2,040	2,110	2,005	2,010	1,950	1,460
Western Europe	1,440	1,540	1,655	1,725	1,635	1,690	1,740	1,680	1,320
Japan	735	745	745	745	775	805	840	875	720
China	1,300	1,520	1,700	1,745	2,015	2,095	2,085	2,285	2,060
India	155	170	170	185	220	245	265	250	225
RoW	1,275	1,295	1,265	1,290	1,325	1,485	1,590	1,595	1,235
Total	**6,650**	**7,085**	**7,460**	**7,730**	**8,080**	**8,325**	**8,530**	**8,635**	**7,020**
Jewellery									
North America	45	40	35	35	35	35	35	35	30
Western Europe	80	75	60	55	55	55	55	55	40
Japan	95	65	55	50	50	50	50	50	40
China	295	145	120	75	75	60	55	50	35
RoW	30	25	25	25	25	25	25	25	20
Total	**545**	**350**	**295**	**240**	**240**	**225**	**220**	**215**	**165**
Industrial									
North America	480	410	385	400	385	365	335	310	270
Western Europe	335	290	285	290	280	270	255	240	210
Japan	565	415	425	430	405	370	345	310	265
China	405	420	385	395	405	405	415	420	395
RoW	540	455	435	430	430	420	425	415	355
Total	**2,325**	**1,990**	**1,915**	**1,945**	**1,905**	**1,830**	**1,775**	**1,695**	**1,495**
Total gross demand									
North America	2,270	2,265	2,345	2,475	2,530	2,405	2,380	2,295	1,760
Western Europe	1,855	1,905	2,000	2,070	1,970	2,015	2,050	1,975	1,570
Japan	1,395	1,225	1,225	1,225	1,230	1,225	1,235	1,235	1,025
China	2,000	2,085	2,205	2,215	2,495	2,560	2,555	2,755	2,490
RoW	2,000	1,945	1,895	1,930	2,000	2,175	2,305	2,285	1,835
Total	**9,520**	**9,425**	**9,670**	**9,915**	**10,225**	**10,380**	**10,525**	**10,545**	**8,680**
Recycling									
Autocatalyst									
North America	930	1,005	975	895	960	1,060	1,135	1,190	950
Western Europe	325	345	365	270	260	305	330	325	280
Japan	125	125	135	125	125	145	180	200	170
China	20	50	60	115	160	165	155	165	80
RoW	85	120	185	205	205	245	240	290	240
Total	**1,485**	**1,645**	**1,720**	**1,610**	**1,710**	**1,920**	**2,040**	**2,170**	**1,720**
Jewellery									
Japan	20	20	20	20	20	20	15	15	15
China	110	125	100	60	60	50	45	40	30
Total	**130**	**145**	**120**	**80**	**80**	**70**	**60**	**55**	**45**
WEEE									
North America	75	75	70	85	70	65	65	65	55
Western Europe	85	90	95	80	70	75	70	70	60
Japan	120	135	145	165	135	120	115	110	100
China	30	40	30	25	35	40	40	45	50
RoW	65	70	90	80	75	80	85	85	80
Total	**375**	**410**	**430**	**435**	**385**	**380**	**375**	**375**	**345**
Total recycling									
North America	1,005	1,080	1,045	980	1,030	1,125	1,200	1,255	1,005
Western Europe	410	435	460	350	330	380	400	395	340
Japan	265	280	300	310	280	285	310	325	285
China	160	215	190	200	255	255	240	250	160
RoW	150	190	275	285	280	325	325	375	320
Total	**1,990**	**2,200**	**2,270**	**2,125**	**2,175**	**2,370**	**2,475**	**2,600**	**2,110**

Source: SFA (Oxford)

Rhodium supply-demand balance

koz	2012	2013	2014	2015	2016	2017	2018	2019	2020f
Primary supply									
Regional									
South Africa	600	590	430	620	615	635	630	635	485
Russia	75	70	75	70	70	75	75	80	80
Zimbabwe	30	35	35	35	45	45	40	40	40
North America	30	35	30	30	25	25	20	20	20
Other	10	10	10	10	10	10	10	10	10
Total	**745**	**740**	**580**	**765**	**765**	**790**	**775**	**785**	**635**
Demand & recycling									
Autocatalyst									
Gross demand	770	780	840	875	855	880	920	1,005	835
Recycling	235	260	275	260	280	295	335	350	290
Net demand	535	520	565	615	575	585	585	655	545
Industrial demand	**150**	**145**	**160**	**150**	**185**	**165**	**205**	**170**	**140**
Other recycling	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
Gross demand	**920**	**925**	**1,000**	**1,025**	**1,040**	**1,045**	**1,125**	**1,175**	**975**
Recycling	**235**	**260**	**275**	**260**	**280**	**295**	**335**	**350**	**290**
Net demand	**685**	**665**	**725**	**765**	**760**	**750**	**790**	**825**	**685**
Market balance									
Balance (before ETFs)	60	75	-145	0	5	40	-15	-40	-50
ETFs (stock allocation)	35	50	5	-5	5	-20	-50	-15	
Balance after ETFs	**25**	**25**	**-150**	**5**	**0**	**60**	**35**	**-25**	

Source: SFA (Oxford)

Rhodium demand and recycling summary

koz	2012	2013	2014	2015	2016	2017	2018	2019	2020f
Gross demand									
Autocatalyst									
North America	200	220	240	265	260	245	240	230	170
Western Europe	195	195	220	240	205	210	230	290	235
Japan	150	140	140	125	125	125	130	130	105
China	90	95	110	110	130	150	155	185	195
India	20	15	15	15	20	20	20	20	15
RoW	115	115	115	120	115	130	145	150	115
Total	**770**	**780**	**840**	**875**	**855**	**880**	**920**	**1,005**	**835**
Industrial									
North America	15	15	15	10	20	15	15	15	15
Western Europe	20	10	15	10	15	15	25	20	15
Japan	45	35	25	30	30	30	30	35	30
China	30	45	50	50	60	50	55	45	40
RoW	40	40	55	50	60	55	80	55	40
Total	**150**	**145**	**160**	**150**	**185**	**165**	**205**	**170**	**140**
Total gross demand									
North America	215	235	255	275	280	260	255	245	185
Western Europe	215	205	235	250	220	225	255	310	250
Japan	195	175	165	155	155	155	160	165	135
China	120	140	160	160	190	200	210	230	235
RoW	175	170	185	185	195	205	245	225	170
Total	**920**	**925**	**1,000**	**1,025**	**1,040**	**1,045**	**1,125**	**1,175**	**975**
Recycling									
Autocatalyst									
North America	145	165	160	150	160	165	180	190	150
Western Europe	60	55	60	45	50	55	60	60	50
Japan	25	25	30	30	35	35	45	45	35
China	0	5	5	10	5	5	5	5	5
RoW	5	10	20	25	30	35	45	50	50
Total	**235**	**260**	**275**	**260**	**280**	**295**	**335**	**350**	**290**

Source: SFA (Oxford)

GLOSSARY OF TERMS

AEL
Alkaline water electrolysis.

Basket price
Collective revenue of metals divided by 4E oz.

BEV
Battery electric vehicle.

BRPM
Bafokeng Rasimone Platinum Mine.

CAGR
Compound annual growth rate.

CAPEX
Capital expenditure.

CCM
Catalyst coated membrane.

CCUS
Carbon capture, utilisation and storage.

Economy of scale
The cost advantage obtained due to the scaling up of an operation.

ETF
Exchange-traded fund.

FCEV
Fuel cell electric vehicle.

GDP
Gross domestic product.

Gross demand
A measure of intensity of use.

GW
Gigawatt.

HDD
Hard disk drive.

ICE
Internal combustion engine.

koz
A thousand troy ounces.

kW_{el}
Kilowatt electrical.

LED
Light-emitting diode.

Merensky Reef
A PGM-bearing horizon within the Bushveld Igneous Complex, South Africa. Also contains nickel and copper sulphides that are mined as by-products.

moz
A million troy ounces.

MW
Megawatt.

Net demand
A measure of the theoretical requirement for new metal, i.e. net of recycling.

Net supply
Proxy supply of metal surplus to requirements.

NO_x
Nitrous oxides.

oz
Troy ounce.

P2X
Power-to-X.

PEM EL
Polymer electrolyte membrane electrolysis.

PGM
Platinum-group metals.

Primary supply
Mine production.

PMI
Purchasing Managers' Index.

R&D
Research and development.

RBP
Royal Bafokeng Platinum.

REN
Renewable energy.

Secondary supply
Recycling output.

SOEC
Solid oxide electrolysis cell.

Thrifting
Using less metal in order to reduce costs.

TOCOM
Tokyo Commodity Exchange.

UG2 Reef
A PGM-bearing horizon within the Bushveld Igneous Complex, located stratigraphically below the Merensky Reef. One of the main chromite-bearing reefs of the Bushveld Igneous Complex. Typically comprises lower base metals contents than the Merensky Reef.

WEEE
Waste electrical and electronic equipment.

WTI
West Texas Intermediate.

4E
Platinum, palladium, rhodium and gold.

Currency symbols

ZAR	South African rand.
$	US dollar.

METHODOLOGY

Primary supply is calculated from actual mine production and excludes the sale of stock in order to provide pure production data. Stock sales are treated separately in SFA's database as movement of stocks. Therefore, state stock sales from Russia are excluded in tabulations.

Gross demand is a measure of intensity of use.

Net demand is a measure of the theoretical requirement for new metal, i.e. net of recycling.

Automotive demand is based on vehicle production data not sales.

ACKNOWLEDGEMENTS

SFA (Oxford) would like to thank all those whose hard work contributed to turning what began as an ambitious idea into the finished report you now see in front of you.

In particular, we would like to acknowledge our team:

Aisling Hubert	Alex Biddle
Beresford Clarke	Carol Lu
David Mobbs	Francesca Price
Jamie Underwood	Jenny Watts
Jo Holmes	Jordan Roberts
Karen Darley	Lakshya Gupta
Oksan Atilan	Ralph Grimble
Stephen Forrest	Thomas Chandler

We should also mention a team of Associate Consultants, without whom this publication would not have been possible.

A special mention should also be given to Jeremy Coombes and Andy Smith whose combined knowledge of and expertise in compiling such an ambitious PGM industry review helped to fashion a report of which we could all be thoroughly proud.

We thank Janice Hurst and Karen Darley for proofreading *The Platinum Standard* throughout its production.

Then there are our third-party data suppliers: LMC Automotive, Oxford Economics, Power Systems Research, Bloomberg, and GTIS whose data form the basis of many of the charts in this report.

Finally, to our clients and all those who have supported us throughout our time in business, we would like to dedicate this report as a mark of our gratitude for your continuing support.

NOTES

Please note: Some tabulated data may not add up owing to rounding of individual numbers. © Published in May 2020 by SFA (Oxford) Ltd.

ABOUT HERAEUS

Heraeus Trading Desks

Europe, Middle East,
Africa & other regions
Phone: +49 (0) 6181 35-2750
edelmetallhandel@heraeus.com

South East Asia
Phone: +852 2773 1733
tradinghk@heraeus.com

United States of America
Phone: + 212 752 2180
tradingny@heraeus.com

China
Phone: +86 21 3357 5658
tradingsh@heraeus.com

www.herae.us/trading-market-report

The **PLATINUM STANDARD 2020**
produced in collaboration with:

SFA (Oxford) Ltd
United Kingdom
Phone: +44 1865 784366
www.sfa-oxford.com
info@sfa-oxford.com

SFA Oxford
consulting analysts in tomorrow's commodities and technologies

The Oxford Science Park, Oxford, United Kingdom, OX4 4GA