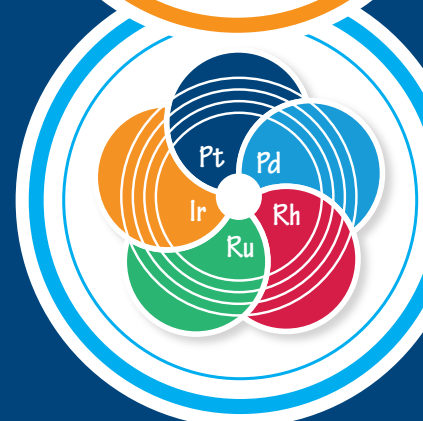


THE PLATINUM STANDARD

May 2021





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May 2021

Issue 14

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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 – RADICAL CHANGE AHEAD



Foreword – Radical change ahead

Despite all the disruption to PGM demand and supply caused by Covid-19 in the last twelve months, in the world after the pandemic – however far off that might seem – lie opportunities for a reset that can benefit PGMs. It seems increasingly likely that after Covid we will be in a different place, in which new priorities for the environment and personal living will have emerged. These may be driven by regulation or by public demand, or both, but they will affect the ways we produce and use PGMs.

During the last twelve months, it feels as if the tipping point towards electrification of transport may have been reached. Increasing numbers of OEMs declare their commitment to converting their entire vehicle output to battery power and discontinuing further development of internal combustion engines (ICEs). It's a response to legislation to ban sales of new ICEs sometime next decade, public pressure for cleaner air in our polluted cities – where most voters live – and the onset of a race not to be left behind the new technology trends. But it also reflects a change in the zeitgeist (and we cannot help but think that record palladium and rhodium prices have only strengthened the OEMs' readiness to abandon internal combustion as the prime means of getting around).

The more necessary – or obligatory – this transition appears to be, the more inventive the auto companies and their suppliers will become in finding solutions to the obstacles to electrification. Nevertheless, there are plenty of high hurdles, which suggests the switch away from ICEs might not be as fast as regulations are beginning to demand. Let's see: charging infrastructure, battery safety, vehicle cost, adequate mine supply and responsible sourcing of battery metals, range anxiety, charging times – the list goes on. These are not insignificant challenges, so it's not going to be all over for the catalytic converter for some time yet. Eventually, however, it will be, and this requires an intensification of market development effort by the PGM industry to maintain demand for its products. Stepping up to the plate will be the imperative of the PC (post-Covid or politically correct – some would say it is becoming much the same thing) world.

Opportunities for PGMs in the new paradigm

As Mark Freed explains in '**Anglo American: Shaping the future of PGMs – hydrogen and beyond...**', the PGM industry needs to invest in rational, effective market development to ensure that PGMs remain part of the future clean and low-carbon/carbon-free

transport solution. The hydrogen economy offers the most obvious opportunities, through fuel cells and hydrogen electrolyzers, to grow demand for PGMs substantially; but Mark goes on to identify other, perhaps surprising, potential demand opportunities for PGMs which can meet the needs of the new paradigm. A detailed template for engineering market growth – describing Anglo’s global approach to collaborative development and shaping the conditions in which new technologies can prosper – is included.

How will today’s other applications for PGMs fare in the post-Covid world? For platinum, jewellery is an important component of demand which has stagnated in recent years. In **‘Covid, the trend catalyst’**, Tim Schlick of Platinum Guild International attempts an early look over the horizon with a review of how consumer attitudes have been affected by the pandemic and what this implies for market promotion going forward. PGI describes how pre-existing trends in the jewellery trade, such as industry consolidation, an increasing emphasis by consumers on sustainability and meaning in the products they buy, and the growth of the digital economy have been accelerated or altered by Covid-19 – and which of these changes can be positive for platinum jewellery demand.

A shift in the PGM mining pattern

It’s an ill wind that blows nobody any good: despite the pandemic, PGM producers are making hay, largely due to record prices for palladium and rhodium. In **‘Transformation of the PGM revenue basket’**, SFA (Oxford)’s Francesca Price and Alex Biddle examine how the current high PGM basket price is steering production of PGMs in South Africa. With revenue now skewed relative to the physical ratios of metals in the basket – owing to the inflated rhodium price – the UG2 orebody provides a more balanced revenue compared to the Merensky and Platreef orebodies, encouraging the extension of mine life in high-cost shafts and the restarting of shuttered UG2 operations. Happily, the returns from mining UG2 are further enhanced by its higher iridium and ruthenium content; increased output from UG2 will help to secure the future supply of these two metals, which are vital to the hydrogen economy through their co-use with platinum in electrolyzers and fuel cells.

COVID, THE TREND CATALYST



Covid, the trend catalyst

How a global pandemic is accelerating, altering and creating consumer trends in jewellery

Tim Schlick, Chief Operating Officer, Platinum Guild International

Like most other industries, jewellery was impacted by the Covid pandemic as business came to a standstill, often for extended periods of time. At the time of writing, it is too early to foresee the full impact of the pandemic on consumers in general and jewellery in particular.

However, extensive research studies conducted by PGI over the past year indicate findings that will shape the jewellery industry well beyond the end of the pandemic: how Covid-19 has either accelerated, altered or reverted global consumer trends and fast forwarded the jewellery industry into the future.

Covid-19 has changed platinum jewellery trends

Trend	Covid-19 impact	Key insight	Impact on platinum
Retail market consolidation	Accelerated	Smaller shops with lower cash reserves are forced to leave the market, providing opportunities for larger chains to gain market share	++
Return of meaningful luxury consumption	Accelerated	'Bling' has become less of a purchasing motivator in luxury, as consumers seek meaning in what they are buying	+
Sustainability and transparency gain importance	Prioritised	Consumers spend more time than ever researching products, with sustainability increasing as a decisive factor	0
A longing for deep and meaningful relationships	Accelerated	Consumers spending more time with their partners and the dislocation caused by digital communications are fuelling the desire for love, intimacy and togetherness	++
Experience as a luxury product	Reverted	With limited travel, 'luxury experiences' have been curtailed – prompting many to re-evaluate how they spend discretionary income	TBD
Jewellery industry digitalisation	Accelerated	Slow to integrate digitalisation into operations and marketing, yet digitalisation has been integral to survival and winning	+

Source: PGI

Retail market consolidation

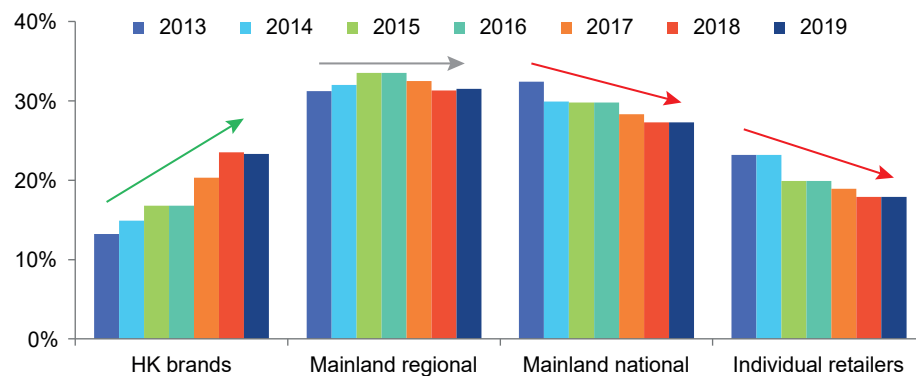
Large parts of the jewellery category have always been a cottage industry. In many markets, small, local, independent jewellers, often family-owned, represent the majority of the retail landscape. In developed markets this is often as a result of decades or even centuries of jewellers selling precious products; in emerging markets it is often an outcome of very pragmatic entrepreneurship: a shop inventory that consists largely of precious metals provides an extra safety net should a jewellery entrepreneur face bankruptcy. While expensive to launch, jewellery is a relatively forgiving business: very high margins mean that a couple of good customers a year are often enough to keep the shop open. This easy-going business model has in the past often resulted in complacency. As long as the economy was growing, there was simply no need to develop expertise and invest in areas that are essential to other businesses, e.g. marketing. In China, a market that had seen substantial economic growth for more than two decades, even a sub-par jewellery retailer was still able to grow. This period has ended – and not just in China.

Market has become less forgiving, especially for smaller independent retailers

As a result, we are seeing large, national/regional retailers, as well as strong independent chains, that have spent the past two decades and longer in building strong jewellery retail brands – through investment into marketing, differentiated and branded products and a strong distribution – take market share from smaller independents. This is particularly visible in markets such as China and India. In Q4 2020 alone, Chow Tai Fook, for example, opened 286 new POS (Points of Sale) in mainland China.

Strong retail jewellery brands that have invested in marketing, product and distribution are now taking share from these smaller independents

Market share of jewellery stores across Hong Kong and China



Net increase of POS	2019	2020
Chow Tai Fook	653	552
Luk Fook	249	197
Lao Feng Xiang	372	557

Source: SFA (Oxford), PGI

In India, the shift from unorganised to organised trade has accelerated, and organised trade is estimated to account for 45% of the total market. For platinum, this market consolidation is a particularly positive trend, as small local shops typically carry few or no platinum products, while large jewellery retailers use platinum as a key differentiator and an important element of their product portfolio strategy.

Market consolidation is supportive for platinum jewellery in India

Return of meaningful luxury consumption

There is a common misconception outside (and sometimes even within) the jewellery industry, that consumers purchase jewellery either for an occasion or in relation to wallet size. This notion that consumers make rational purchasing decisions is as prevalent as it is wrong. Especially in the past decade, a great deal of ground-breaking research has shown very clearly and consistently that consumers buy products based on emotions first and foremost. Most consumers even struggle themselves to explain why they have bought a certain product and often revert to post-rationalisation – which negates much of the consumer research based on focus groups.

Emotional pull is key to jewellery purchasing – less about occasions or disposable income

PGI has conducted the world's most comprehensive consumer segmentation study in jewellery which clusters consumers into segments or 'tribes'. These jewellery tribes differentiate groups of consumers based on their needs and attitudes towards jewellery. Through this study, PGI has identified six consumer segments that are relatively consistent throughout all markets.

Which jewellery tribe do you belong to?

Common segments/tribes	Key attitudes & needs towards jewellery	Size of segment compared to total
Status Seekers	Buy jewellery to display status and social standing	10% to 23%
Value Obtainers	Buy jewellery based on personal, current and future value	17% to 33%
Meaning & Symbolism	Buy jewellery to commemorate meaningful events or as a personally relevant symbol	8% to 19%
Convention Conformers	Buy jewellery to follow social norms within a cultural context	11% to 32%
Trendsetters	Buy jewellery to display fashion and trend consciousness	8% to 23%
Connoisseurs	Buy jewellery to appreciate ingredients and craftsmanship	9% to 23%

Source: PGI

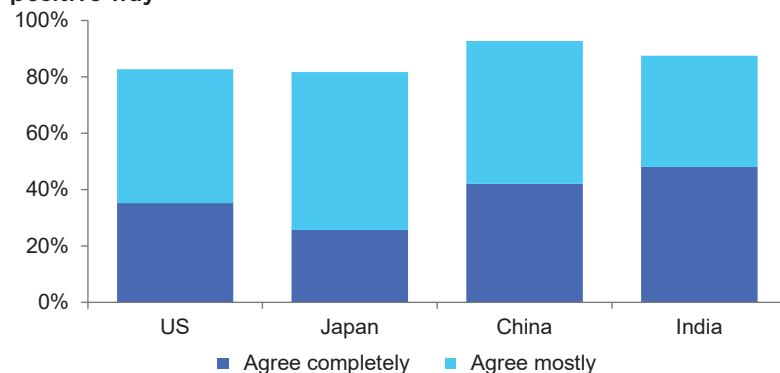
The Platinum Standard

Consumers buying for superficial reasons, such as validation from peers, i.e. to display trend consciousness, status and the consumer following their lead, make up to half of the jewellery purchases in any given market.

Since the start of Covid, many consumers have experienced the pandemic and the resulting lockdowns as a time of reckoning and re-calibration of priorities. While it is too early to call it a sustained change of hearts and minds, we can see how consumers are increasingly turning away from superficiality or 'bling' and towards more meaning.

Has 'bling' had its day?

Poll: 'Covid-19 has made me re-evaluate my life and priorities in a positive way'



Source: PGI, 'Consumer under COVID-19', May 2020. Results in % unless otherwise noted.

Whether this is a temporary or permanent reckoning, platinum benefits from more meaningful purchases as it is considered the 'metal of meaning' in all four major markets and is associated by consumers with 'love' more than any other jewellery metal.

Consumers increasingly looking for meaning in their jewellery purchases – good fit for platinum

Sustainability and transparency gain importance

Sustainable and responsible sourcing and production of products is not just a 'nice-to-have' for luxury products anymore. Largely driven by the millennial cohort, consumers are taking a close look at every product they buy and assessing its impact on the ecosphere and society as seriously as its value for money.

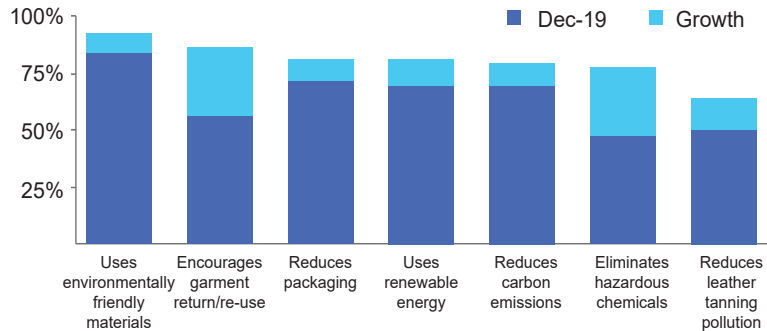
Millennials turning towards environmentally-aware and ethical purchasing

Covid has supercharged this trend. According to a 2020 global survey by management consultancy firm Accenture, consumers "have dramatically evolved", and 60% were reporting making more environmentally friendly, sustainable or ethical purchases since the start of the pandemic. Accenture added that nine out of ten of that percentage said they were likely to continue doing so.

The Platinum Standard

Another study by research group Kantar indicated that sustainability was more of a concern for consumers than before the Covid-19 outbreak. Luxury brands around the globe were quick to respond to this and have accelerated their sustainability efforts.

Growth in adoption of sustainability policies since December 2019



October 2020, n = 50 luxury brands featuring in both indexes

Source: Vogue Business

The substantial efforts of the platinum producers in South Africa to mine responsibly will help the platinum jewellery industry shape its sustainability narrative. However, it also depends on how quickly and seriously other parts of the jewellery supply chain adopt and implement sustainability practices and policies.

Increased consumer awareness of sustainability presents an opportunity for platinum producers

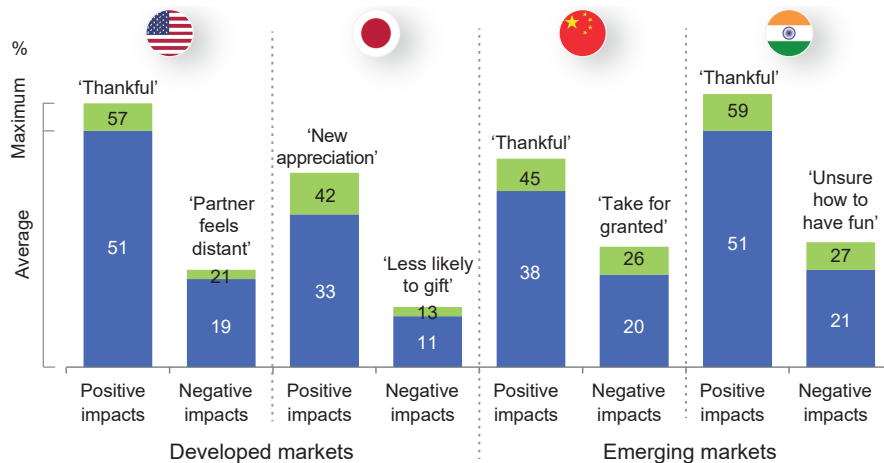
A longing for deep and meaningful relationships

At the beginning of the pandemic, the outlook was often grim. Many analysts and commentators predicted a massive surge in divorce rates once the pandemic was over. While it is, of course, true that the effect of lockdowns is, in many cases, dramatic and will leave many consumers psychologically or even physically traumatised, when looking at jewellery consumers, there are reasons for optimism.

PGL's consumer research clearly indicates that the pandemic has had a more positive than negative impact on relationships across all markets.

Our relationships post-pandemic – more good than bad

Poll: Impact of Covid-19 on relationships



Source: PGI, 'Consumer under COVID-19', May 2020. Results in % unless otherwise noted.

What is the reason for this? On the one hand, it is important to note that many jewellery buyers are part of a consumer cohort with significantly higher than average spending power, and hence entered into the pandemic with much bigger wallets and less substantial anxiety about their lives. But on the other hand, it is also an indication of a trend we see with many consumers, especially younger ones. Having grown up in a fully digital world where everything that is not perfect is sub-par and a new, potentially better, relationship is just one click or swipe away, there is an increased yearning for deeper connection, intimacy and meaningful relationships.

Hence, we are seeing what is probably the most romantic consumer generation in decades entering the market for fine jewellery. A clear positive for platinum, the metal of love.

Fine jewellery buyers generally had fewer financial worries during the pandemic

Consumers seeking more meaningful relationships – platinum jewellery speaks their language of love


Experience as a luxury product

In recent years there has been no shortage of articles and opinions predicting the demise of jewellery as consumers shifted from 'product to experience', apparently preferring to spend their discretionary income on travel, events and other experiences rather than on a piece of jewellery. While in reality there was always a lot more nuance to this, this is a trend that without a doubt has been impacted by the pandemic. With most consumers around the world being under some form of lockdown and international travel halted, they simply could not spend on travel or entertainment outside the home. PGI's consumer research shows that consumers do reprioritise their spending and prefer to save more, and that jewellery has risen to the top of their priority lists in most markets.

Pandemic curbed consumers' spend on experiences – raising jewellery in their priorities

Poll: Luxury spending during the Covid-19 crisis period

Differentials of willingness to spend ('spend more or same' vs. 'spend less'), %

 US			 Japan		
Rank	Item	Diff.	Rank	Item	Diff.
1	Clothes/ fashion	15	1	PC, Tablets, Smartphone	0
2	PC, Tablets, Smartphone	13	2	Kitchen furniture & equipment	-8
3	Wine/ champagne	12	3	Cosmetics & perfume	-14
4	High-quality spirits	5	4	Writing utensils	-15
5	Cosmetics & perfume	1	5	Clothes/ fashion	-19
6	Kitchen furniture & equipment	-2	6	Furniture	-24
7	Jewellery	-4	7	Eating out	-26
8	Eating out	-5	8	Cars	-26
9	Furniture	-5	9	Wine/ champagne	-29
10	Writing utensils	-6	10	Handbags	-32
11	Exclusive accessories	-9	11	Jewellery	-32
12	High-end audio & video	-10	12	Watches	-34
13	Watches	-10	13	Holidays & travel	-36
14	Cars	-13	14	Exclusive accessories	-37
15	Handbags	-14	15	High-quality spirits	-39
16	Holidays & travel	-19	16	High-end audio & video	-44
17	China and glassware	-24	17	China and glassware	-46
18	Antiques	-28	18	Antiques	-57
19	Cufflinks	-35	19	Cufflinks	-66
Average		-7	Average		-31

 China			 India		
Rank	Item	Diff.	Rank	Item	Diff.
1	Jewellery	40	1	Clothes/ fashion	26
2	Clothes/ fashion	36	2	Jewellery	13
3	PC, Tablets, Smartphone	32	3	PC, Tablets, Smartphone	13
4	Cosmetics & perfume	25	4	Cosmetics & perfume	12
5	Kitchen furniture & equipment	23	5	Kitchen furniture & equipment	4
6	Writing utensils	21	6	Watches	0
7	Wine/ champagne	13	7	Eating out	-7
8	Exclusive accessories	6	8	Handbags	-9
9	Handbags	6	9	Exclusive accessories	-9
10	Watches	3	10	Furniture	-13
11	Furniture	-2	11	High-quality spirits	-14
12	China and glassware	-9	12	Wine/ champagne	-16
13	Cars	-10	13	High-end audio & video	-16
14	High-quality spirits	-10	14	Writing utensils	-18
15	High-end audio & video	-16	15	Cars	-21
16	Cufflinks	-21	16	Holidays & travel	-25
17	Eating out	-24	17	Antiques	-34
18	Holidays & travel	-26	18	China and glassware	-37
19	Antiques	-41	19	Cufflinks	-38
Average		2	Average		-10

Jewellery tops the charts in China and India for consumers' increased willingness to spend on luxury

Source: PGI, 'Consumer under COVID-19', May 2020

This is not perhaps as surprising as it seems. It is most likely a side-effect of consumers rediscovering meaning and appreciation for their loved ones. As one consumer put it when describing his purchase for his girlfriend: “We could not get on that trip to Europe that we were both so looking forward to, but I still wanted to give you something nice”.

How this dynamic pans out for jewellery remains to be seen. Once travel is possible again, consumers will most likely return to spending on it too. However, the current state presents a significant opportunity for the industry: for once, the marketing machinery of the travel industry is silent – which means that gaining share of voice and wallet has seldom been less expensive. We already see some jewellers taking the opportunity – if and how others follow, remains to be seen.

But once travel is possible again, will consumers switch back to spending on experiences and cut back on jewellery?

*Opportunity is there **now** though for jewellers to gain share of voice and wallet*

Jewellery industry digitalisation

The jewellery industry has long been a laggard in applying digital processes to operations, whether behind the scenes or in marketing. The virtual and remote working practices forced upon the industry by the pandemic have accelerated the uptake of many of these. Most notably, online to offline has kept many retailers in business, allowing customers to order online and either pick up in-store or have home delivery. Live streaming, often from an empty shopfloor, has kept the buyer-seller relationship alive and jewellery at the forefront, turning sales associates into key opinion leaders from Shanghai to St. Louis. Retailers with seamless e-commerce and social media ecosystems have consolidated their leadership and emerged as winners.

e-commerce platforms and strong social media presence characterise successful jewellers

Conclusion

It will take years for the world to recover from Covid, a pandemic that has impacted not just every industry but also, more importantly, every life in so many ways. Despite the pain and sorrow, our research indicates that many of the trends accelerated by this event appear to benefit jewellery, and platinum in particular. An outlook we are happy to believe in.

Platinum jewellery is poised to play its part in the global recovery

Please feel free to get in touch with us to learn more about the topics covered in this article

Tim Schlick
COO

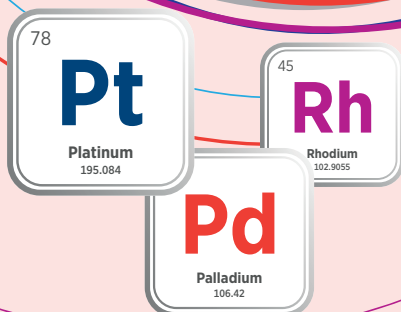
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The PGM Radar

Market Outlook Report Q1'21



Stay up-to-date with short-term developments of the PGM markets and our latest three-year outlook

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.**

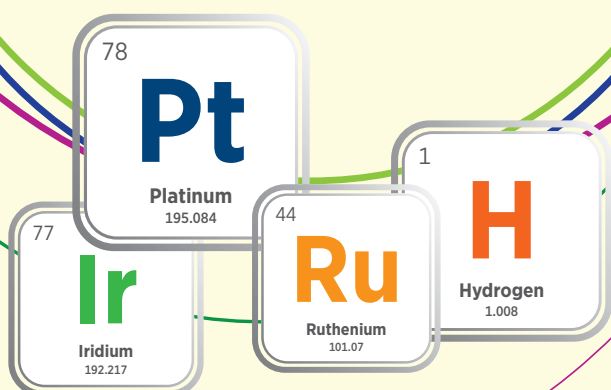
Specific content for each report varies according to market events and demand developments, but is **tailored to incorporate the client's specific interests** in the PGM industry.

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.**

Hydrogen report

The sustainable energy revolution



SFA's hydrogen metals market report joins the dots between the hydrogen economy and the critical PGMs required for decarbonising industry and transport

SFA (Oxford)'s expertise enables us to leverage our unique insights into the connections between the hydrogen market and PGMs, the strategic metals required in this fast-developing sector.

Throughout SFA's history, we have provided our clients with unparalleled analytical insights, showing that technological innovation, legislation and business developments all point to the greater adoption of electrolyser and hydrogen fuel cell technology as a global key clean energy solution.

SFA (Oxford) has worked with clients in the hydrogen fuel cell space on projects ranging from assessing the role of fuel cell vehicles in underground mining, to understanding the supply and pricing dynamics of platinum, iridium and ruthenium to assess the long-term viability of the hydrogen market, through to assisting investors seeking an understanding of the industry and the role of the PGMs in its future.

Naturally, transport remains one of the most visible applications of fuel cell technology and SFA (Oxford)'s PGM demand forecast model enables us to identify the growth opportunities and mitigate the risk. Nearly 20 years of forecasting PGM demand in autocatalysts – light-duty and heavy-duty, gasoline and diesel, in regions subject to a range of air quality standards – has enabled us to move seamlessly into forecasting demand for the critical metals deployed in hydrogen fuel cell vehicles and hydrogen production. The key themes in our bespoke reporting include:

- Identification and analysis of the hydrogen chain of players.
- Evolving technology and patents.
- Critical investments, as well as government and regional support for the hydrogen sector.
- Main markets, including electrolysers and fuel cells in different transport modes (trucks, buses, trains, ships, cars and more) and the timescale for regional and global growth.
- The critical role of platinum, iridium and ruthenium in the hydrogen economy and forecast end-use demand.
- Evaluating the risks from competing technologies and how hydrogen fuel cell based technologies can be competitive.

**ANGLO AMERICAN:
SHAPING THE FUTURE OF
PGMs – HYDROGEN AND
BEYOND**



Anglo American: Shaping the future of PGMs – hydrogen and beyond

Nurturing ideas. Commercialising concepts. Engineering growth.

Mark Freed, Head of Market Development, Anglo American

In terms of future demand for the platinum-group metals (PGMs), there is no question that hydrogen and the prospect of an emerging global hydrogen economy present an exciting opportunity. That said, it is not the only contender vying for attention.

Hydrogen economy has great potential for new PGM demand






There are several other emerging, in our view potentially ‘hydrogen-sized’, opportunity areas for our metals that have not yet found their way into the forecasts. In this article, I will explore the pivotal role that market development activities in the PGM space can play to drive innovation and sustainable growth, and why I think the future for PGMs is exciting.

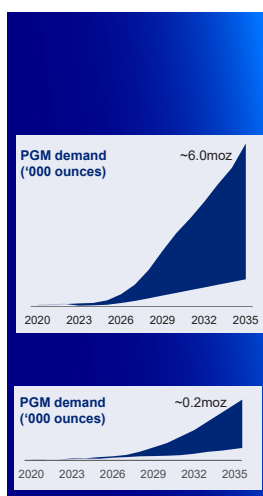
But not the only potential new market – other opportunities in the frame too

The annual potential for platinum in the hydrogen value chain could be up to six million ounces if fuel cells find reasonable traction in the automotive sector. As such, hydrogen is a sector which we focus on supporting, not only in principle as a credible and promising enabler of the transition to sustainable energy, but also with tangible actions. However, once the analysts and industry in general begin to bake demand and uptake into their forecasts, the role of market development changes. It shifts from being the early pioneer forging new paths and starting the debate, to targeted activity to support sector acceptance.

Potential demand of up to 6 moz Pt across the hydrogen value chain

Growth and scale in hydrogen could mean as much as ~6 moz annual demand for PGM in the long-term

	Application	Fuel cell vehicles, %	Potential PGM ounces ¹ , '000
Mobility	 Passenger vehicles (m/l)	15	3 400
	 Heavy duty trucks	50	2 000
	 Passenger vehicles (small)	5	350
	 Buses	25	80
	Application	Unit of capacity	Potential PGM ounces ² , '000
Electrolysis	 PEM electrolysis	5 GW	40



Source: Anglo American Platinum. Note: ¹Assumes 0.125 g/kW. ²Assumes 0.15 g/kW for iridium and 0.10 g/kW for platinum

Market development can often result in radical change, so I think it is useful to look at how Anglo American views the challenge of developing new demand. In so doing, it will hopefully highlight that hydrogen is not, by any means, the only game in town.

A proven track record

Anglo American has been developing markets for many years and has a great track record – for example, it is more than 45 years since we joined forces with other producers to set up the Platinum Guild International (PGI) to grow demand for platinum jewellery in new markets. Without the PGI, the millions of ounces of jewellery demand created in China would not have been realised. This success continues, with platinum jewellery demand in India being grown from a base of near zero to approximately 200 koz of annual demand today.

Prominence in developing markets for the PGMs – PGI, WPIC, Hydrogen Council, Chinese International Hydrogen Fuel Cell Association, AP Ventures

In 2014, we led the formation of the World Platinum Investment Council (WPIC). Today, the WPIC works globally with over 15 partners, reaching thousands of retail investors and, in so doing, making platinum investment easily accessible and developing new demand.

In 2016, with 12 other companies, we jointly launched the Hydrogen Council. Today, the council brings together a diverse group of more than 100 organisations based in 20+ countries across the entire hydrogen value chain, including large multinationals, innovative SMEs, and investors. We spearheaded the creation and launch of the Chinese International Hydrogen Fuel Cell Association and played a key role in creating the excitement, visibility and support that hydrogen and fuel cell technology enjoys in China today.

In 2018, we led the creation and spin-out of AP Ventures which now has eight limited partners and capital commitments in excess of \$300 million. In the short period since its launch, AP Ventures has grown its portfolio to over 14 investments across the hydrogen value chain, including in production, storage, transportation and end-uses, thus positioning it as the pre-eminent, hydrogen-focused venture capital fund globally.

Looking at practical deployment opportunities, Anglo American is in the process of developing the largest fuel cell powertrain yet to replace the diesel engines of the world's largest mine haul trucks. This will create, for Anglo American managed operations alone, electrolysis demand nearing a gigawatt before 2030.

Not just industry organisations – on the ground too, developing fuel cell mining trucks for operations

It is fair to say that today Anglo American is seen as a leader and trusted corporate partner across the hydrogen value chain, with start-up companies, other corporates and governments globally helping us drive this sector forward.

Collaborations key to driving demand in hydrogen value chain

Sustainable, diversified demand

Our objective for PGM market development is simple: to discover, nurture and scale new and existing end-user applications and markets to create sustainable, diversified demand segments and growth.

Market development opportunities must meet certain criteria to become new demand segments

So how do we approach the challenge of market development? We think of our world as a set of opportunity areas, which are potentially new demand segments or sub-segments in-the-making. We evaluate each opportunity space to ensure it meets a few specific requirements, for example:

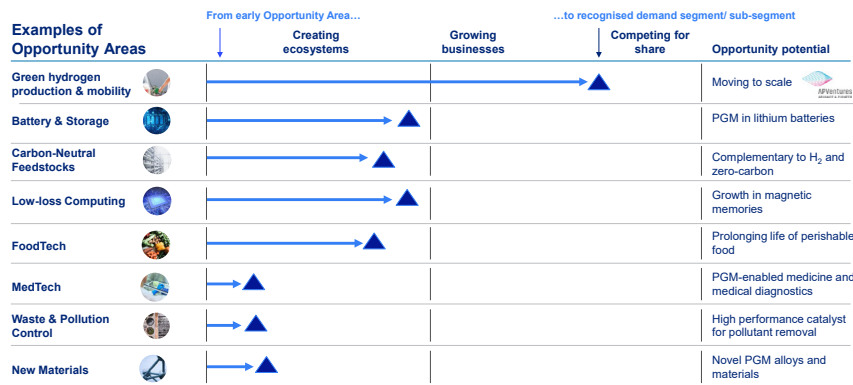
1. It must be a space that, independent of metal use, is an exciting one into which to build businesses, i.e. non-PGM aficionados are as excited as we are.
2. PGM-based technologies should, in our view, offer a distinct competitive advantage over alternatives in that segment.
3. It must be big enough to be commercially interesting. Importantly, we do not overlay a supply constraint on any opportunity space; we simply measure the size of the prize.
4. It must yield incremental demand.
5. The emergence or growth of the demand segment will be enhanced by our involvement.

Must be an exciting business, not just to 'PGM-heads'

Focusing on existing applications alone will not be enough to secure an exciting and positive future for PGMs, especially if we think along the time horizons within which our mining assets are expected to operate. Our critical mission is thus to embed optionality into the future of PGMs, by finding and discovering more opportunity areas. This is the hardest part of our job and requires a global approach with multiple partnerships across sectors and across the innovation ecosystem.

Consider novel applications for PGMs in tandem with mining assets' time horizons

We discover and nurture opportunity areas into demand



Source: Anglo American Platinum

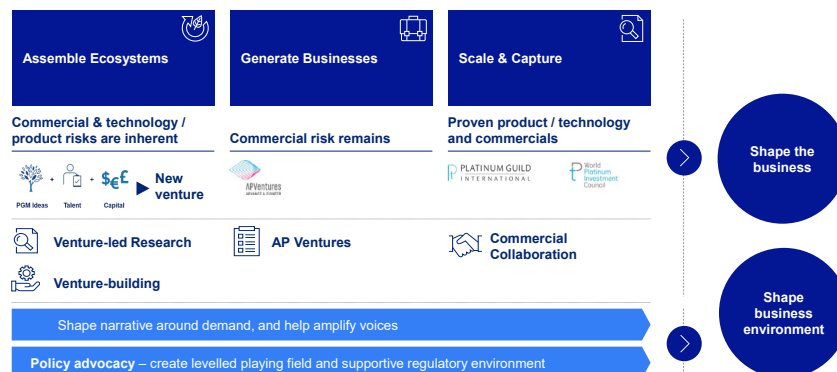
Once an opportunity area is identified, we must move the opportunity from its infancy to a legitimate demand segment that is scalable. However, the successful realisation of any new PGM demand requires us to not only nurture those technologies and/or companies which directly consume our product, but also to shape the environment within which they exist. The poet John Donne said it best, “No man is an island”.

Need to shape the entire product environment, not just the product itself

The hydrogen and jewellery sectors are good examples of where successful demand creation requires the growth or emergence of entire industries, comprising a plethora of individual companies, and the support from fit-for-purpose policies and standards. Within each of these sectors some companies will directly consume our metals in their products, while others will not. However, only the success of the entire sector will ultimately lead to meaningful incremental demand for PGMs.

Involvement in shaping policies and standards too

Market development shapes the business and its environment



Source: Anglo American Platinum

Demand growth for products using PGMs will depend on many associated activities

Market development ecosystems – hydrogen as an example

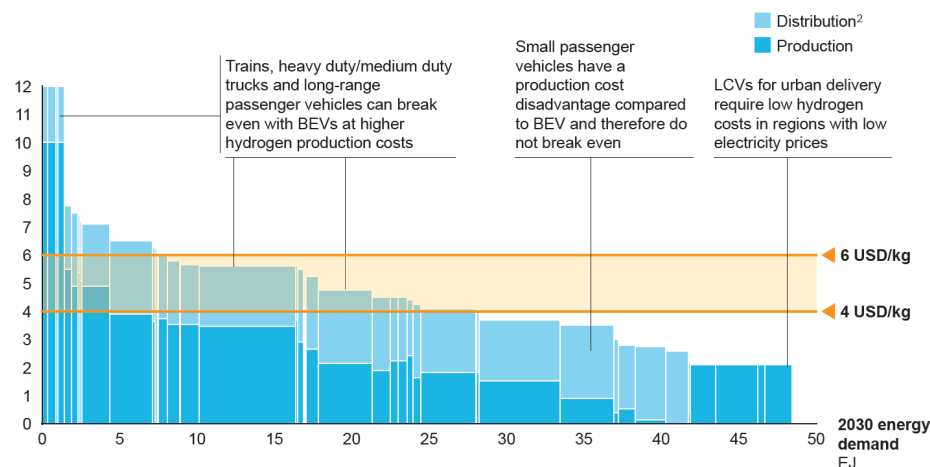
To propel a specific opportunity forward, we construct a set of interventions or activities around one or more hypotheses that would need to be true for a specific company or, more often, an entire industry/sector to succeed.

Using hydrogen as an example, it is our hypothesis that a sufficiently low (between \$4/kg and \$6/kg) cost of decarbonised hydrogen, delivered at pressure, will unlock most end-use applications. Importantly for PGMs, the major demand for our metals will come from the light- and heavy-duty automotive sector which requires costs at the lower end of this range.

Recognising the importance of availability of low-cost decarbonised hydrogen to deliver automotive fuel cell PGM demand

Cost curve for hydrogen for transportation across segments and regions

Breakeven hydrogen costs at which hydrogen mobility applications becomes competitive against low-carbon alternative in a given segment in focus regions¹
USD/kg at nozzle



Source: Hydrogen Council, (2020). 'Path to hydrogen competitiveness: A cost perspective'. Note: 'Regions assessed are the US, China, Japan/Korea, and Europe.

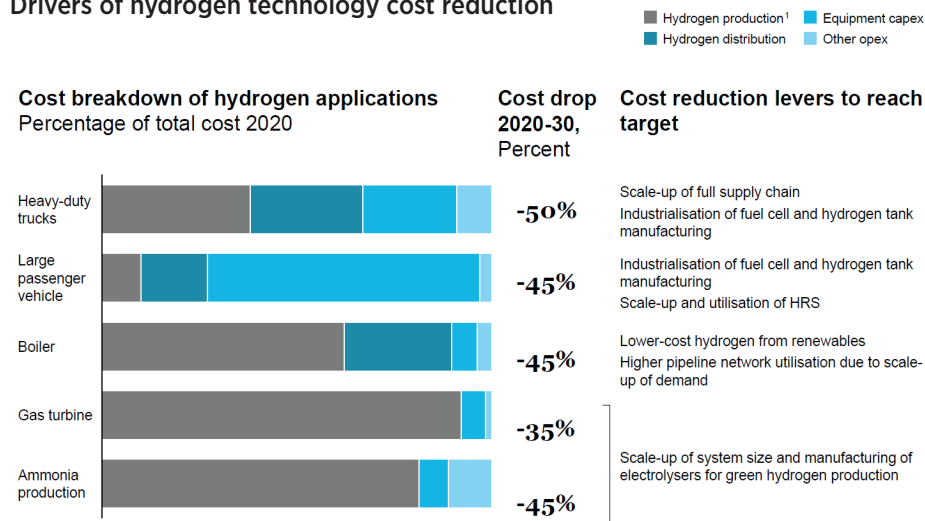
²No distribution costs for aviation as it can be distributed as liquid fuel.

The question then becomes what is required to drive down the delivered cost of hydrogen. Research and industry consensus today suggest three key interventions:

1. Lower hydrogen production costs and distribution costs.
2. Improved utilisation of (and access to) hydrogen infrastructure.
3. Increased scale of manufacturing (for end-use applications. An example is FCEVs but also for all technology components in the supply chain).

Identifying what needs to be done to lower the cost of hydrogen for potential automotive consumers

Drivers of hydrogen technology cost reduction



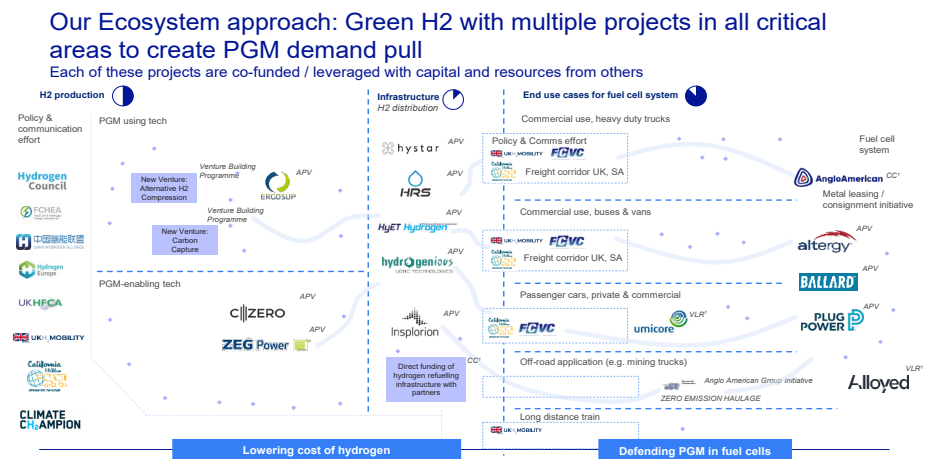
Source: Hydrogen Council, (2020). 'Path to hydrogen competitiveness: A cost perspective'. Note: 'Assumes 50/50 blend of low-carbon and average renewable hydrogen. HRS = hydrogen refuelling stations.

Finally, for market development, we answer the question “where and how do we engage?” to (a) support the wider industry to achieve the above objectives and (b) do so in a way that maximises impact and direct benefit back to Anglo American.

With this in mind, we can show what we mean by shaping the business and the environment of the business by overlaying each of our direct and indirect hydrogen-related investments and activities on a ‘market shaping canvas’.

Market shaping canvas shows direct and indirect investments in hydrogen ultimately create PGM demand pull

PGM market development: Hydrogen market shaping canvas



Source: Anglo American Platinum. Note: 'CC = Commercial collaboration, VLR = Venture-led research.

As a result, all our efforts, as shown across the market shaping canvas, seek to address cost, utilisation and scale, and are interconnected. They are either:

- New technologies that address known technology barriers and/or offer step changes in cost or higher performance vs. incumbent options. Examples of this would include:
 - › Liquid organic hydrogen carrier technology, an alternative low-cost option to distribute hydrogen developed and commercialised by Hydrogenious LOHC Technologies GmbH.
 - › Lower-cost, high-performance hydrogen compression technology such as the one developed by HyET Group, a leader in electrochemical hydrogen compression.
- Aggregating or initiating demand for end-use applications to help address access, utilisation and scale, for example:
 - › Spearheading the creation of hydrogen freight corridors in the UK and South Africa to aggregate end-user demand for hydrogen trucks/buses and vans while simultaneously coordinating refuelling infrastructure.
 - › Co-funding the construction of hydrogen refuelling stations in key early markets such as California, alongside partners such as Shell, Toyota and Hyundai.
- Shaping regulatory environments to facilitate government support, through the removal of regulatory barriers, the creation of financial subsidies and/or technology adoption incentives.

In operationalising our strategy and organising our day-to-day work, we have sought to engage in activities in a way that amplifies our potential impact through taking a programmatic approach founded on partnerships and leveraged funding. This enables us to reach the scale, both monetary and human resource-wise, required to efficiently coordinate the right capital and the right actors, at the right time to facilitate the creation of ecosystems needed to shape new demand opportunities.

Developing hydrogen economy by influencing cost, utilisation and scale

Lower-cost hydrogen distribution through liquid organic carriers and high-performance compression

Driving demand for hydrogen transport by creating freight corridors and coordinating refuelling infrastructure

Assisting a supportive regulatory environment

Using partnerships and leveraged funding to amplify in-house efforts

New demand segments

Finally, I return to our view that there are several other potentially 'hydrogen-sized' demand opportunities for our metals that have not yet found their way into forecasts. PGMs in batteries, in low-loss computing and medical diagnostics are such examples.

Some other 'hydrogen-sized' demand opportunities

In the case of batteries, our work has shown that there is a very real possibility that PGMs can enable yet-to-be-commercialised battery chemistries such as lithium sulphur and lithium air. Palladium, in particular, can significantly improve the energy density of today's lithium-ion chemistries. We are not suggesting this is a 'done deal' by any means. But the possibility is there and, if realised, it could materialise as a potential prize in the millions of ounces of demand for platinum and/or palladium annually – possibly beyond what we see as the potential for platinum in the fuel cell sector.

Energy density of some pre-commercial battery chemistries – lithium sulphur and lithium air – may be improved via use of PGMs

The computation space is another valid example. Here we have seen and are actively working to realise the potential for PGM-containing spintronics, e.g. MRAM and ReRAM, which in turn relies on alloys of PGMs in multiple use cases; in-memory computing being one of them. Again, if successful, this technology could pave the way to one million ounces plus annual demand opportunity in the longer term.

Low-loss computation can be enhanced via PGM-containing spintronics

The world of plasmonic chips in clinical metabolic fingerprinting is yet another motivating area in development. Here, optimised alloys of PGMs enhance laser desorption/ionisation efficacy in mass spectrometry and, coupled with machine learning, enable the diagnosing of a growing list of diseases in seconds with high diagnostic sensitivity, specificity and accuracy not previously possible. Developments such as this have the potential to generate platinum or palladium demand, in China alone equivalent to the production of an average mining shaft.

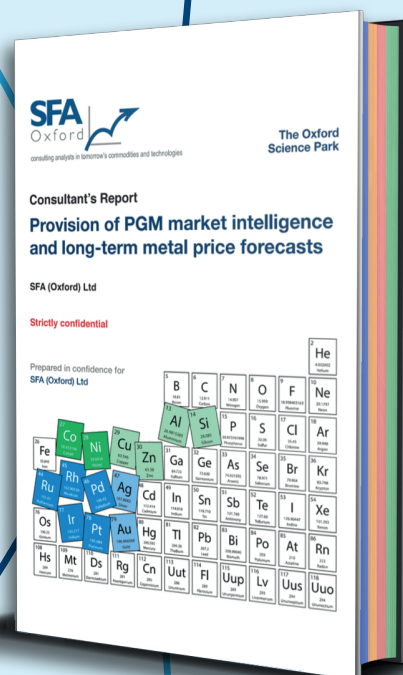
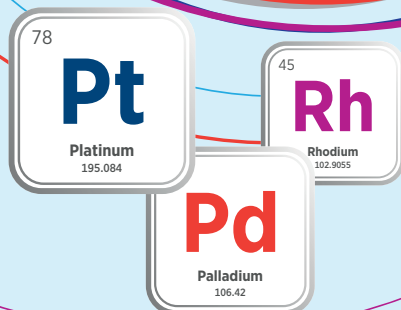
Medical diagnostics can be more sensitive, specific and accurate via PGM-based technologies

In conclusion, we believe that there are plenty of reasons to be genuinely enthusiastic about the role of PGMs in a greener, healthier, more technologically advanced and better-connected world. Not very long ago, the examples I mentioned above were not even ideas yet, nothing was preordained. While many individuals and companies will still need to take great risk to realise each opportunity, the possibility is there. Anglo American stands ready with its holistic ecosystem of programmes and workstreams to support these PGM-relevant innovations from the spark of an idea, through commercialisation to creating and sustaining scale. The future of PGMs is truly exciting.

PGMs can help to make greener, healthier, better-connected societies – but individuals and companies must be prepared to take risks along the way

Long-term PGM Market Outlook

The changing nature of the PGM
market out to 2031



Well-reasoned, value-adding market intelligence on the
upstream and downstream chain-linkages of the PGM industry

SFA (Oxford)'s Long-term PGM Market Outlook is an in-depth, forward-looking report on the current and long-term trends and influences acting on the global PGM markets, their sources of supply and demand, and their investment vehicles.

This report examines the changing nature of the PGM market out to 2031. It provides a **long-term sensitivity analysis of demand** with vital information needed to best gauge the impacts in the usage of palladium, platinum and rhodium as a result of **tightening tailpipe emissions standards**, intra-metal **substitution** trends, shifts in powertrains (advances in electrification of powertrains and pure battery electric vehicles), and **recycling**. It provides an analysis of the changes in and economics of global supply, as well as **long-term production profiles**. Also included is a detailed forecast evaluation of the PGM markets (including metal prices and their influence on the jewellery, industrial, chemical, petroleum and investment sectors) out to 2031.

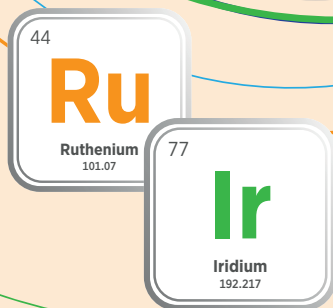
The key themes of the March 2021 issue include:

- **Covid-19 influences on supply and demand** and lasting impacts.
- **Latest developments in tailpipe emissions** standards and considerations for PGM use.
- Potential high price induced regional and global **substitution impacts on palladium demand** from using platinum in three-way catalysts.
- **The rhodium dilemma**: where to get rhodium from to meet tomorrow's needs and how might this influence metal prices. SFA investigates using scenario outcomes based on supply constraints, medium-term risk and substitution to palladium.
- **Long-term sustainability and potential of the palladium market** and prices, and **platinum market uncertainties**.
- **Electrification of automobiles**: opportunities and threats for PGMs.
- Consideration of the effects of **environmental, social and governance (ESG)** criteria on the platinum industry.
- The latest developments in **the hydrogen economy** and likely near-term outcomes for platinum demand.
- A detailed evaluation of **supply potential from mothballed mines and new projects** worldwide.
- **Project incentive pricing**, evolving supply mixes and end-user needs.

For companies needing an even longer-term view on the PGM markets and prices, for either strategic requirements or asset valuations, **SFA released its 2040 market outlook report in October**. Not only does this extend the view on PGM market segments and metal prices for another 10 years, but it also includes **more detail on the drivers affecting these metals over the long term**; for example, the acceleration of electric vehicle use and drivers behind it, fuel cell demand light-off against security of supply, recycling potential and existing mine reserve depletion, and evaluation of project resources for tomorrow's demand, which will all have varying degrees of impact on each PGM. Both are hugely insightful reports depending on your business needs.

The Ruthenium & Iridium Markets

Quarterly Core Analysis Package Q2'21



Stay up-to-date with short-term supply and demand developments of the iridium and ruthenium markets and our latest five-year outlook

Critical metals for the hydrogen economy

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, and the emerging hydrogen economy.

It offers **commercial insights into primary metal supply** and the link to the rest of the PGM basket, plus insights into end-uses, their price elasticity and the risks of substitution.

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

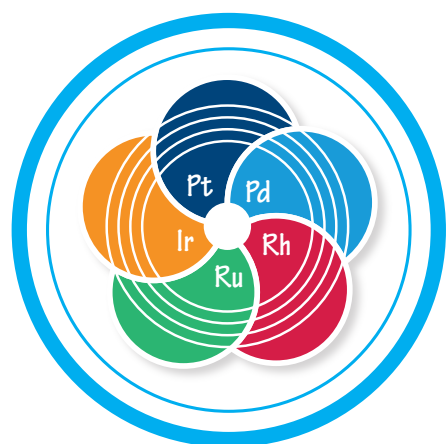
Key report features:

- Market summary
- Price outlook and drivers to 2025
- Demand trends
- The only S-D market balance available
- Trade flow analysis
- Supply challenges and mine economics

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

- Post-pandemic **recessionary risks to demand recovery**
- **Technology developments** in business and consumer electronics sustaining markets for Ru and Ir
- Impact of **supply disruptions** in South Africa during 2020 and 2021 on output
- How **changes to the geology mined** in South Africa will affect Ir and Ru supply

TRANSFORMATION OF THE PGM REVENUE BASKET



Transformation of the PGM revenue basket

Francesca Price and Alex Biddle, SFA (Oxford) Ltd.

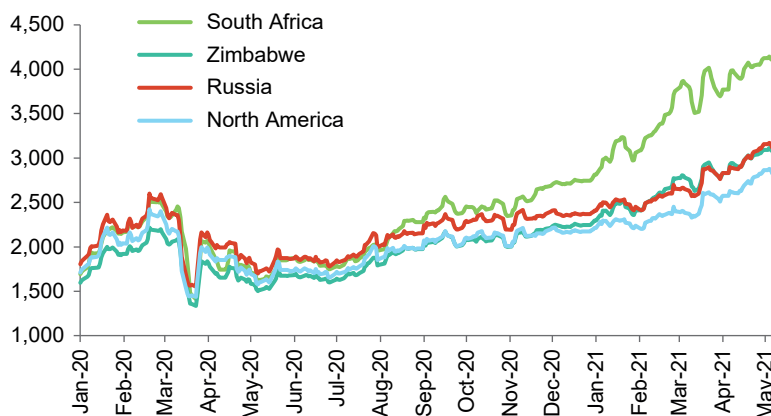
South African PGM producers are outperforming

Despite the challenges of Covid-19, all PGM producers in South Africa made a significant profit last year, as high basket prices and a weak rand kept cash flowing. The PGM basket generated the largest proportion of revenue across all commodities in the South African mining sector in 2020, overtaking coal for the first time since 2010¹. All regions benefitted from the PGM price rally in the second half of 2020, although the South African basket price was the clear winner, gaining 66% over the course of the year, compared to 33% for producers in Russia, 44% for Zimbabwe and 29% for North America.

66% gain in the South African PGM revenue basket in 2020

Global 4E PGM basket prices

USD/4E oz



Source: SFA (Oxford), Bloomberg

Rhodium revenue from South African mines accounted for ZAR94 billion in 2020 (US\$5.7 billion), almost three times as high as in 2008. The previous record year was 2019, but this was surpassed as the rhodium price almost doubled (increase of \$8,400/oz) in the second half of 2020.

Depleting Merensky reserves being replaced by Rh-rich UG2 production

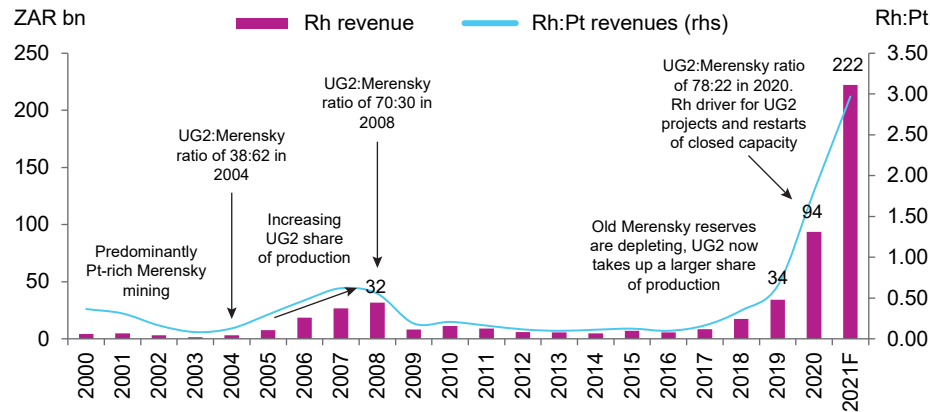
As well as high prices, today's revenues also reflect the changing orebodies in South Africa, compared to 2008. Mature Merensky mines are being depleted on the Western Limb (Pt-rich) and more UG2 ore is being mined with a higher proportion of palladium and rhodium compared to Merensky ore. The bonus from replacing depleting Merensky ounces with rhodium-rich UG2 production is an increase in iridium and ruthenium supply.

¹PwC South Africa, 'SA Mine 2020'

The Platinum Standard

When Merensky was the dominant revenue stream for South Africa's PGM producers, investment was very much dictated by the platinum market. Now that revenue is led by the UG2 basket price, rhodium and palladium are the main drivers for the future of the industry, with increasing influence from iridium and ruthenium as well.

Total South African rhodium revenue

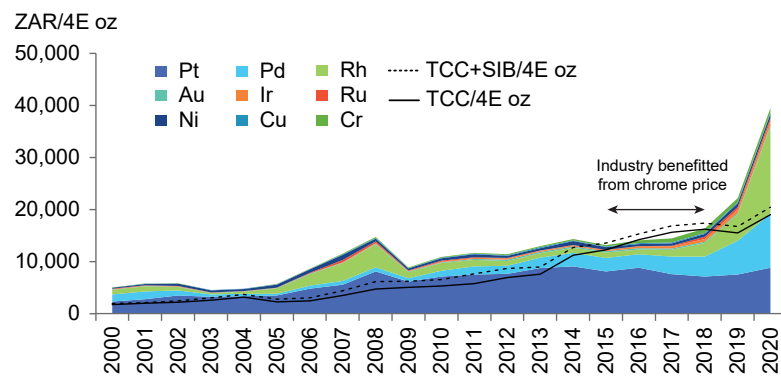


Source: SFA (Oxford)

Given the price has exceeded \$30,000/oz already this year, rhodium revenues could be in excess of ZAR200 billion (US\$14 billion) in 2021. As a proportion of total revenues from South African PGM mines, rhodium revenue reached 36% in 2020 and could account for more than 50% this year.

Rhodium revenue now >50% of the SA revenue basket

Revenue by metal vs. cost, Western Bushveld

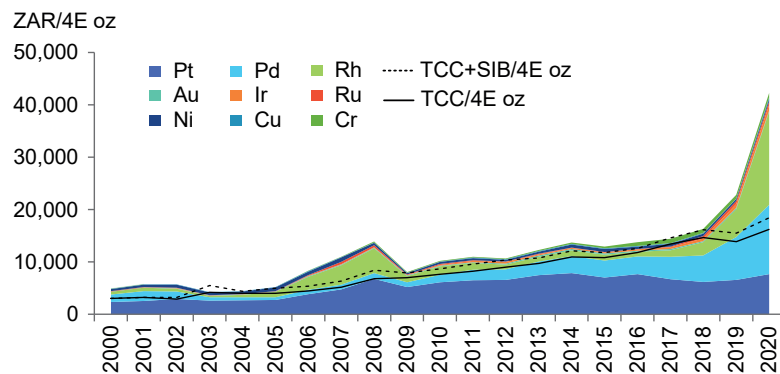


Source: SFA (Oxford)

During low PGM price regimes, chrome became an important part of the UG2 mine basket of revenues for some producers and helped keep higher-cost operations in profit.

Western Limb mines benefit from chrome...

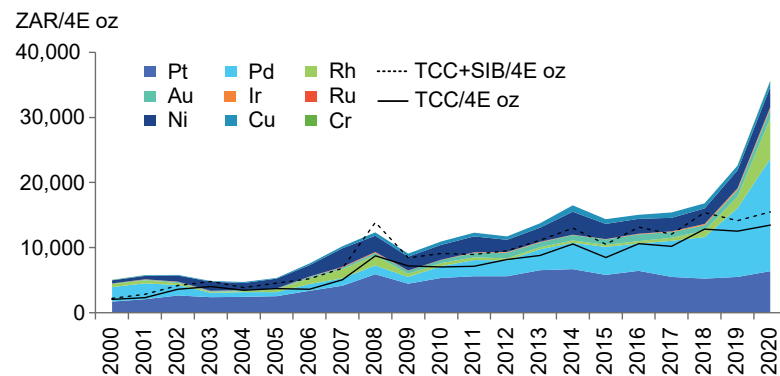
Revenue by metal vs. cost, Eastern Bushveld



Source: SFA (Oxford)

...Rh price is crucial for Eastern Bushveld mines...

Revenue by metal vs. cost, Northern Bushveld



Source: SFA (Oxford)

...Pd price is the key driver for the Northern Bushveld

Bushveld mine output is elastic to the rhodium price

In 2008, the UG2 basket price was dominated by rhodium which accounted for 30% of producer revenues. Owing to rhodium's high price, a number of UG2 mines began operation but when the price crashed shortly afterwards, many producers placed uneconomical mines on care and maintenance.

Rhodium revenues per tonne for South African producers in the Eastern Bushveld (Rh-rich UG2 ore) were 241% higher in 2020 compared to the previous year, reflecting the escalation in the price and a weaker rand, which averaged 16.45:1 against the US dollar compared to 14.44:1 in 2019. In the year to date, rhodium revenue per tonne has already risen by a further 127% year-on-year.

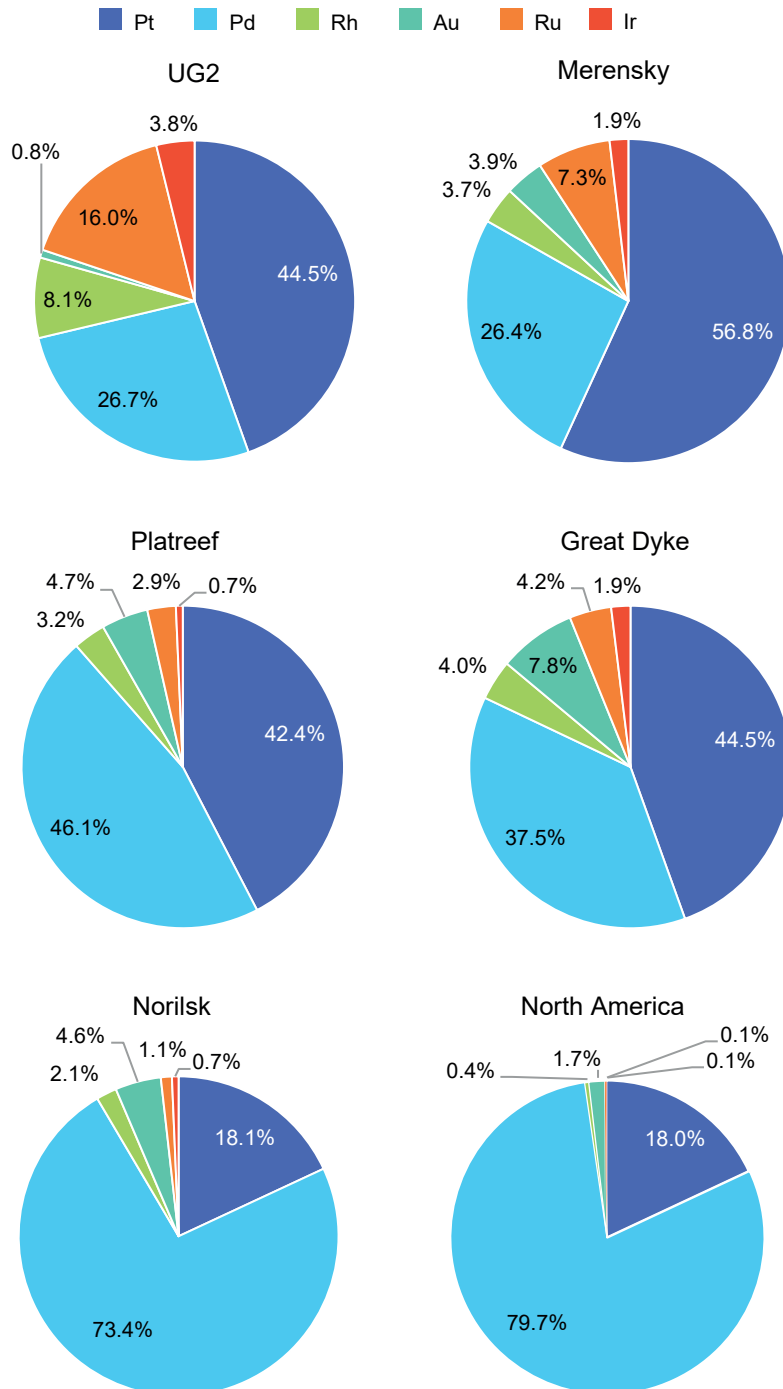
Mining mix and rand exchange rate are key drivers too

However, it is not only rhodium which has made impressive price gains. Palladium and iridium prices have recorded higher percentage growth than rhodium over the past decade, and as a result the PGM mine basket of revenues is more rounded today than it was in 2008.

The Platinum Standard

Producers have been stung before by rhodium's high price volatility, but even taking that risk into account, the case for UG2 is stronger than ever. The UG2 Reef contains the highest proportion of ruthenium and iridium of any orebody worldwide, and the potential for higher prices for these minor metals is significant.

PGM prill splits



UG2 contains the highest proportion of Ru and Ir

Outside of Southern Africa, minor metals are scarce

Source: SFA (Oxford). Note: Totals may not sum owing to rounding.

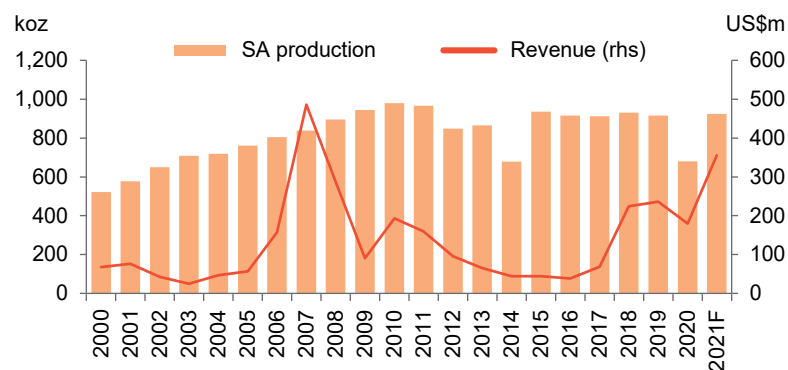
The South African UG2 basket price reached levels in excess of ZAR60,000/oz in the first quarter of 2021 and now commands a premium over the Merensky and Platreef of 14% and 48%, respectively. Basket prices are only expected to rise further this year, as a tight rhodium market and Nor Nickel's production issues keep PGM prices high. For UG2 producers, which benefit from a higher Pd:Pt ratio and are more weighted towards rhodium, iridium and ruthenium than producers of any other orebody, the 4E basket price is expected to remain particularly strong.

The UG2 basket price commands a premium over Merensky and Platreef

Iridium and ruthenium – the ones to watch

At no risk of being crowded out of the revenue basket are iridium and ruthenium. Minor metal revenues have been rising over the past few years, and with scope for even higher prices from strong demand, producers are starting to pay attention.

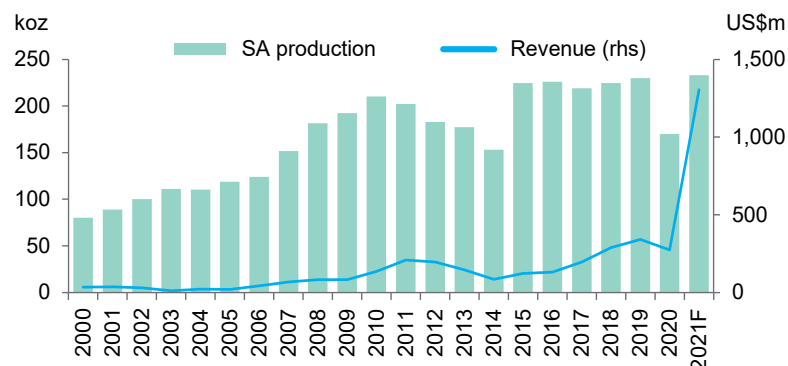
SA ruthenium production and revenue



Source: SFA (Oxford)

Ru mine revenue on a rising trend since 2016

SA iridium production and revenue



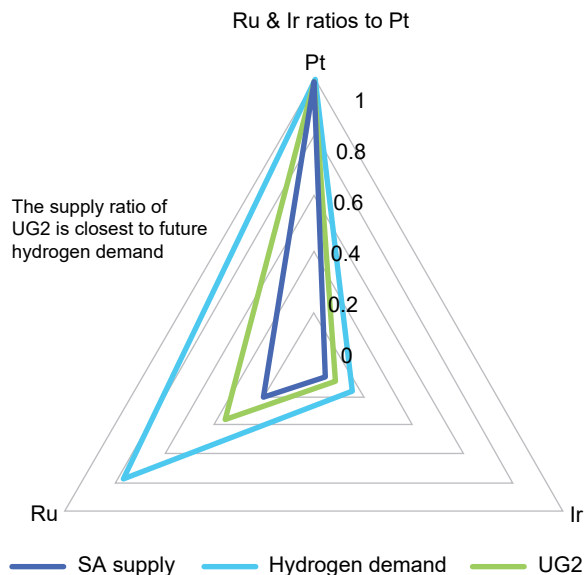
Source: SFA (Oxford)

All time high prices push mine revenues >\$1 billion this year

Supply of iridium and ruthenium is almost entirely derived from South Africa, accounting for 81% and 87% of global production last year, respectively. Recycling of these metals is limited so the future of supply is heavily reliant on growth in South Africa. The current outlook for iridium and ruthenium supply sees mine output peak in 2022 before depletion begins to take effect. However, long-term demand, driven by the burgeoning hydrogen economy, will need significant growth in supply to keep pace with consumption by industrial end-users. Iridium and ruthenium have key roles in the hydrogen sector, used both in polymer electrolyte membrane (PEM) fuel cells (Ru) and in hydrogen production via PEM electrolysis (Ir). While there is ongoing innovation to reduce the intensity of PGM use, these metals are hard to replace entirely and are vital in certain technologies. The metal supply ratio of the UG2 Reef is the best placed to meet future hydrogen demand, owing to its higher weighting towards iridium and ruthenium than current supply from South Africa.

Minor metal supply is heavily exposed to SA, with limited recycling...

Hydrogen demand ratios vs. SA supply



Source: SFA (Oxford)

...However, current H₂ demand forecasts are still more skewed towards Ru and Ir

UG2 restarts are key to securing future iridium and ruthenium supply

Already, the strength of the basket prices is motivating producers to invest in replacement projects to extend the life of mines and keep high-cost operations open for longer. Previously uneconomic areas of shafts are now viable under current basket prices, lifting supply projections in the near term, particularly for mature ruthenium- and iridium-rich operations.

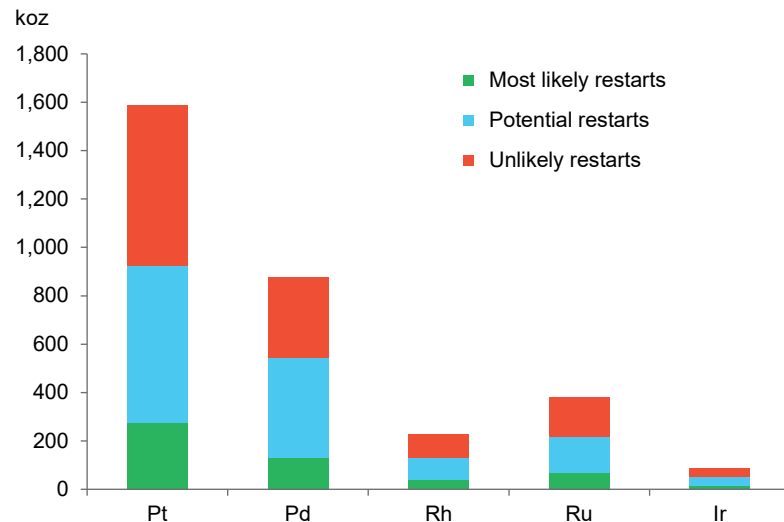
Uneconomic areas are now profitable

The Platinum Standard

Since 2009, shaft closures have cut over 1.8 moz of 3E PGM capacity across South Africa. Predominantly UG2 operations were affected because they are rhodium-rich and typically poorer in base metal by-products, but as a result of the higher basket prices there is now significant production capacity that can be restarted with relatively low capital requirements and short (~1-2 years) lead times to production. In total, 37% of ruthenium and 31% of iridium capacity in 2021 remains closed.

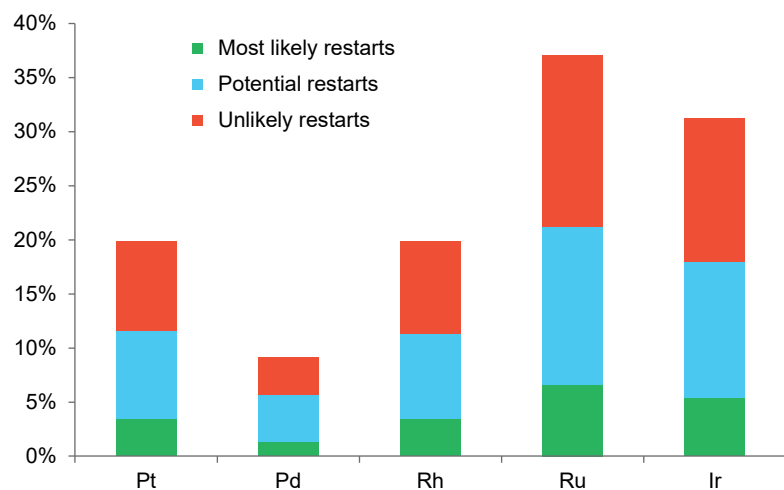
Closed capacity is predominantly Ru-/Ir-rich UG2

Closed SA PGM mining capacity



Source: SFA (Oxford)

% of 2021 global supply



Source: SFA (Oxford)

Sibanye-Stillwater's K4 shaft and the Two Rivers Merensky expansion project are now included in SFA's base case, adding 25 koz Ru and 5 koz Ir to supply by 2025. Brownfield projects are also active. Anglo American Platinum is expected to announce the Der Brochen replacement project this year (adding up to 15 koz Ru and 5 koz Ir by 2025), while it also has the options to offset the depletion at Amandelbult with mechanised projects and to expand Mogalakwena. Sedibelo's Triple Crown project (Pilanesberg replacement) and Zimplats' Phase 3 expansion are both in final stages of approval.

Some restarts and brownfield projects are now on the go

Conclusion

The investment case for UG2 mining has never been stronger as the orebody currently commands a premium over all others globally. In South Africa between 2009 and 2016, a significant amount of mining capacity and projects were mothballed (1.6 moz Pt, 0.9 moz Pd, 0.2 moz Rh, 0.4 moz Ru, 0.1 moz Ir). However, some closed capacity has restarted and replacement projects and expansions are likely on the horizon. Nonetheless, SFA estimates that reserve depletion in South Africa (125 koz Pt p.a.) remains a feature in mine profiles over the next decade.

The investment case for UG2 has never been stronger

Unquestionably, the UG2 orebody boasts the best PGM mix to meet future end-user demand from the hydrogen economy owing to its high proportion of ruthenium, iridium and platinum.

It is important that producers work continually in conjunction with end-users to ensure that the future PGM demand ratios are in alignment with planned production. This reduces price volatility and will provide confidence to end-users adopting these precious metals for the long term.

THE PGM MARKETS IN 2020/21



The PGM markets in 2020/21

Dr. Ralph Grimble, SFA (Oxford) Ltd

The platinum market

The effects of Covid-19 resulted in significant drops in both the supply of and demand for PGMs last year. Lockdowns closed both mines and shops, and recycling was impacted too. Automotive, jewellery and industrial demand all fell sharply. However, the net impact on the market balance was modest and the platinum market had another year with a large surplus (ex. investment).

Another year with a >1 moz surplus is in prospect...

This year, with both platinum supply and demand predicted to recover at similar rates, the market once again is forecast to have a significant surplus (>1 moz). In 2020, investment soaked up most of the 1.1 moz surplus. It looked unlikely at this point last year that investment demand would be sufficient, but investors picked up the pace in the second half of the year. The platinum price's wide discount to gold and palladium, a surge in news about developments in the hydrogen economy and confirmation that platinum substitution into gasoline autocatalysts was taking place combined to draw investors back to platinum, and ETF holdings reached new highs.

Can investors absorb the >1 moz surplus for a third year in a row? Once again it appears to be a challenging target. ETF holdings are still edging up but will investors that are already positioned for the reasons given above add more to their holdings? The higher price could result in disinvestment in Japan where investors are price-sensitive and the platinum price is back above the psychological ¥4,000/g level for the first time since 2015.

...but will investors come to the rescue again?

Mine supply

Primary platinum supply was down by 19% last year to 4,950 koz, which was less than 5 moz for the first time since 2014 when mines were impacted by strikes in South Africa. The majority of the decline was in South Africa where output fell 26% to 3,255 koz as a result of Covid-related mine closures, a cautious reopening and processing problems. North American production was 20 koz lower with less severe pandemic-related stoppages. Russian output was down a marginal 5 koz and yield from other regions also dipped by 10 koz. Zimbabwe managed to produce 20 koz more than in 2019.

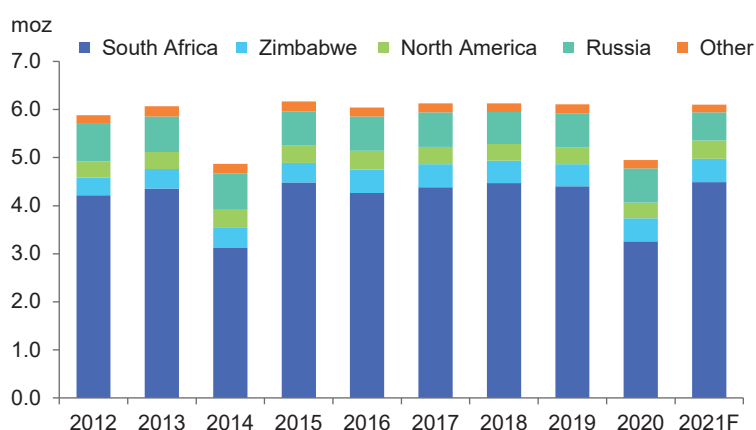
Last year, primary platinum production was less than 5 moz

This year global production is predicted to return to 2019 levels, at 6,100 koz. The recovery would have been even stronger without mine flooding in Russia cutting output there by an estimated 18% to 580 koz. Processing problems in South Africa last year built up a stockpile of material, some of which will be processed this year and is expected to boost refined production to 4,490 koz. A return to normal output levels in Canada and a resumption of the ramp-up at the Blitz project are estimated to increase North American supply to 375 koz. The ramp-up of Zimplats' Mupani and Bimha mines should lift Zimbabwean output while production from other regions declines modestly.

Platinum supply likely to recover to 2019 levels this year

With palladium and rhodium prices continuing to hit record levels, replacement capacity, mine restarts and projects are all being scrutinised. Sibanye-Stillwater decided to restart K4 shaft, Impala Platinum and ARM announced the Two Rivers Merensky project and Anglo American Platinum is likely to invest in Der Brochen to extend Mototolo's mine life.

Primary platinum supply



Source: SFA (Oxford)

Recycling

In 2020, both jewellery and autocatalyst recycling shrank, leading to a decrease of 14% in secondary platinum supply to 1,720 koz. Autocatalyst recycling provides 75% of total secondary platinum supply and with fewer vehicles being scrapped last year, it fell by 13% to 1,300 koz. The drop was not as great as it might have been because refineries were able to operate during lockdowns and could work through the backlog of material that had built up. This year, recycled platinum is forecast to climb by 8% to 1,865 koz, with autocatalyst recycling expected to recover more strongly than jewellery recycling.

Recycling could rebound to 1.9 moz in 2021

Demand

Global platinum demand (ex. investment) slumped by 18% to 5,580 koz last year as the pandemic and lockdowns seriously disrupted economic activity. Total consumption was already below 7 moz in 2019, a level not seen since the aftermath of the credit crisis. The impact of Covid reduced total demand to the lowest level in more than 20 years. Lower vehicle sales and further shrinkage in the diesel passenger car market share in Western Europe weighed on automotive demand. Jewellery demand contracted by 25% as retail sales were hit by lockdowns which closed shops and delayed wedding plans. Industrial demand proved slightly more resilient but was still down by 13% as all segments had lower requirements.

Last year, gross platinum consumption was less than 6 moz for the first time since the 1990s

The economic recovery this year is estimated to lift total demand by 22% to 6,805 koz, close to 2019 levels. Industrial and automotive usage are expected to be higher than in 2019, rebounding by 19% and 33% respectively, while jewellery demand fails to make up all the lost ground. The pandemic is not yet over, and the uneven rollout of vaccines means there is some uncertainty over the strength of the recovery in various countries. India is currently suffering from a surge in infections which could result in forecasts being downgraded.

Platinum demand in 2021 is set to recover to 2019 levels

Automotive demand

At the start of 2020, automotive demand was expected to be marginally lower than in 2019. Instead, the pandemic cut requirements by 17% to 2,315 koz. Lockdowns resulted in the almost complete cessation of light-vehicle sales in some European countries and India in April. Although car sales subsequently rebounded, they were held back by economic uncertainty and further restrictions being imposed later in the year as Covid cases ramped up again. BEV and hybrid sales performed strongly whereas diesel car sales suffered, taking the market share of diesel passenger cars in Western Europe below 30% for the first time in more than 10 years. With online sales taking over from in-store sales, the need for goods delivery helped heavy-duty vehicle (HDV) sales recover strongly in the second half of the year.

Automotive demand dropped 17% last year

This year, autocatalyst demand is predicted to make the largest contribution to platinum consumption growth, gaining 710 koz to 3,025 koz. Growth will be driven by recovering vehicle sales, higher loadings to meet stricter HDV emission standards in China and India, and the beginning of some substitution in gasoline three-way catalysts (TWCs). Western Europe's diesel share is forecast to decline further but the expansion of light-vehicle sales means that diesel vehicle numbers are projected to be only modestly lower than in 2020. This year, HDV demand gains from the first full year of Bharat VI regulations in India and the introduction of China VI emissions standards in July.

Western European diesel car market share fell below 30%

Tightening emissions standards in India and China lift heavy-duty requirements this year

Speculation about the substitution of some platinum into TWCs at the expense of palladium started almost as soon as palladium first traded at a premium to platinum in late 2017. It was confirmed last year that the research had been done and this year catalysts with the new formulation are starting to appear on vehicles. While the impact on platinum usage in 2021 is forecast to be modest, with palladium still trading at twice the price of platinum a broader rollout of these catalysts is likely and platinum demand will benefit.

Substitution of platinum into gasoline autocatalysts should add modestly to demand this year

Jewellery demand

Last year, global platinum jewellery demand slumped by 25% to 1,575 koz owing to a combination of lockdowns, cautious consumers and delayed weddings. The largest contraction in volume terms was in China, although the country was the least bad performer on a percentage basis, and purchasing by manufacturers was better than expected.

Jewellery demand fell by 25% in 2020

This year, jewellery consumption is projected to rise by 13% to 1,770 koz. Although the pandemic is still causing problems, particularly in India, all regions are predicted to see growth in demand amid improved economic prospects and a return to more normal retail conditions over the course of the year. Demand in China is estimated to recover by 10% but that still leaves it well below 2019 levels. Fabricators took the opportunity of the sell-off last year to stock up, but consumer demand has not yet recovered to the same extent.

Covid and cautious shoppers to limit jewellery demand recovery

Industrial demand

Industrial platinum requirements decreased by 13% to 1,690 koz last year as the pandemic disrupted demand across all regions. The petroleum industry accounted for the largest fall owing to oil refinery closures, slower refinery capacity expansion and lower refinery utilisation rates. Chemical, electrical, glass, medical and other end-uses all declined.

Industrial usage forecast to expand by 19% this year

In 2021, industrial demand is predicted to increase by 19% to 2,010 koz, mainly owing to robust rebounds in petroleum, chemical and other applications. Net petroleum requirements are set to be bolstered by greater oil refinery capacity expansions and a major gas-to-liquids plant. With growing vehicle production, more automotive sensors and plugs will be needed, boosting other end-use demand.

Investment and movement of above-ground stocks

Investment demand had another strong year in 2020 despite significant sales from ETFs in March and April, as the platinum price collapsed in the midst of the first wave of the pandemic. By the end

The Platinum Standard

of the year, ETFs had gained 500 koz and bar and coin demand hit 450 koz. Increased mintages led to higher coin sales and the price collapse in March resulted in a surge in bar buying in Japan. However, Japanese investors started to sell some of their bars in Q4'20 as the price rose.

Platinum ETF holdings are near record highs

So far this year, investment demand has been modest. ETF holdings have risen by 58 koz and at 3.91 moz are just shy of the record level set in April. Coin sales have been robust but with the price above the psychological ¥4,000/g level for the first time since 2015 there is a risk that disinvestment in Japan could result in a net supply of bars to the market.

The high price could induce disinvestment of bars in Japan

The palladium market

After all the turbulence caused by Covid lockdowns, the palladium market in 2020 ended up with a deficit of 220 koz. This was considerably smaller than predicted at the start of the year. Despite disruptions cutting supply, particularly from South Africa, palladium's exposure to the automotive industry meant that the substantial drop in light-vehicle sales (>12.5 million units) pulled demand down by over 1 moz. With industrial and jewellery requirements also declining, gross consumption of 9,010 koz was more than 1.3 moz lower than in 2019.

Total demand was just 9 moz last year

The palladium market was initially expected to have an even smaller deficit in 2021 than in 2020. However, upgrades to light-vehicle sales forecasts have resulted in higher automotive demand projections and operational problems in Russia have cut refined production estimates by more than 500 koz, likely leaving the market with a deficit of close to 1 moz.

This year, the palladium market deficit expands to close to 1 moz as Russian supply is curtailed while demand recovers

Last year, global palladium production declined by 11% to 6,395 koz. Supply from South Africa fell 28% to 1,845 koz as mines were temporarily closed at the start of the lockdown and then operated at reduced capacity, with some mines taking the rest of the year to return to full operational capacity. Output from Russia slipped 2% to 2,810 koz but that was mostly the result of stock being processed in 2019, lifting that year's output, rather than the effect of the pandemic. Zimbabwe was the only region that managed to increase output last year owing to the ramp-up of the Bimha and Mupani mines.

This year, South African palladium supply is predicted to rise by more than 40% to 2,650 koz, including the processing of some pipeline stocks that built up last year.

However, with Russian output suffering from both a processing outage and mine flooding, refined production there is expected to be more than 500 koz lower this year. With higher output from Zimbabwe and North America, global palladium production is projected to be 5% higher than last year at 6,740 koz.

Primary palladium supply is projected to expand by 5% this year...

Secondary palladium supply is forecast to rebound by 16% to 2,785 koz. With the automotive market recovering, more old vehicles are likely to be scrapped, helping to bolster the total. More Euro 5 cars are being scrapped in Western Europe which means that the average loading on the catalysts is also rising. High palladium and rhodium prices are incentivising the recovery of spent autocatalysts but also mean that recyclers need to allocate more working capital to acquire the catalysts.

...while secondary supply jumps by 16%

Palladium demand is estimated to climb by 16% this year to 10,485 koz, which makes it slightly higher than in 2019. Automotive demand is projected to rebound by 19% to 8,770 koz. Having been less severely impacted in 2020 than many countries, China is expected to lead the way with light-vehicle sales above those seen last year. However, globally light-vehicle sales are not likely to get back to 2019 levels and the early stage of the rollout of catalysts with some platinum substituted for some palladium slightly limits the upside this year. However, with further tightening of emissions standards, higher catalyst loadings mean overall metal requirements are higher than in 2019.

Palladium demand this year exceeds 2019's level as light-vehicle sales rebound

Industrial demand is predicted to increase by 2% to 1,510 koz in 2021. Stronger economic activity is set to lift requirements in the chemical and other sectors even as the high price continues to weigh on electrical demand.

The rhodium market

The rhodium market is anticipated to see an expanded deficit of 90 koz this year, as the revival in demand outweighs the supply recovery.

The rhodium market remains in deficit in 2021

Global rhodium production dropped 21% to 630 koz last year, owing to the sharp contraction in South African output, while production elsewhere was little changed. South African supply slumped by 26% to 475 koz after Covid mitigation efforts, which temporarily closed mines and reduced operating capacity once mining restarted, were compounded by processing problems which reduced refined output.

Total supply is estimated to rebound by 24% to 775 koz this year. The anticipated recovery in South Africa, including the processing of some pipeline stocks, is predicted to boost rhodium output to 635 koz. This more than offsets the mine flooding incident in Russia which is expected to cut yield there to 65 koz.

Secondary rhodium supply is projected to grow by 9% to 365 koz this year as the anticipated recovery in the car market leads to larger numbers of old vehicles being scrapped.

Rhodium consumption is predicted to expand by 21% to 1,230 koz this year after slipping 12% to 1,015 koz last year. Rhodium demand is dominated by the automotive industry, and the ongoing tightening of emissions standards, combined with the rebound in light-vehicle sales, is set to lift automotive requirements to 1,085 koz this year, exceeding 1 moz for the first time. Industrial rhodium demand is forecast to grow by 7% to 145 koz as a result of increasing economic activity.

Automotive rhodium demand exceeds 1 moz this year for the first time

The price outlook for the next six months

Platinum \$1,175/oz

The platinum market is forecast to have yet another year with a surplus of over 1 moz (ex. investment). Jewellery and automotive demand are both expected to rebound but while automotive usage is estimated to exceed 2019's level, jewellery requirements are predicted to fall some way short. Hydrogen hype and more concrete news of substitution of platinum into gasoline autocatalysts encouraged investment last year, lifting the price. The momentum carried the platinum price to its highest level since 2014 earlier this year. A higher price tends to discourage investment in Japan and ETFs are up by only ~60 koz so far this year, leaving a great deal of metal still to be absorbed by the market. This leaves the price rise looking overdone as we enter platinum's seasonally weaker period, hence the price is expected to average \$1,175/oz.

Platinum's price rise looks overdone

Palladium \$2,950/oz

The automotive market is predicted to rebound this year but now has to contend with chip shortages reducing production and risks failing to keep up with recovering consumer demand. Automakers are finding ways to deal with the problem, including building cars without the chip-less component and storing them until the part can be installed. Therefore, the impact on palladium demand looks modest and certainly less than the supply disruption in Russia which has resulted in a notable increase in the deficit expected this year, enabling the palladium price to reach \$3,000/oz for the first time.

Supply disruption could impact Q3

The price has run up ahead of the actual dip in refined output from Russia which is likely in Q3 owing to the lengthy processing pipeline, but an average of \$2,950/oz is anticipated. Price risks remain to the upside and any further supply shortfalls could see the price move even higher.

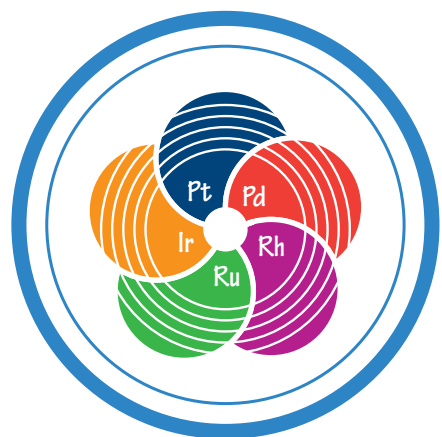
Rhodium \$29,000/oz

The recovery in the automotive sector is expected to take automotive rhodium demand above 1 moz this year for the first time. Although chip shortages have developed into a longer-lasting problem than initially thought, automakers are finding solutions and still producing cars.

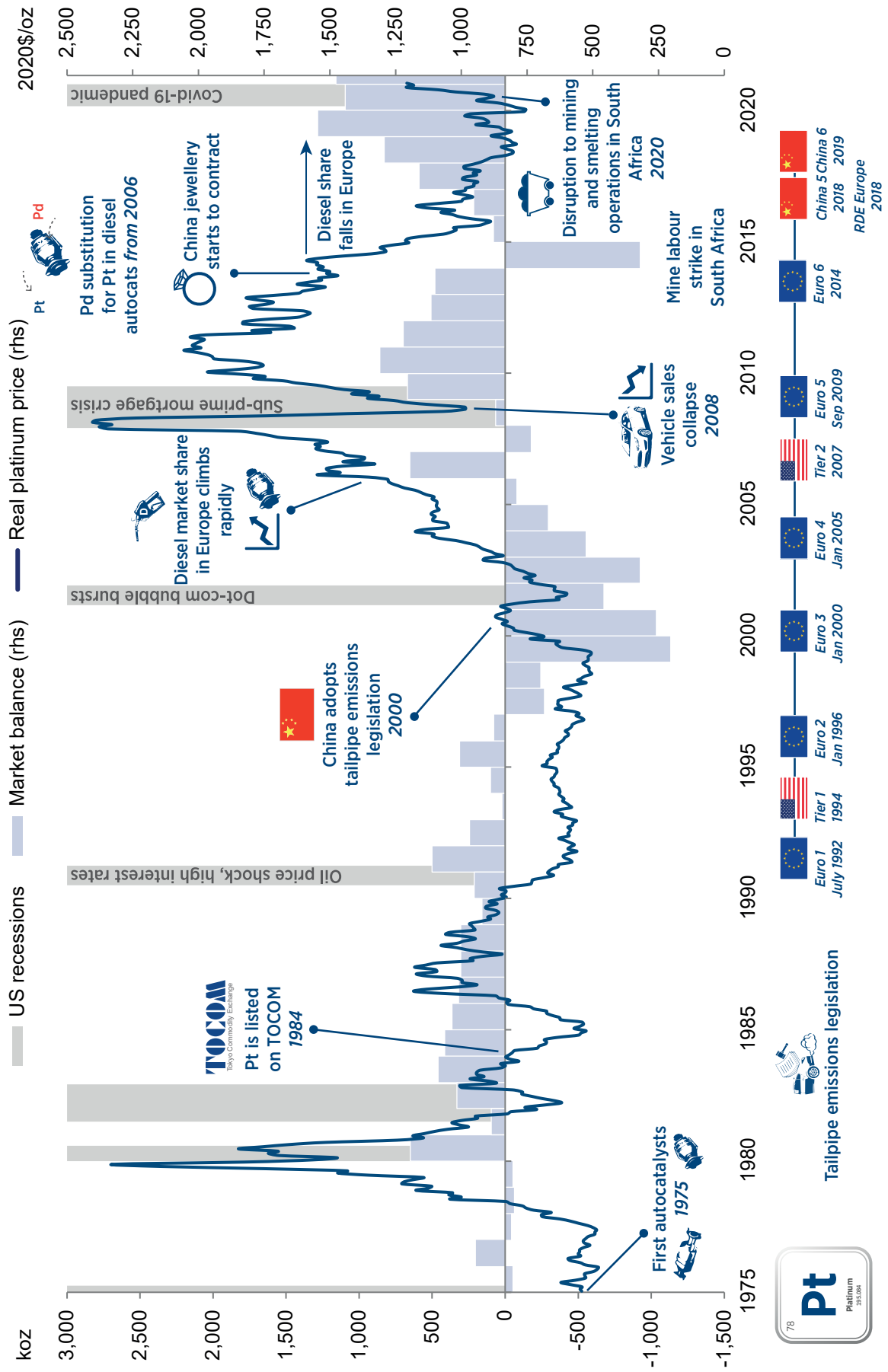
Record automotive demand and a record price

Unprocessed stocks held in South Africa are likely to be refined during the year, boosting supply. The production loss in Russia is relatively small but any drop in output is a problem with such a tight market. Overall, the market is predicted to remain in deficit and the price is estimated to average \$29,000/oz over the next six months. However, the price risks are to the upside and any further supply disruptions could easily see the price jump higher.

PGM PRICE HISTORY

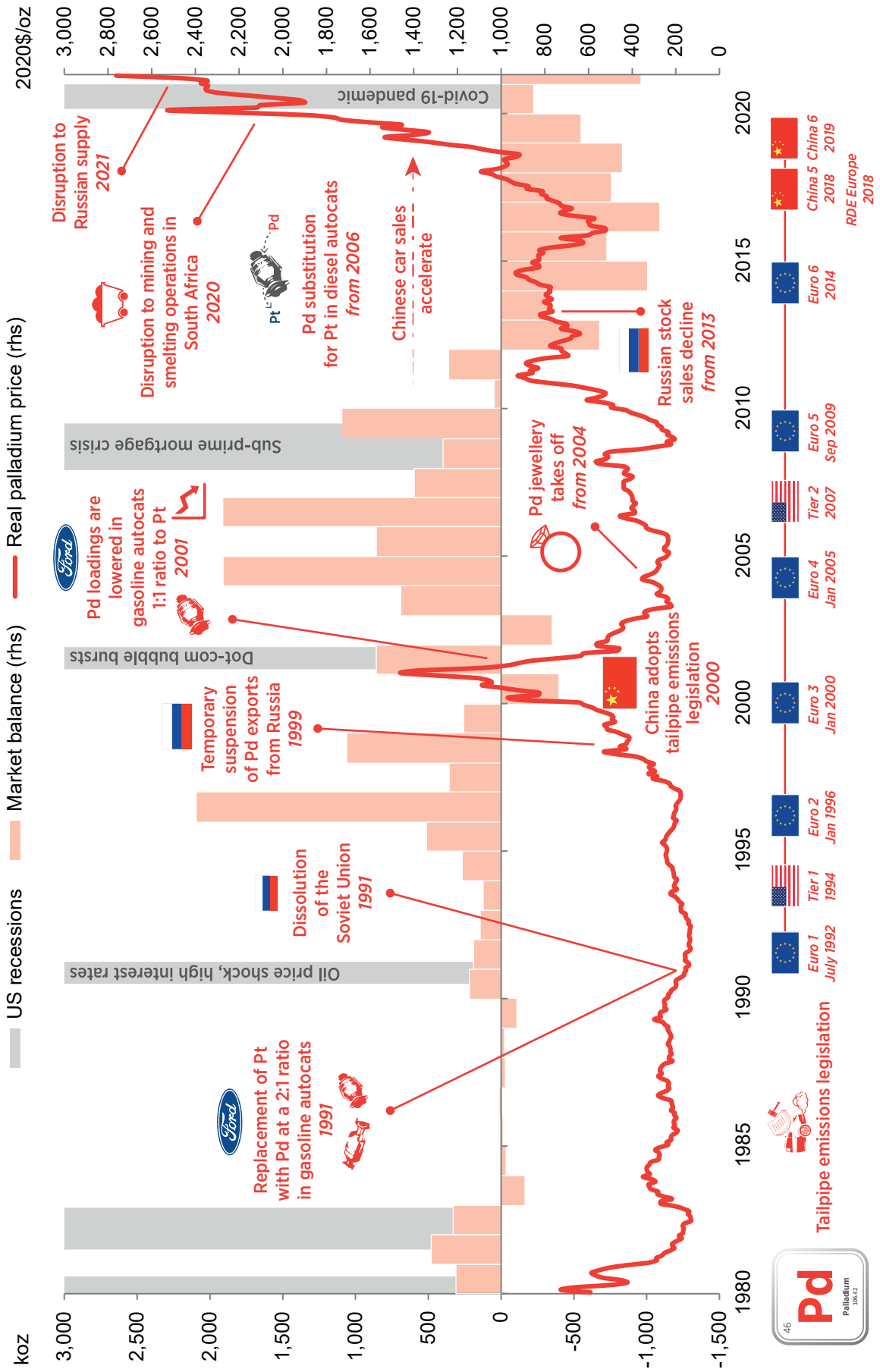


Platinum



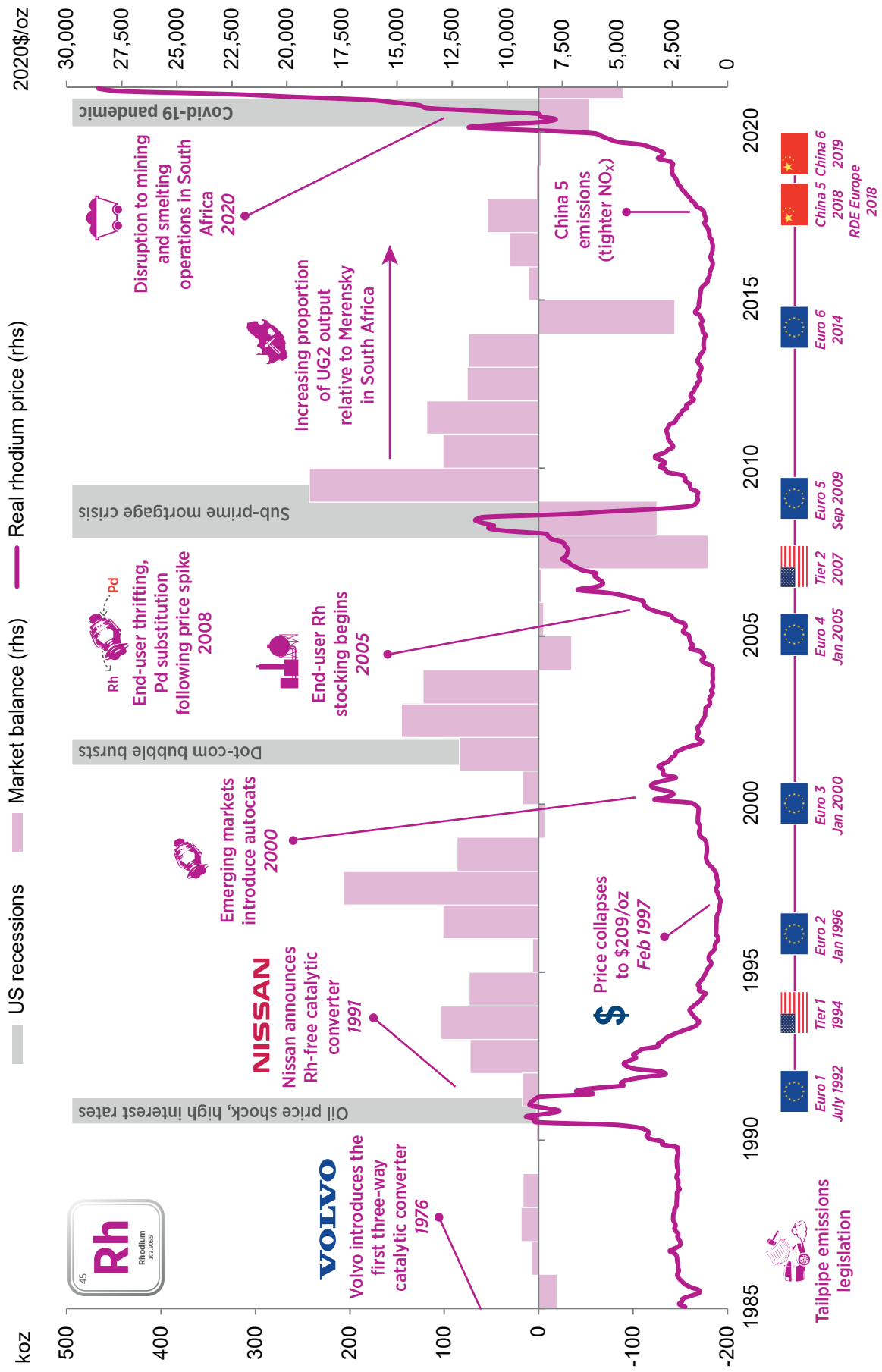
Source: SFA (Oxford), Bloomberg

Palladium



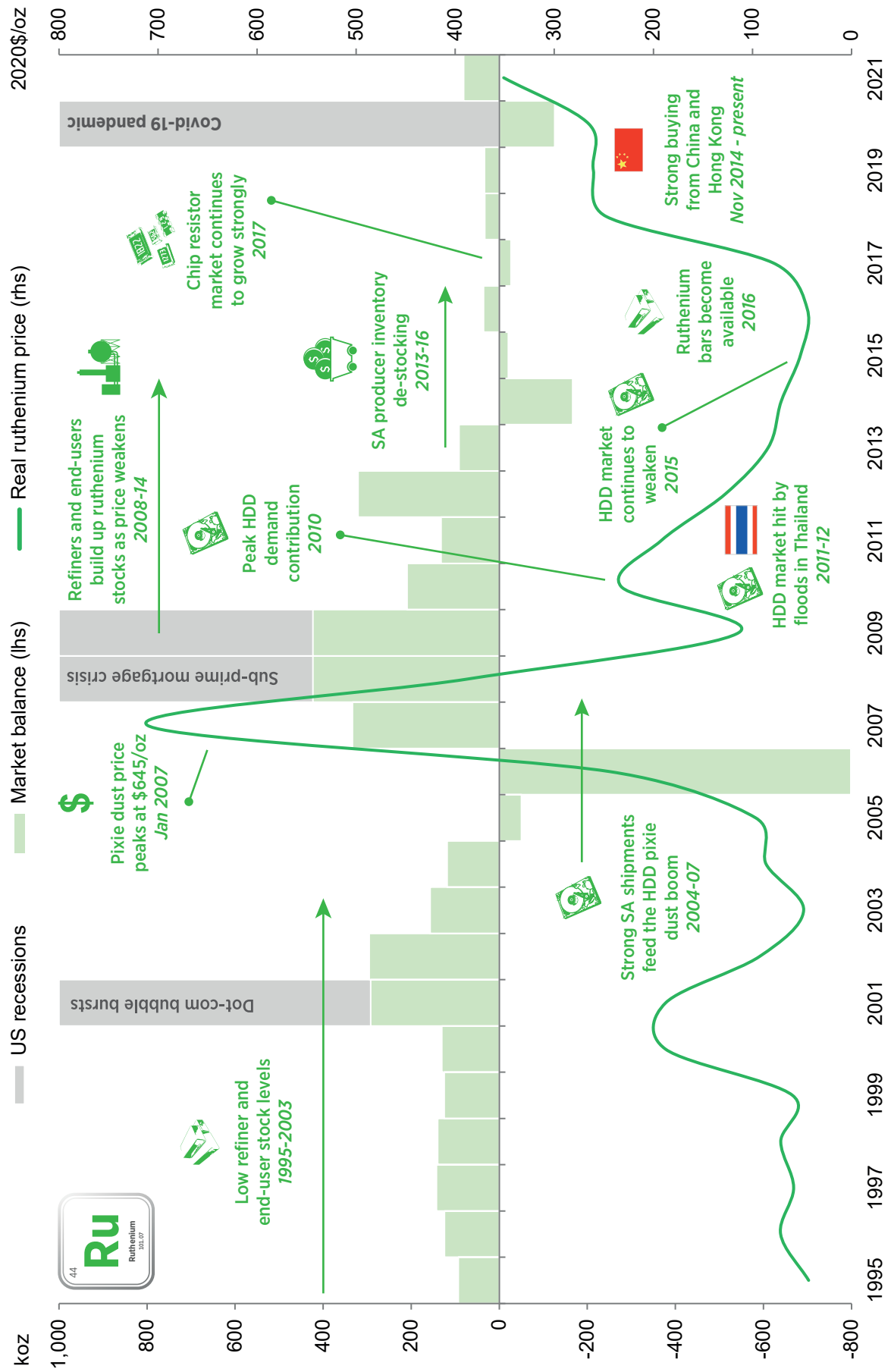
Source: SFA (Oxford), Bloomberg

Rhodium

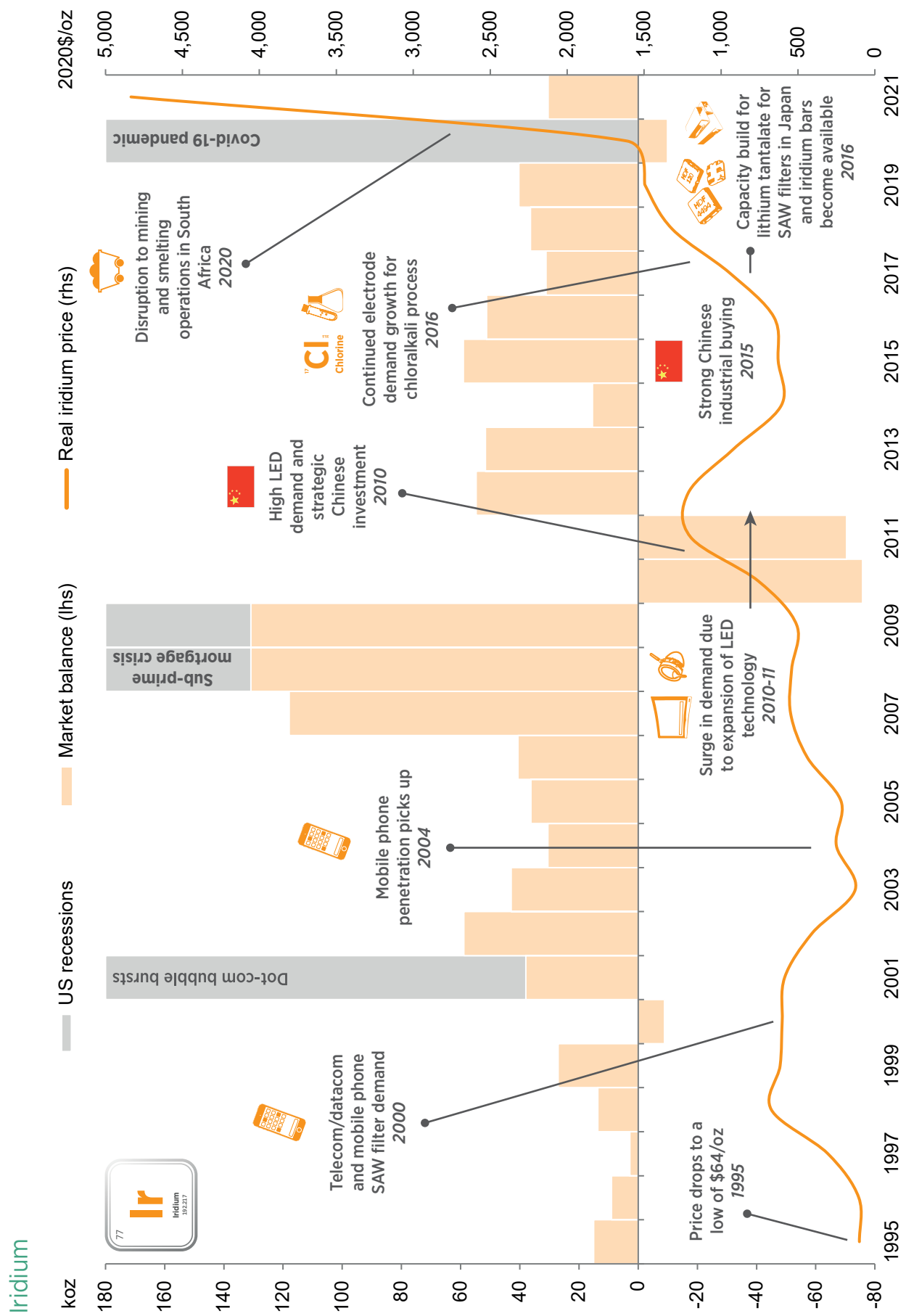


Source: SFA (Oxford), Bloomberg

Ruthenium



Source: SFA (Oxford), Bloomberg



Source: SFA (Oxford), Bloomberg

Battery Raw Materials

Price Radar Report Q1'21



Follow the evolving influences on the lithium, nickel and cobalt markets and prices with our Battery Raw Materials Quarterly Report

Bringing together SFA (Oxford)'s expertise in the lithium, cobalt and nickel markets, this quarterly Price Radar Report is designed to aid investors and industry stakeholders to monitor and contextualise market impacting events.

The market is evolving rapidly and if you are not following it every day for client projects, as we are, it is easy to miss major market impacting developments. **Our battery industry analysts, chemists, battery supply chain experts and on-the-ground China office help to capture these rapid developments and tease out what you need to know.** Our Battery Raw Materials Quarterly reports **forensically evaluate the state of the EV ecosystem to establish the existing (and emerging) opportunities and threats for investors** and industry stakeholders alike. The report is **coexistent with and linked directly to SFA's PGM analysis and market view.** The key themes of the Q1'21 issue include:

- Analysis of 2020 full-year EV sales, major OEM developments, and latest EV forecast revisions following the **effects of Covid-19** on the sector, and what this mean for medium-term demand for **lithium, nickel and cobalt.**
- Have apparent **changes to consumer sentiment as a result of Covid-19-related lockdowns** actually improved the EV market outlook?
- **How is market sentiment affecting prices** ahead of looming market deficits?
- **Which producers have fared best** during the pandemic?
- What changes have been witnessed in the **lithium carbonate and nickel sulphate precursor markets?**
- Evaluating where the **next wave of lithium supply** will come from.
- Evaluating **Tsingshan's NPI-matte technology's** impact on the nickel market.
- Evaluating the **supply impact from Nornickel's suspension** of mine operations.
- How might **above-ground stocks and destocking affect the prices** in the short to medium term?
- Updated supply-demand balances for cobalt, lithium and nickel, out to 2025.

The Battery Raw Materials Quarterly Report is available covering lithium, cobalt and nickel or a bespoke version can be provided covering any one or two of these metals.

APPENDIX



Platinum supply-demand balance

koz	2013	2014	2015	2016	2017	2018	2019	2020	2021f
Primary supply									
Regional									
South Africa	4,355	3,135	4,480	4,265	4,385	4,470	4,405	3,255	4,490
Russia	740	740	710	715	720	665	710	705	580
Zimbabwe	405	405	405	490	480	465	460	480	490
North America	355	395	365	390	360	345	350	330	375
Other	215	200	200	185	185	180	185	175	160
Total	6,070	4,870	6,165	6,045	6,125	6,130	6,105	4,950	6,100
Demand & recycling									
Autocatalyst									
Gross demand	3,130	3,245	3,250	3,350	3,285	3,065	2,800	2,315	3,025
Recycling	1,120	1,255	1,185	1,210	1,325	1,420	1,495	1,300	1,415
Net demand	2,010	1,990	2,065	2,140	1,960	1,650	1,305	1,010	1,610
Jewellery									
Gross demand	2,950	3,000	2,835	2,510	2,450	2,245	2,090	1,575	1,770
Recycling	855	775	515	625	560	505	500	410	440
Net demand	2,090	2,225	2,325	1,885	1,890	1,740	1,595	1,165	1,330
Industrial demand	1,490	1,555	1,680	1,765	1,650	1,850	1,885	1,630	1,925
Hydrogen	5	25	25	45	50	75	50	60	85
Other recycling	5	5	5	5	10	10	10	10	10
Gross demand	7,575	7,825	7,795	7,675	7,435	7,235	6,825	5,580	6,805
Recycling	1,985	2,035	1,705	1,845	1,895	1,930	2,000	1,720	1,865
Net demand	5,595	5,795	6,090	5,830	5,540	5,305	4,825	3,855	4,940
Market balance									
Balance (before ETFs)	480	-920	75	210	585	825	1,280	1,095	1,160
ETFs (stock allocation)	905	210	-240	-10	100	-240	995	500	
Balance after ETFs	-425	-1,130	315	220	485	1,065	285	595	

Source: SFA (Oxford)



Platinum demand and recycling summary

koz	2013	2014	2015	2016	2017	2018	2019	2020	2021f
Gross demand									
Autocatalyst									
North America	425	465	480	410	375	355	335	290	405
Western Europe	1,350	1,395	1,450	1,640	1,550	1,330	1,140	790	925
Japan	585	585	510	450	440	430	410	330	330
China	130	125	145	195	230	220	245	395	680
India	165	170	180	170	175	195	155	105	190
RoW	475	505	485	485	515	535	515	405	495
Total	3,130	3,245	3,250	3,350	3,285	3,065	2,800	2,315	3,025

Platinum demand and recycling summary (continued)

koz	2013	2014	2015	2016	2017	2018	2019	2020	2021f
Gross demand									
Jewellery									
North America	200	230	250	265	280	280	275	210	250
Western Europe	220	220	235	240	250	255	260	190	210
Japan	335	335	340	335	340	345	330	245	270
China	1,990	1,975	1,765	1,450	1,340	1,095	945	755	825
India	140	175	180	145	175	195	210	120	155
RoW	60	65	70	70	75	75	75	55	65
Total	2,950	3,000	2,835	2,510	2,450	2,245	2,090	1,575	1,770
Industrial									
North America	320	315	245	385	335	335	285	220	320
Western Europe	185	235	290	265	265	305	290	270	270
Japan	90	25	85	70	30	90	90	75	90
China	520	450	525	580	545	485	550	545	580
RoW	375	530	535	465	475	635	670	520	665
Total	1,490	1,555	1,680	1,765	1,650	1,850	1,885	1,630	1,925
Hydrogen	5	25	25	45	50	75	50	60	85
Total gross demand									
North America	950	1,020	980	1,070	1,000	990	910	730	990
Western Europe	1,760	1,855	1,980	2,155	2,070	1,895	1,690	1,250	1,400
Japan	1,010	950	945	880	835	895	850	675	730
China	2,640	2,555	2,440	2,225	2,110	1,805	1,740	1,705	2,105
RoW	1,220	1,450	1,450	1,340	1,420	1,655	1,640	1,220	1,580
Total	7,575	7,825	7,795	7,675	7,435	7,235	6,825	5,580	6,805
Recycling									
Autocatalyst									
North America	560	560	510	530	585	640	645	575	560
Western Europe	365	470	370	400	440	465	505	425	520
Japan	95	105	95	90	100	110	115	100	115
China	20	30	55	40	40	35	40	30	35
RoW	80	90	155	150	160	170	190	170	185
Total	1,120	1,255	1,185	1,210	1,325	1,420	1,495	1,300	1,415
Jewellery									
North America	0	0	5	5	5	5	5	5	5
Western Europe	0	5	5	5	5	5	5	5	5
Japan	250	235	160	150	160	145	140	110	115
China	600	530	340	460	385	340	340	285	305
RoW	5	5	5	5	5	10	10	5	10
Total	855	775	515	625	560	505	500	410	440
WEEE	5	5	5	5	10	10	10	10	10
Total recycling									
North America	560	565	515	535	590	645	650	580	570
Western Europe	365	475	375	405	445	470	515	430	525
Japan	345	340	255	245	265	255	255	210	230
China	625	560	395	500	425	380	380	320	340
RoW	90	95	165	160	170	180	200	180	200
Total	1,985	2,035	1,705	1,845	1,895	1,930	2,000	1,720	1,865

Source: SFA (Oxford)



Palladium supply-demand balance

koz	2013	2014	2015	2016	2017	2018	2019	2020	2021f
Primary supply									
Regional									
South Africa	2,360	1,870	2,560	2,375	2,530	2,500	2,555	1,845	2,650
Russia	2,580	2,690	2,605	2,555	2,740	2,670	2,870	2,810	2,290
Zimbabwe	315	330	325	395	395	380	385	405	415
North America	975	1,055	995	1,065	985	1,035	975	950	1,055
Other	450	460	455	420	415	395	395	385	335
Total	6,680	6,405	6,940	6,810	7,065	6,975	7,180	6,395	6,740
Demand & recycling									
Autocatalyst									
Gross demand	7,105	7,475	7,585	7,925	8,135	8,280	8,420	7,385	8,770
Recycling	1,640	1,720	1,605	1,710	1,920	2,035	2,175	2,010	2,330
Net demand	5,465	5,760	5,980	6,215	6,215	6,245	6,250	5,375	6,440
Jewellery									
Gross demand	355	290	245	240	225	220	215	150	200
Recycling	145	120	80	75	70	60	60	50	55
Net demand	205	170	165	165	155	155	155	105	150
Industrial demand	1,985	1,915	1,950	1,905	1,825	1,780	1,695	1,480	1,510
Other recycling	410	435	430	390	380	375	375	345	400
Gross demand	9,445	9,680	9,775	10,075	10,185	10,280	10,330	9,010	10,485
Recycling	2,200	2,270	2,115	2,180	2,370	2,475	2,605	2,400	2,785
Net demand	7,250	7,405	7,660	7,895	7,815	7,805	7,720	6,615	7,700
Market balance									
Balance (before ETFs)-570	-1,005	-720	-1,085	-755	-830	-545	-220	-955	
ETFs (stock allocation)	-5	930	-665	-640	-375	-560	-90	-115	
Balance after ETFs	-565	-1,935	-55	-445	-380	-270	-455	-105	

Source: SFA (Oxford)



Palladium demand and recycling summary

koz	2013	2014	2015	2016	2017	2018	2019	2020	2021f
Gross demand									
Autocatalyst									
North America	1,820	1,930	1,855	1,935	1,845	1,845	1,790	1,460	1,815
Western Europe	1,545	1,665	1,785	1,685	1,700	1,715	1,670	1,245	1,540
Japan	750	740	745	780	805	840	875	770	835
China	1,525	1,705	1,725	1,985	2,050	2,035	2,255	2,415	2,745
India	170	170	185	220	245	265	240	200	310
RoW	1,295	1,265	1,290	1,320	1,490	1,580	1,590	1,295	1,525
Total	7,105	7,475	7,585	7,925	8,135	8,280	8,420	7,385	8,770
Jewellery									
North America	40	35	35	35	35	35	35	30	30
Western Europe	75	60	55	55	55	55	55	25	55
Japan	65	55	50	50	50	50	50	40	50
China	145	120	75	75	60	55	50	40	45
RoW	25	25	25	25	25	25	25	20	25
Total	355	290	245	240	225	220	215	150	200
Industrial									
North America	410	385	400	385	365	335	310	250	255
Western Europe	290	285	290	280	270	255	240	205	215
Japan	415	425	430	405	370	345	310	260	260
China	415	385	395	405	400	420	420	415	420
RoW	455	435	435	430	420	425	415	350	360
Total	1,985	1,915	1,950	1,905	1,825	1,780	1,695	1,480	1,510
Total gross demand									
North America	2,270	2,350	2,295	2,360	2,245	2,215	2,135	1,740	2,105
Western Europe	1,910	2,005	2,130	2,020	2,025	2,020	1,965	1,480	1,805
Japan	1,225	1,220	1,225	1,235	1,225	1,235	1,235	1,070	1,140
China	2,085	2,205	2,195	2,460	2,515	2,505	2,725	2,865	3,215
RoW	1,950	1,895	1,930	2,000	2,180	2,300	2,270	1,865	2,215
Total	9,445	9,680	9,775	10,075	10,185	10,280	10,330	9,010	10,485
Recycling									
Autocatalyst									
North America	1,005	975	895	960	1,060	1,130	1,190	1,130	1,240
Western Europe	345	365	270	260	305	330	335	300	395
Japan	125	135	125	125	145	180	195	185	200
China	50	60	110	160	165	155	165	150	180
RoW	115	185	205	205	245	240	290	245	315
Total	1,640	1,720	1,605	1,710	1,920	2,035	2,175	2,010	2,330
Jewellery									
Japan	20	20	20	15	20	15	15	15	15
China	125	100	60	60	50	45	45	35	40
Total	145	120	80	75	70	60	60	50	55
WEEE									
North America	75	70	85	70	65	65	65	55	60
Western Europe	90	95	75	70	75	70	70	60	70
Japan	135	145	165	135	120	115	110	100	110
China	40	30	25	35	40	40	45	50	65
RoW	70	95	80	80	80	85	85	80	95
Total	410	435	430	390	380	375	375	345	400
Total recycling									
North America	1,080	1,045	980	1,035	1,125	1,195	1,250	1,185	1,305
Western Europe	435	455	345	330	380	400	405	365	465
Japan	280	300	305	275	285	315	325	295	325
China	215	195	195	255	255	240	255	235	285
RoW	190	275	290	285	325	325	370	320	405
Total	2,200	2,270	2,115	2,180	2,370	2,475	2,605	2,400	2,785



Rhodium supply-demand balance

koz	2013	2014	2015	2016	2017	2018	2019	2020	2021f
Primary supply									
Regional									
South Africa	590	425	620	615	620	625	640	475	635
Russia	70	75	70	70	75	75	80	80	65
Zimbabwe	35	35	35	45	45	40	40	45	45
North America	35	30	30	30	25	25	25	25	25
Other	10	10	10	10	10	10	10	10	10
Total	740	580	765	765	775	770	790	630	775
Demand & recycling									
Autocatalyst									
Gross demand	785	840	865	835	865	900	985	880	1,085
Recycling	265	280	260	280	305	335	355	330	360
Net demand	525	565	605	555	565	565	630	545	725
Industrial demand	145	160	150	175	155	205	165	135	150
Other recycling	1	2	2	2	2	2	2	2	3
Gross demand	935	1,005	1,020	1,015	1,025	1,110	1,150	1,015	1,230
Recycling	265	280	265	280	305	340	355	335	365
Net demand	670	720	755	735	720	770	795	680	865
Market balance									
Balance (before ETFs)	75	-145	10	30	55	0	-5	-55	-90
ETFs (stock allocation)	50	5	-5	5	-20	-50	-15	-10	
Balance after ETFs	25	-150	15	25	75	50	10	-45	

Source: SFA (Oxford)



Rhodium demand and recycling summary

koz	2013	2014	2015	2016	2017	2018	2019	2020	2021f
Gross demand									
Autocatalyst									
North America	220	240	240	235	230	225	220	175	215
Western Europe	200	225	250	210	210	225	285	220	280
Japan	140	140	125	125	125	130	130	110	115
China	95	110	110	130	150	155	180	235	305
India	15	15	15	20	20	20	20	15	25
RoW	115	115	120	115	130	145	150	120	140
Total	785	840	865	835	865	900	985	880	1,085
Industrial									
North America	15	15	10	20	15	15	15	15	15
Western Europe	10	15	10	15	10	25	20	10	15
Japan	35	25	30	25	30	30	30	30	30
China	45	50	50	60	50	55	45	40	45
RoW	40	55	50	55	50	80	55	40	45
Total	145	160	150	175	155	205	165	135	150
Total gross demand									
North America	235	255	255	255	245	240	235	190	230
Western Europe	210	240	265	225	225	250	305	235	295
Japan	175	160	155	155	155	160	160	140	150
China	140	160	160	190	200	210	225	275	350
RoW	175	185	185	190	205	245	225	180	210
Total	935	1,005	1,020	1,015	1,025	1,110	1,150	1,015	1,230
Recycling									
Autocatalyst									
North America	170	165	150	160	165	180	190	180	190
Western Europe	55	60	45	50	55	60	65	60	70
Japan	25	30	30	35	40	45	45	40	45
China	5	5	10	5	5	5	5	5	10
RoW	10	20	25	30	40	45	50	45	45
Total	265	280	260	280	305	335	355	330	360

Source: SFA (Oxford)



GLOSSARY OF TERMS

ARM

African Rainbow Minerals Ltd.

Basket price

Collective revenue of metals divided by 4E oz.

BEV

Battery electric vehicle.

Bharat VI

India's current heavy-duty vehicle emissions standard.

CAGR

Compound annual growth rate.

CAPEX

Capital expenditure.

CCM

Catalyst coated membrane.

China VI

China's current heavy-duty diesel vehicle emissions standard.

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.

HRS

Hydrogen refuelling station.

ICE

Internal combustion engine.

koz

A thousand troy ounces.

LED

Light-emitting diode.

LOHC

Liquid organic hydrogen carrier.

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.

MRAM

Magnetoresistive random-access memory.

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

Oxides of nitrogen.

OEM

Original equipment manufacturer.

oz

Troy ounce.

PEM EL

Polymer electrolyte membrane electrolysis.

PGI

Platinum Guild International.

PGM

Platinum-group metals.

POS

Point of Sale.

Primary supply

Mine production.

ReRAM

Resistive random-access memory.

R&D

Research and development.

SAW filter

Surface acoustic wave filter.

Secondary supply

Recycling output.

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.

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.

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NOTES

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