# PLATINUM ESSENTIALS

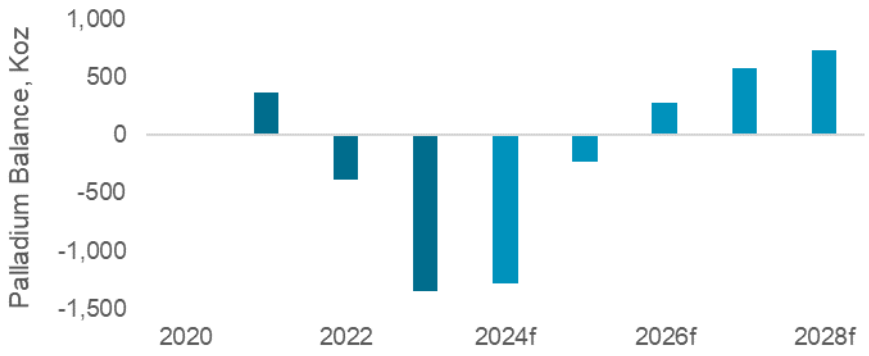
## Updated palladium supply/demand outlook: Reduced supply and stronger near-term demand prolong larger deficits

*This Platinum Essentials presents our updated estimates for palladium market balances from 2024 through 2028. Palladium is still forecast to transition into a market surplus, but this is delayed by a year to 2026 and the deficit in 2024 is increased by over 1 Moz to 1,281 koz. Both changes are supply driven, with mine supply expectations cut back by producer restructuring and maintenance, and recycling supply growth being delayed. Indeed, the projected transition to a surplus is entirely contingent on a significant increase to recycling (up by >1.3 Moz p.a. by 2028), but this outlook is predicated on a number of challenges being resolved. Any delays to solving these issues could easily slow the pace of the growth in recycling supply, resulting in deeper and more persistent deficits and further postpone the surplus. This would in turn feed into value expectations and provide upward support for palladium prices.*

Forecast five-year palladium market imbalances are more dependent on supply growth, particularly recycling, than demand decline. More PGM-rich vehicles produced during periods of rising emission standards are now reaching end-of-life, and are expected to increase annual palladium recycling supply by more than 1.3 Moz p.a. by 2028. The compound annual growth rate (CAGR) of 9% from 2023 to 2028, is nearly twice that of platinum recycling. Near-term deficits are deeper than our previous forecasts, and the tipping point into a market surplus is delayed to 2026 from 2025. This is due to higher automotive demand and lower mine supply, together with a slower-than-expected recovery in automotive recycling. Nevertheless, the anticipated substantial growth in recycling supply is expected to increase the availability of the metal over the longer term, leading to a palladium surplus of 725 koz in 2028. However, there are significant downside risks to the pace of growth in recycling supply due to the ongoing shortage of end-of-life vehicles and regulatory challenges. Should these headwinds persist, they could increase near-term deficits and further delay the transition into a surplus.

In contrast, the outlook for platinum is much more constructive over the longer-term. Compared to palladium, platinum faces the same downside risks to supply and the potential for higher-for-longer automotive ICE demand, but it also benefits from a more diversified demand base and significant growth in demand from an emerging hydrogen economy. We forecast the platinum market to remain in deficit for the foreseeable future.

*Figure 1. Palladium demand remains resilient with the tipping point into a surplus from 2026 strongly contingent on the pace of recycling growth.*




*Source: Metals Focus from 2020 to 2023f, WPIC Research from 2024f – 2028f*

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**WPIC in-house supply research is based solely on published supply data, including forward looking guidance, with any adjustments noted. It does not represent the views of any WPIC members or those of Metals Focus which independently prepare our Platinum Quarterly reports. Demand data is based on public data but includes WPIC in-house analysis.*

*Figure 2. Palladium supply/demand summary table.*

| | METAL FOCUS ESTIMATES† | | | WPIC PALLADIUM ESTIMATES‡ | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2021 | 2022 | 2023 | 2024f | 2025f | 2026f | 2027f | 2028f |
| **PALLADIUM SUPPLY** | | | | | | | | |
| **Refined mine production** | | | | Production at mid-point of aggregate guidance ranges | | | | |
| - South Africa | 2,726 | 2,238 | 2,337 | 2,272 | 2,408 | 2,381 | 2,386 | 2,404 |
| - Zimbabwe | 407 | 404 | 410 | 385 | 405 | 452 | 474 | 474 |
| - North America | 897 | 822 | 844 | 839 | 842 | 842 | 720 | 599 |
| - Russia | 2,617 | 2,790 | 2,692 | 2,374 | 2,731 | 2,731 | 2,731 | 2,731 |
| - Other | 236 | 234 | 228 | 233 | 233 | 233 | 233 | 233 |
| - Producer inventory movement | | | | | | | | |
| **Total mining supply** | **6,882** | **6,487** | **6,511** | **6,102** | **6,619** | **6,639** | **6,544** | **6,440** |
| **Total recycling** | **3,374** | **2,792** | **2,496** | **2,644** | **3,040** | **3,406** | **3,679** | **3,832** |
| **Total supply** | **10,256** | **9,280** | **9,008** | **8,747** | **9,659** | **10,044** | **10,223** | **10,272** |
| **PALLADIUM DEMAND** | | | | | | | | |
| **Automotive** | **8,033** | **8,011** | **8,588** | **8,450** | **8,326** | **8,222** | **8,096** | **8,006** |
| **Jewellery** | **209** | **224** | **228** | **224** | **224** | **224** | **224** | **224** |
| **Industrial** | **1,572** | **1,504** | **1,457** | **1,387** | **1,377** | **1,357** | **1,361** | **1,351** |
| **Total investment** | **76** | **-70** | **87** | **-34** | **-34** | **-34** | **-34** | **-34** |
| - Bar & coin | 23 | 18 | 1 | 1 | 1 | 1 | 1 | 1 |
| - ETF | 53 | -88 | 86 | -35 | -35 | -35 | -35 | -35 |
| **Total demand** | **9,891** | **9,669** | **10,360** | **10,027** | **9,893** | **9,770** | **9,648** | **9,547** |
| **Supply/demand balance** | **365** | **-389** | **-1,352** | **-1,281** | **-234** | **274** | **575** | **725** |

*Source: Metals Focus from 2021 to 2023, Company guidance, WPIC Research from 2024f*

## Key projections

In our second edition of *Platinum Essentials* palladium supply/demand outlook, we unpack the palladium market and compare our outlook to our previous forecast published in September 2023. Since then, macroeconomic conditions have improved, albeit remaining volatile, with geopolitical uncertainties abound. Inflation has slowed, but remained persistently above central bank targets, leading to a higher-for-longer interest rate environment, which is typically negative for hard and consumer assets. In the Middle East, wider regional conflict is a concern following recent developments, including disruption of shipping transporting petroleum. The IMF has previously indicated that a 10% rise in the price of crude would raise global inflation by 0.4%. The impact of conflict contagion could reduce the positive impact central banks have had on controlling inflation, which, may hamper automotive and industrial growth as financing costs remain elevated.

### Key highlights for 2024:

- **The Palladium Balance:** is forecast to remain in a deep deficit for 2024, albeit reduced by 5% year-on-year, driven by supply side disruption.
- **Palladium Above Ground Stocks:** despite consecutive market deficits the palladium forward curve remains in deep contango, suggesting adequate supply from above ground stocks at current prices.
- **Automotive palladium demand:** We anticipate a slowdown in global vehicle production in 2024 following a robust performance in 2023, driven primarily by pent-up demand. With a muted macroeconomic backdrop, we forecast a marginal decrease of -2% in automotive palladium demand.
- **Total mining supply**: Expected to drop -6% year-on-year as Nornickel postponed planned maintenance of the Nadezhda furnace into 2024.

*Both supply and demand have been lowered in our latest outlook*

- **Recycling supply:** Recycling supply is forecast to grow 6% year-on-year as spent autocatalyst collection supply chains recover, albeit remaining 25% below the 2021 level.

**For the period 2025-2028, we have made the following key revisions to our projections:**

- **Total mining supply** is revised -6% lower on average as mines restructure in reaction to lower metal prices.
- **Total recycling supply** is forecast to be -8% lower that our previous forecast on average. End-of-life vehicle volumes continued to suffer in 2023 leading to an extended forecast recovery in recycling volumes.
- **Automotive palladium demand** is forecast to be -2% lower on average over the forecast period. Slower BEV penetration, increased hybridisation and reverse substitution are offset by the slower introduction of new emission regulations.
- **Industrial demand** is forecast to be 5% higher on average due to upward revisions for electrical palladium demand with lower metal prices expected to slow the pace of thrifting and substitution.

Fundamentally the palladium market dynamic is unchanged with the supply/demand balance, pivoting from consecutive market deficits to growing surplus within the forecast horizon. However, supply side changes to our five-year outlook have impacted timing, with lower primary and secondary supply acting to push back the tipping point for the palladium market to enter a deficit by an additional year, with 2026 now expected to be the point when a modest surplus is expected. In addition, a reduced supply outlook reduces the magnitude of market surpluses thereafter.

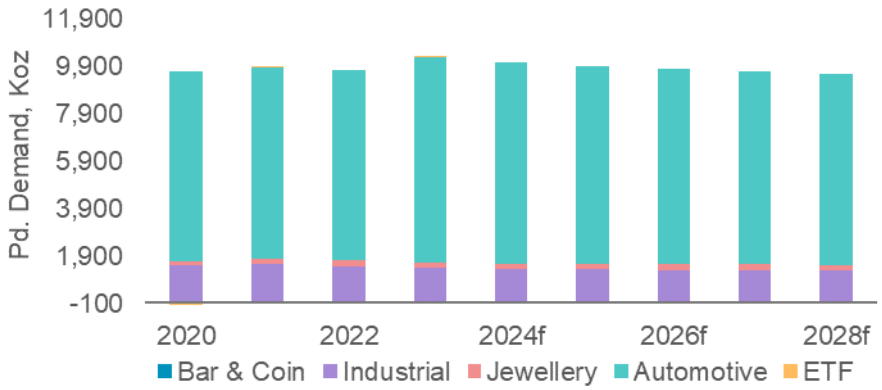
## Conclusion – Year-on-year surplus

In September 2023, we forecast the palladium market would transition into a structural surplus by 2025. We still expect the market to move into surplus, but now anticipate a delay in this turning point to 2026, mostly due to a slower-than-expected recovery in automotive recycling supply. Demand remains resilient, with automotive demand only declining at a -1% CAGR to 2028, as palladium for platinum substitution and increased hybridisation offset lower pure ICE output. Growing recycling supply is the key driver of the market surplus, with a total increase of over 1.3 Moz per annum by 2028 (versus 2023). This growth is primarily attributed to the end-of-life vehicles projected to be scrapped in this time period being palladium-heavy vehicles, combined with a recovery in scrappage rates.

Despite 2024 representing a third consecutive deficit (and the third largest in the previous 10-years), an extreme level of net short positions in the futures markets suggest the market believes above ground stocks are sufficient to fill the supply/demand balances at current prices. As the market tips into a surplus, we expect reverse substitution – palladium for platinum – to eventually occur. From our methodology this is in 2026 as palladium moves into surplus and availability increases.

Highlighting some risks to the outlook, there are uncertainties regarding the rate of drivetrain electrification, primary mine supply outlook, and the pace of growth in recycling rates. These could all act to further postpone the tipping point into a palladium market surplus.

*Figure 3. Palladium demand remains resilient. Total demand to decline at 1.4% CAGR (2023 to 2024) but remains broadly in line with 2020-2021 levels of demand.*




*Source: Metals Focus from 2020 to 2023f, Company guidance, WPIC Research from 2024f – 2028f*

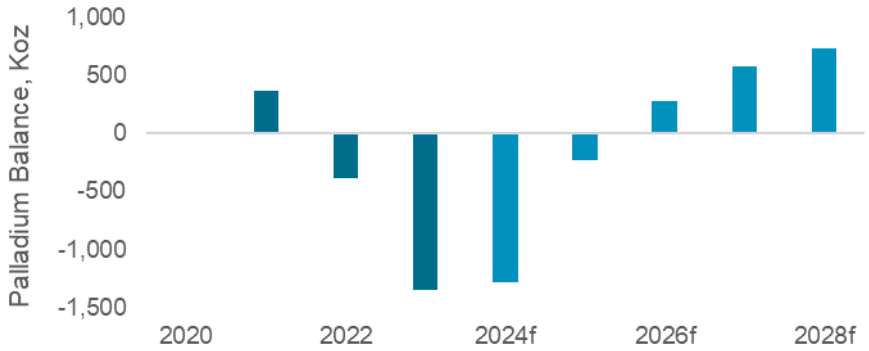
## Risks lean towards a tighter supply outlook:

Similar to its sister metal platinum, continued suppressed metal prices result in downside risks for primary mine supply. Our supply/demand estimates use mine supply numbers that are the aggregate midpoints of published guidance ranges for our forecast time-period. However, it's widely acknowledged that producers face pressure to enhance efficiencies and reduce costs, prompting many PGM miners to announce recent and ongoing restructuring plans. Based on 2023 published data, approximately 25% of the mine supply was loss-making. Nevertheless, the upper quartile has notably flattened due to the depreciation of the rand, easing some of the pressure. This trend should further improve with successful implementation of profitability measures.

Similarly, built into our model is the assumption of a recovery in recycling supply. However, a key theme at London Platinum Week has been the ongoing challenges facing the recycling industry and the potential for a slower recovery in output. The challenges facing recycling include a shortage of spent catalytic converters (due to a reduction in end-of-life vehicles and some reported hoarding at scrap yards in anticipation of higher prices), as well as regulatory headwinds in the US and China.

Our projection is for palladium to move into surplus in 2026, with surpluses progressively growing, reaching 725 koz by 2028. In contrast to platinum, the investment case for palladium appears comparatively weaker. However, when factoring in supply side risks and slower developments in electrification, it's important to consider the compounding effects. Each 1% increase in recycling supply equates to 65 koz by 2028, while each 1% increase in automotive demand equates to 80 koz. Given the projected market surpluses, such as 274 koz in 2026, it would only take a moderately lower than expected recovery in recycling rates combined with elevated ICE demand to eliminate the 2026 surplus and for market tightness to continue. We are currently in a period of technological transition, and despite the consensus opinion, a significant improvement in palladium's outlook carries a relatively high probability.

*Figure 4. Palladium balance to move into surplus in 2026. One year later than previously forecast as recycling recovery was slower than expected.*




*Source: Metals Focus from 2020 to 2023, Company guidance, WPIC Research from 2024f – 2028f*

## Electrification and relaxed emission legislation drag slightly on resilient palladium demand:

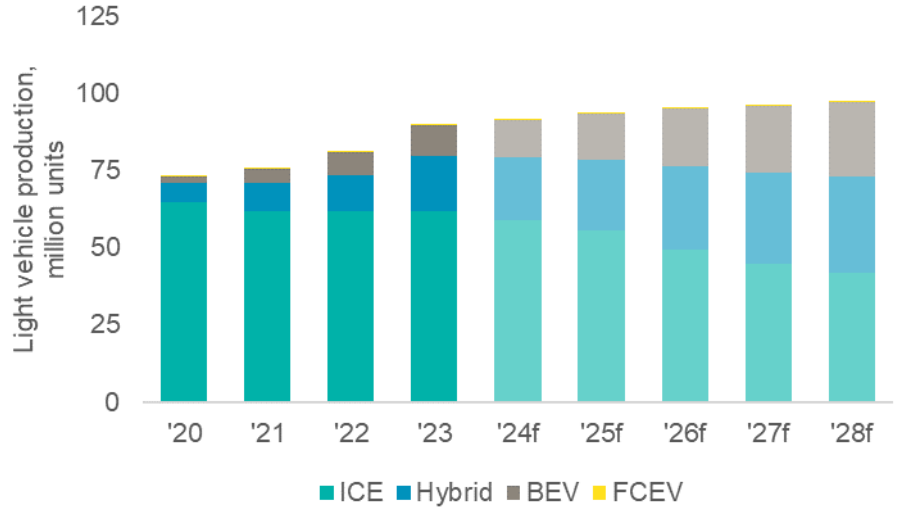
Light-duty vehicle production increased by 10% year-on-year in 2023 to reach 90M units, driven by pent-up consumer demand. Palladium benefited from this trend, with automotive demand rising to just below 8,600 koz. Internal combustion engine (ICE) vehicle production increased by a robust 9% year-on-year, most or all of which was hybrid vehicles, but pure electrification showed a slowdown compared to previous growth rates. Despite strong new vehicle demand in 2023, growth is anticipated to slow in 2024 due to persistent inflationary pressures. Initial expectations for five rate cuts from the Fed have been revised downwards, with two cuts now the consensus for 2024. Although, none have materialised yet, indicating a prolonged period of higher interest rates. This is expected to dampen consumer appetite for new vehicles, leading to forecast total light-duty vehicle growth of only 2%. The increase in absolute production is driven exclusively by battery electric and hybrid vehicles gaining increasing market share over traditional ICE. Pure ICE production is expected to decline -4% YoY. Whilst absolute production continues to increase for BEV and HEV, its YoY growth rates are estimated to be scaled back in comparison to previous years to the lowest since 2020.

*Automotive volumes recovered faster than expected in 2023.*

Subsequent strong growth in light-duty vehicle production is projected after 2024. Driven by lower interest rates and continued cost reduction of new BEVs, leading to increased demand. We forecast light-duty production to reach just under 97M units by 2028. The growth consists entirely of BEV vehicles, with ICE containing vehicle market share gradually declining over the period, but only by a -1.7% CAGR. By 2028, we forecast global BEV light-duty market penetration to reach 25%. As PGM catalyst-containing vehicles make up the majority of the balance, this translates into a higher for longer PGM demand outlook. This means that the received market wisdom that palladium demand is going to decline rapidly appears very much overstated.

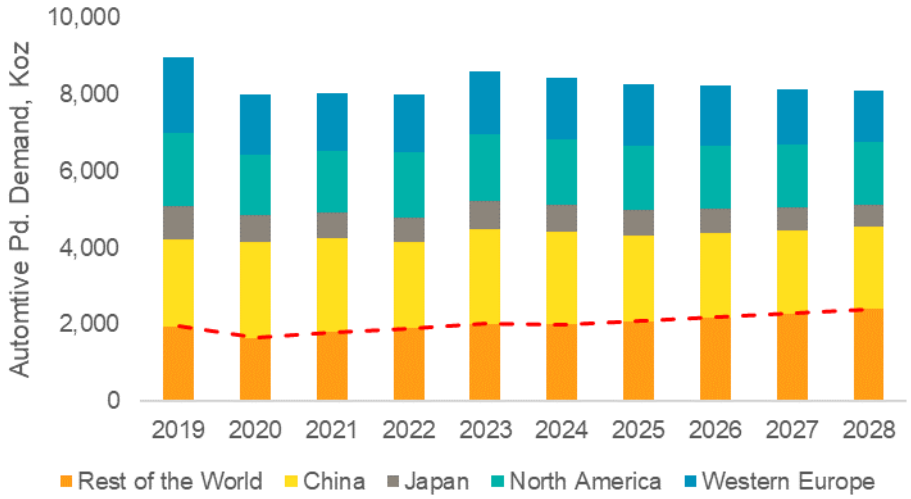
*BEV market share growing but ICE production resilient in near term.*

*Figure 5. Total ICE (ICE + hybrid) production declines only gradually over the forecast period, with BEV making up the increase in total light-duty production.*




*Source: OICA, WPIC Research*

*Figure 6. 2023 represents the post-Covid peak for automotive demand for palladium. Demand decline experiences a long tail-off as increases in the rest of the world off-set electrification in developed markets.*

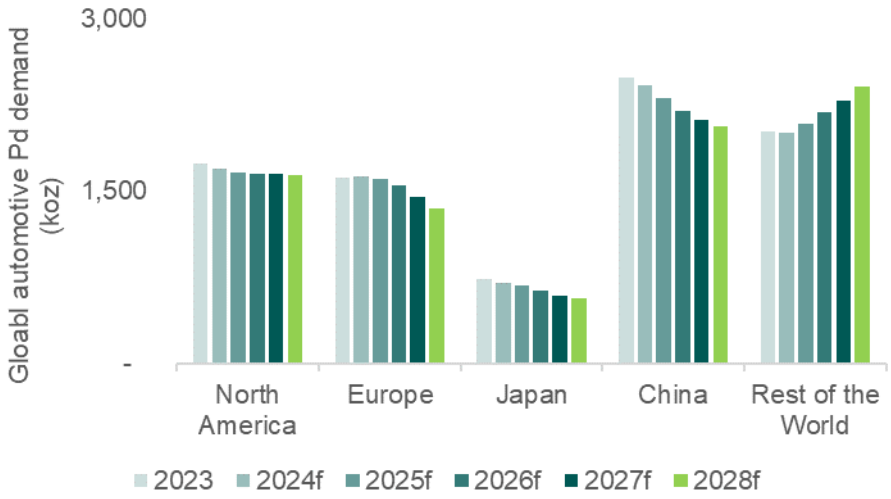



*Source: OICA, WPIC Research*

*2023 represents the final post-covid peak followed by a long tail.*

Turning to detail some medium to long-term drivers; our forecast is underpinned by regional disparities in the automotive drivetrain mix. We anticipate a gradual decline in automotive palladium demand at a compound annual growth rate (CAGR) of -1% from 2023 to 2028, driven by the electrification of drivetrains in most regions, offset by increasing hybridisation, and growth in ICE containing vehicles in emerging markets. The pace of this change in automotive demand varies significantly by geography, as illustrated in figure 7. Demand decline represents a long tail-off as increases in the rest of the world off-set electrification in developed markets.

*Figure 7. Automotive palladium demand is regionally divergent with a global structural decline, partly offset by ICE growth in the "Rest of the world".*



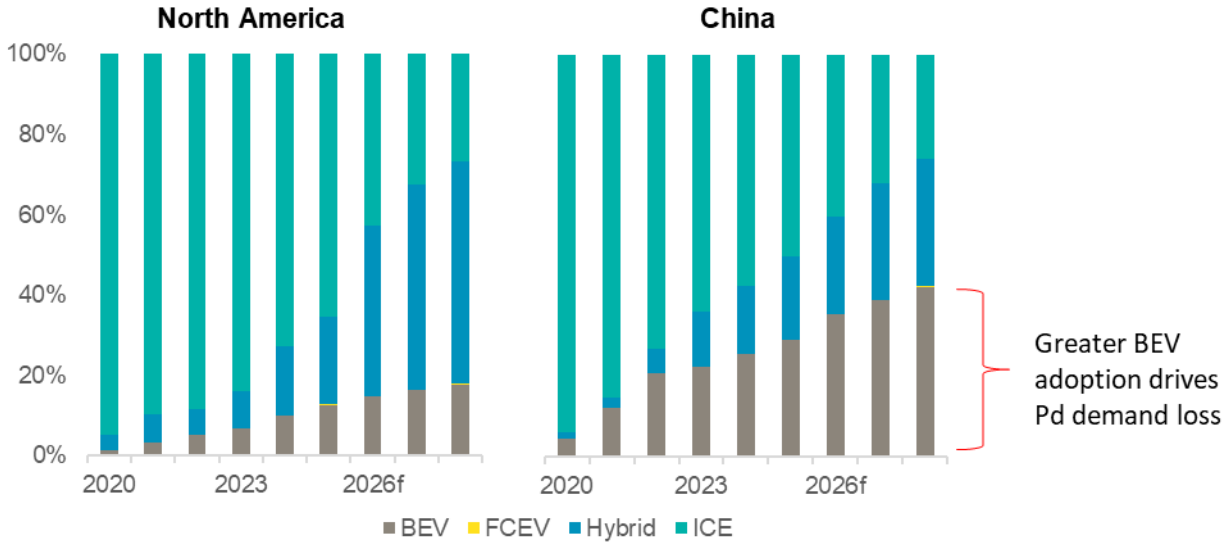

*Source: OICA, WPIC Research*

*Aspirations for car ownership growing palladium demand in the rest of the world.*

*North America hesitant over pure play electrification.*

Automotive consumer groups in different geographies can generally be categorized into two groups: BEV resistors and BEV adopters. As depicted in figure 7, palladium demand is declining in the major auto production centres of Europe, Japan, and China. North America stands as an exception, where the outlook appears relatively flat despite a drop from 2023. These trends can be linked to the preferences of country OEMs and consumers for electric vehicles (EVs). Figure 8 illustrates that China is leading BEV production, with market penetration expected to increase from 22% in 2023 to 42% in 2028, resulting in a 3.7% CAGR decline in palladium demand over the forecast period. Europe and Japan exhibit a comparable trend, albeit with a more diversified fleet that includes higher levels of hybridisation. Initially, Japan's OEMs were slow to pursue electrification. However, major players like Toyota, Nissan, and Suzuki are now introducing new EV models into their global offerings, accompanied by clear strategies. For instance, Mazda plans to roll out a full lineup of EVs starting in 2028, with a production target of 25-40% BEVs by 2030.

*Figure 8. North America retains >80% of its drive train mix as ICE (inc. hybrids) vs ~40% for China by 2028.*




*Source: OICA, WPIC Research*

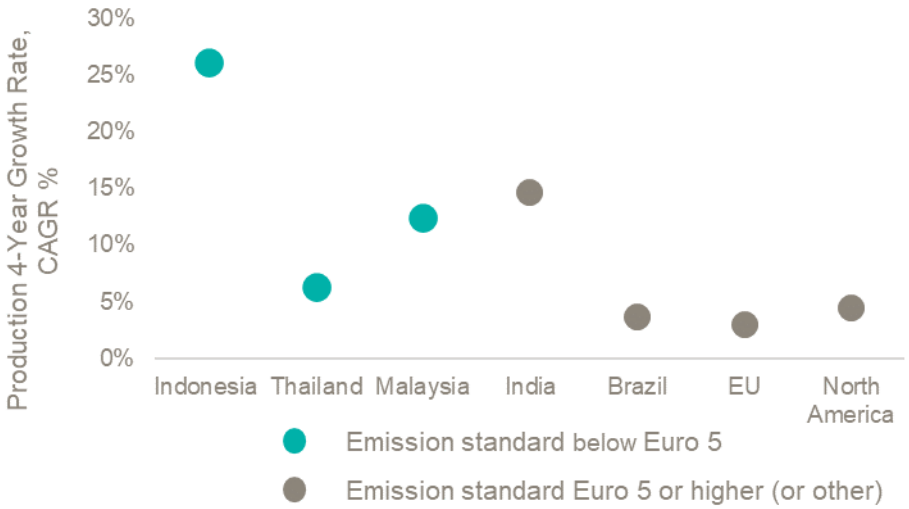
On the other hand, North America seems to be hesitant to fully commit to pure electrification, with over 80% of its fleet projected to remain internal combustion engine (ICE) vehicles by 2028. Instead, we expect automakers to pursue high levels of hybridisation, aligning with traditional automobile preferences among consumers.

Automotive palladium demand from the ‘Rest of the world’ is forecast to grow at CAGR 4% (2023 to 2028f). There are two drivers of this growth, first large Asian emerging markets such as India and ASEAN members (i.e. Malaysia, Indonesia, Thailand) are regions with rising GDP and aspirations for increased car ownership and production. We expect growth to be preferential to ICE over the forecast horizon as electrification is either unsuitable or infeasible where infrastructure lags in-country or in neighbouring export markets. Second, regional emission legislation currently lags major standard setting nations such as Europe and the US. Brazil will contribute to higher average loadings as it introduces its L-8 emission regulations in 2025.

Emission regulation trends are playing a significant role in the decline of automotive palladium demand. Many nations adhere to Euro standards (or adopt a close copy), with countries typically upgrading to the next standard upon its release (e.g., from Euro 4 to Euro 5 upon Euro 6 release). The delay and softening of Euro 7 implementation have negatively impacted European automotive palladium demand, likely influencing loadings in other regions as well. Approximately 40% of production output in the "rest of the world" category conforms to Euro 6 standards. Euro 7 regulations prioritise CO2 reduction, which may be achieved through a higher proportion of battery electric vehicles (BEVs) and hybrids rather than targeting reductions in NOx, HC, and CO emissions that require increased PGM loadings; road testing limits for these have remained unchanged. Consequently, for such a small change, countries adhering to Euro 6 standards may either delay their emissions standard revisions or opt not to revise them at all. Historically, PGM loadings have increased by 5-20% when new regulations are introduced. Considering the roughly 10 million Euro 6 standard vehicles produced in the rest of the world, this could translate to a significant opportunity loss in palladium demand, exceeding 100 koz annually. In fact, with no changes to the limits, consolidation or thrifting of PGM’s can occur, compounding the impact.

Aside from the less stringent than expected Euro 7 standards, there is potential upside risk from increasing emission standard stringency in the medium to long term. Light duty production is expanding in ASEAN member countries, with many currently operating on Euro 4 standards. 4-year average CAGR growth ranged between 5-25% in select East Asian geographies (figure 9) versus <5% for developed markets such as the EU and North America. There is an indication that these nations are reevaluating their emission regulations; however, uncertainty surrounds whether this will result in a transition to Euro 5 or Euro 6 standards and the timing of such revisions, leading us to exclude this from our base case. ASEAN members on Euro 4 currently represent just under 20% of our "rest of the world" vehicle production. Considering that PGM loadings cumulatively increased by approximately 60% in China during the transition from China 4 to China 6 standards, there exists significant potential for an uptick in palladium demand when combined with higher vehicle production levels.

*Figure 9. Vehicle production is expanding rapidly in ASEAN members vs other geographies with developed automobile production.*




*Source: OICA, WPIC Research*

## Substitution to reverse substitution:

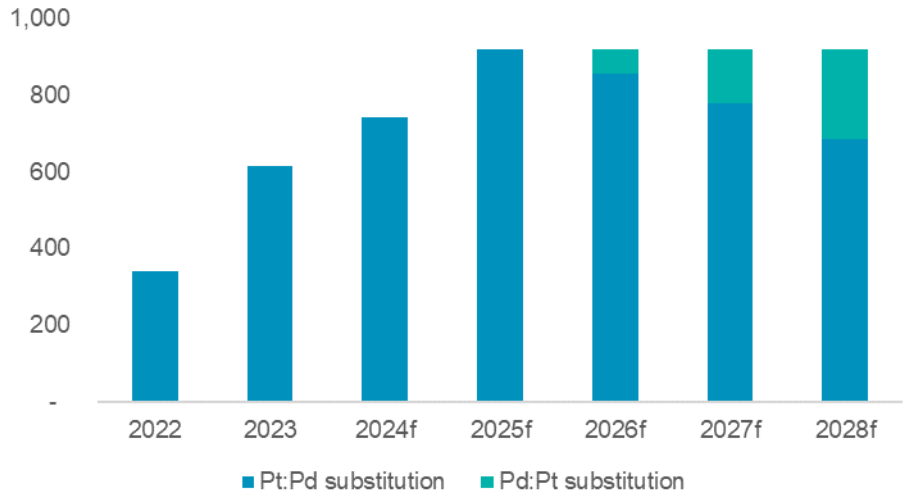
Palladium has consistently traded at a premium to platinum since 2017, prompting the substitution of platinum for palladium in gasoline vehicles at a 1:1 ratio using a tri-metal catalyst. Yet, the metals dominance may be coming to an end. Currently, the futures markets reflect a significant short position on palladium, indicating a prevailing negative sentiment towards the metal's investment case. We initially raised the prospect of reverse substitution (palladium for platinum) in our previous palladium 5-year outlook. Since then, we observed price parity between platinum and palladium in February 2024 for the first time since 2017 and then again in May 2024 (at the time of writing).

Catalyst designs have historically been locked in for the vehicle model life but may change under regulatory requirements or when the economic incentive to switch becomes large enough. This would likely require palladium to be a sizeable discount to platinum, given platinum also holds some strategic value to Western OEM's as they can minimise exposure to Russian palladium supply chain risks. Therefore, we expect substitution to continue in the near term. However, some automakers in the US and Europe are reported to now be dual certifying aftertreatment systems to accommodate changes in metal composition. Additionally, large markets like China have shown a faster adaptation rate than Western markets in adjusting their treatment systems.

We anticipate that when palladium markets shift into surplus, there will be an increase in availability, leading to economic incentives for substituting platinum for palladium. The extent of reverse substitution will vary regionally and be influenced by regulation and automaker supply chain risk management. We estimate reverse (Pd:Pt substitution) to begin to occur from 2026, coinciding with our forecasted first palladium market surplus since 2020. This estimate is one year later than in our previous forecast due to a slower recovery in secondary supply, which keeps the market in deficit for 2025.

As a reminder, as substitution normally only occurs on new vehicle platforms, which only make up 15% of the market in any given year, the pace of palladium for platinum substitution is likely to be slow, even allowing for dual certification. Indeed, our forecast is for reverse substitution to only reach ~230 koz by 2028.

*Figure 10. Our methodology assumes reverse substitution to occur when continued palladium balance surplus' open from 2026.*




*Source: Metals focus, WPIC Research*

## Buoyed Industrial Demand on lower prices:

Total industrial demand is projected to decrease by -7% to 1,360 koz by 2028, representing an upward revision from our previous forecast of a decline of 14%. Palladium plays a critical role in high-reliability multi-layer ceramic capacitors (MLCCs) used in defence technology and semiconductor lead frames. However, elevated metal prices in recent times have spurred substitution and thrifting efforts in electronic applications. With the decline in palladium prices, we anticipate a slowdown in metal demand exiting the industrial sector, potentially leading to increased demand over time. Demand for lead frames is expected to remain stable. Gold is the closest replacement for palladium in electronic applications, the significant price premium of gold (>2X as of May 2024) makes movement towards substitution unlikely.

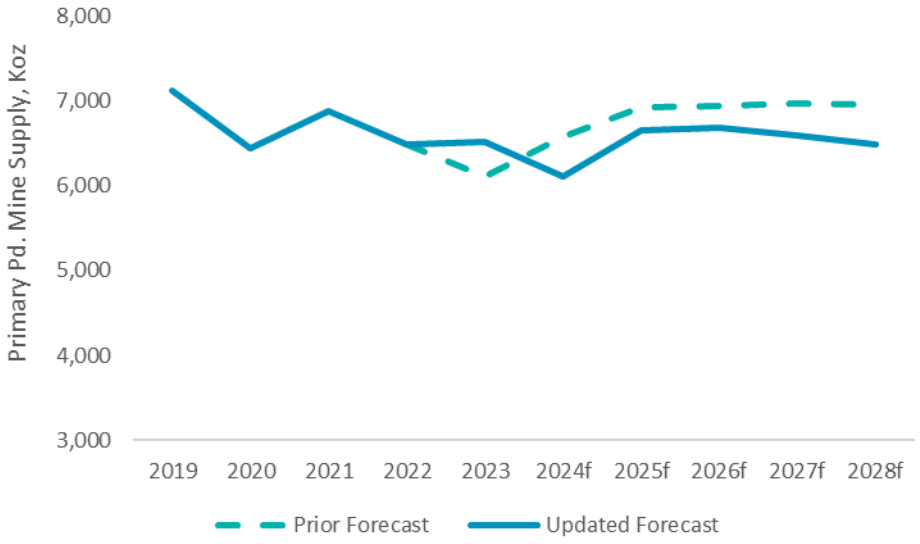
Dental demand will continue to decline at a slow pace. Aging populations and increased access to health care is offset by medical choices to stray from palladium for lower cost substitutes. There is a trend towards more natural looking and cost-effective alternatives.

In our time series, 2023 marked the peak chemical demand for palladium at 487 koz. Chemical demand is predominantly driven by capacity additions in PTA, VAM, and Nitric Acid production, which rely on palladium-based catalysts. The surge in 2023 is linked to the culmination of China's 13th five-year plan, with the completion of planned bulk chemical capacity additions. Considering the economic uncertainty in China and the saturation of production capacity, we do not anticipate further additions in the near term. Over our forecast period (2024 – 2028), we estimate that palladium chemical demand will decline at a compound annual growth rate (CAGR) of 3%. However, the pull back in the palladium price may cause an increase in industrial catalyst demand where palladium catalysts have over recent years been substituted for cheaper but inferior base metal catalysts.

## Primary Supply

We use the aggregated mid-point of public guidance for mine supply. Using this methodology, suggests total mined palladium supply is set to decline by -6% in 2024. This revision is twofold. First a downward revision due to a deferral in furnace maintenance on the Nadezhda metallurgical plant in Russia, which is now occurring in 2024. Second, the reflection of a number of mining companies making downgrades to guidance versus 2023 against the backdrop of lower basket prices and corporate restructuring. Longer-term, the guidance based 5-year outlook has been repositioned to reflect a decline in primary mine supply (figure 11). The five-year (2024-2028) forward looking forecast average of 6,469 koz is below the five-year trailing average of 6,687 koz by 3%. The change in sentiment has materialised from cost-driven closures and deferred development being offset by advanced project ramp ups whereby capital has been committed. We unpack these competing drivers and explain risks to the forecast below.

*Figure 11. The primary mine supply outlook has been revised lower based upon public guidance expectations.*



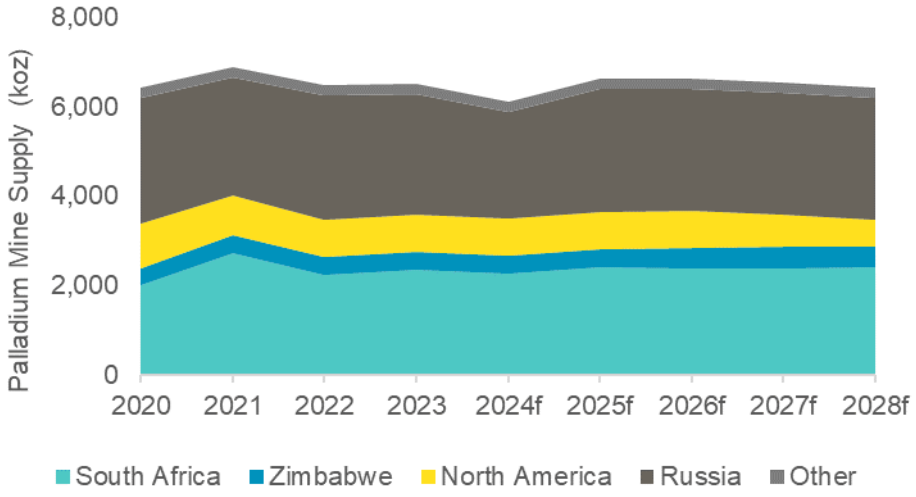

*Source: Metals Focus from 2020 to 2023, Company guidance, WPIC Research from 2024f – 2028f*

Nornickel anticipates a 12% (319 koz) decline in annual refined palladium production compared to 2023, primarily due to ongoing repairs on furnace #2 at Nadezhda metallurgical plant, slated for completion in 2024. Despite these repairs proceeding without Western OEM expertise, we assess the downside risks to 2024 guidance as limited. Notably, a Nadezhda smelter and a grinding mill at the Talnakh concentrator were successfully repaired as scheduled in 2023, utilising new contractors, suggesting minimal disruption.

While Western sanctions impacted the Russian miner with a 3% production decrease in 2023, attributed to the gradual transition to new mining equipment from alternative suppliers, this trend appears to have largely subsided, with mining volumes rebounding in Q4 2023 and Q1 2024, up 3% year-on-year. Russia has not missed guidance whilst western sanctions have been implemented. Citing this, we anticipate that Russian production will gradually normalise over the long term, reverting to the 4-year trailing average of 2,731 koz.

Despite Nornickel's resilience to adverse geopolitical pressures, the longer-term production outlook faces potential risks. Norilsk Nickel has consistently met its stated guidance for two consecutive years despite sanctions, yet the possibility of intensified sanctions could erode the company's operational capacity over time. Norilsk president, Pontantin's announcement in April 2024, via the company's Telegram channel, revealed plans to relocate a portion of smelting capacity for its copper arm to China. This decision follows recent sanctions imposed by the United States and United Kingdom on nonferrous metals from Russia. Pontantin stated that these sanctions have led to revenue reductions of up to 20%, prompting the move to mitigate losses arising from settlement difficulties, supply disruptions, metal discounts, and inventory accumulation. While the relocation of the copper business may not directly impact PGM processing, it underscores the gradual strain sanctions are exerting on Russian operations. Time will reveal if these pressures escalate into tangible operational disruptions.

*Figure 12. Decline is predominantly from cancelled project ramp-ups at US palladium operations.*




*Source: OICA, WPIC Research*

The aggregated mid-point of South African producer guidance for 2024 indicates a -2% year-on-year decline versus 2023. The decline is due to announced restructuring plans, shaft/section closures and slower than previously expected production ramp-ups. South Africa's leading PGM miners launched restructuring initiatives in 2023 to drive cost efficiencies and bolster their balance sheets in reaction to a significant fall in the basket price that eroded mine profitability. This involved the initiation of Section 189A processes to downsize and shutter certain operations. Notably, Shaft 4B at Marikana and Simunye at Kroondal were closed, while Rowland and Siphumelele are being repositioned to achieve sustainable production levels at reduced costs. Furthermore, Sedibelo's Pilanesberg Platinum Mines (PPM) ceased operations. There is a potential downside risk to meeting guidance if basket prices experience a further decline. However, recent closures should not necessarily be seen as indicative of broader supply risks for South African miners. These closures were primarily confined to operations nearing the end of their lifespan with closure accelerated due to low PGM prices and with only higher-cost reserves remaining. Overall, looking at the PGM mining industry as a whole, balance sheets appear robust, and the general depreciation of the rand coupled with restructuring endeavours have contributed to enhanced economics and positioning on the cost curve (the rand has strengthened in recent weeks).

Longer term (2025 – 2028) using the aggregated mid-point of producer guidance, South African palladium supply is expected to rebound 6% to 2,408 koz (2025) and average 2,370 koz over the 5-year forecast. The driver for this rebound is growth projects at Booysendal, BRPM and Two Rivers, where capital is advanced and committed. Having said that, medium to longer-term guidance is updated less frequently than near-term guidance and may not fully factor in the challenges facing the industry and the impacts and risks associated with the restructuring plans. Additionally, mine operators tend to be inherently optimistic about the outlook, which can result in higher than realistic projections being included in guidance.

In North America, headcount reductions will impede production from returning to pre-pandemic levels in 2024. The forward looking five-year average palladium supply stands at 768 koz, with palladium supply projected to decline to 599 koz by 2028. Due to depressed metal prices, Sibanye has cancelled planned expansions at East Boulder and Stillwater, choosing instead to maintain production at current levels. These mines boast an exceptionally high palladium content, with a 2E 78:22 prill split (Palladium:Platinum), making this decision less likely to be reversed in the near term given the current market sentiment for palladium. However, SSW is seeking IRA tax reduction credits for its PGM production due to its strategic importance to US automakers, which could potentially improve mine economics.

Palladium by-product from Canadian nickel operations is expected to decrease as these operations undergo restructuring due to pressure from cheap Indonesian nickel operations flooding the market. Additionally, Impala Canada’s Lac des Illes expected life-of-mine has been shortened to 2027 following restructuring.

Zimbabwe stands out as the outlier amongst the negative sentiment for PGM operations, with guidance pointing towards growth at a 5% compound annual growth rate (CAGR) projected from 2024 to 2028. Zimplats, the country's leading PGM producer, is scaling up production at its low-cost near-surface assets in the Bimha and Mupani mines. Furthermore, plans for a new concentrator, base metal refinery, sulphuric acid plant, and a 110 MW solar plant are expected to contribute an additional 89 koz to the country's output by 2028.

## Secondary Supply: Palladium Scrap

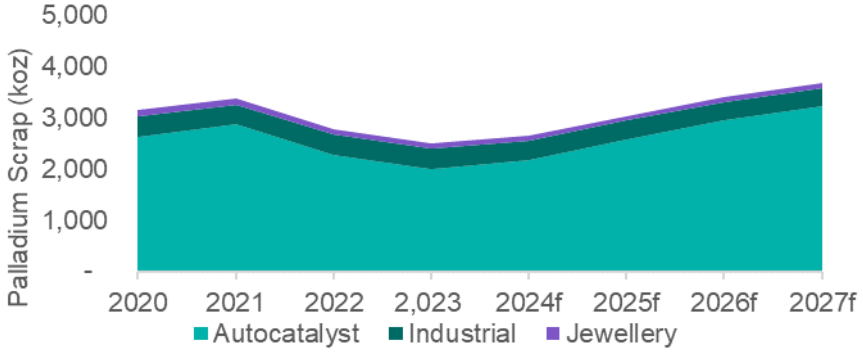
We expect notable (6%) growth in secondary palladium scrap additions in 2024, the first projected increase since 2021. We have used a methodology of projecting recycling output based upon historical trends in vehicle models, loadings and average vehicle age at the point of scrappage. We do not attempt to adjust for changes observed in recovery rates driven by moves in PGM prices as a) we think the economics of the car breaking and scrappage industry likely only allows for short-term efforts to time pricing, and b) we do not forecast PGM prices.

Growth in secondary scrap primarily stems from autocatalyst recycling, while the industrial and jewellery segments are experiencing declines. Palladium spent autocatalyst decreased from its peak of 2,870 koz in 2021 to 2,004 koz in 2023. This decline was influenced by the alleged autocatalyst theft/provenance scandal in the US, the impact of post-COVID-19 trends, such as prolonged vehicle usage due to a shortage of new vehicles, lower mileage and increased remote work patterns, as well as regulatory restrictions in China. We anticipate 2024 to mark a turning point, with these issues largely mitigated, paving the way for structural growth in secondary supply.

We project global secondary supply to reach record levels of 3,830 koz by 2028. Representing a growth of over 1.3 Moz versus 2023, this is the major contributing factor to surplus palladium market balances. Western markets are anticipated to maintain steady vehicle recycling rates, benefiting from well-established secondary supply chains. In the US, the retirement of palladium-heavy gasoline vehicles will further contribute to secondary supply growth. Meanwhile, China's recycling sector is undergoing evolution, with a forecasted 7% increase in recycling rates over the period, resulting in a 2.2x surge in auto scrap recycle supply from 199 koz in 2023 to 443 koz in 2028. This in part reflects an increase in the end-of-life vehicles coming through in China now having emissions control systems containing meaningful levels of PGMs, mainly palladium. There are strategic reasons for growing recycling in China, offering cost and emission advantages over primary supply. Major recyclers BASF and Heraeus are investing in new facilities. For instance, a new 10,000 t PGM recycling facility is set to be commissioned in Pinghu in 2024, capitalising on these opportunities. However, regulatory restrictions and recently implemented changes to taxation are headwinds to growth.

While the challenges facing the recycling industry are eminently solvable and likely to be solved, there are significant risks to the timing of solutions being enacted and therefore the pace of the growth in recycling supply. Obviously, any delays to this could have a significant bearing on the timing of when palladium markets move into oversupply.

*Figure 13. Recycling supply is set to grow to a record 3,830 koz, driven by capital investments in China and Pd rich vehicles reaching end-of-life globally.*




*Source: Metals Focus from 2020 to 2023, Company guidance, WPIC Research from 2024f – 2028f*

## Jewellery & retail investment demand

Currently, the jewellery and retail sectors contribute minimally to palladium demand, representing approximately 2% of total annual demand. This proportion is anticipated to remain relatively unchanged in the foreseeable future.

## Conclusion

In conclusion, palladium demand is expected to remain resilient with market wisdom of a rapid decline overstated. Further, developing markets provide potential avenues for increased PGM demand, offsetting the impacts of drive-train electrification. Secondary supply will be the major contributing variable in shifting palladium markets into a structural surplus. As, such the timing and extent of the recovery of scrap supply chains is key. With this uncertainty in mind there is scope for medium term palladium market strength and short covering.

Conversely, the investment case for platinum is resoundingly stronger. Excess recycling supply is a palladium biased narrative and platinum's diverse demand base coupled with lower primary mine supply brings tighter markets in deceit through to our forecast end of 2028.

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