

Recycling: volume, momentum and consequences for PGMs

A. RYAN, B. CLARKE, O. ATILAN, J. WATTS, and S. TRICKEY
SFA (Oxford) Ltd, UK

This conference paper provides an overview of the global PGM recycling industry. An analysis is provided of the industry's drivers, characteristics, feedstock sources, metal flows and its impact on global PGM supply. Using SFA's independent supply-demand projections and estimates of the potential contribution from global PGM recycling, conclusions are drawn on whether secondary supply will continue to be sufficient to fill the gap between primary supply and PGM demand in the future.

Introduction

PGM recycling is the recovery of metal, contained in scrapped end-use products, back to the global PGM supply stream. In an ideal world all recycling of PGMs would be closed loop, whereby every ounce of metal incorporated into a product or component would come back to the market (less a small percentage in recovery losses) at the end of the component's useful life. This is, however, not the case for a large portion of global PGM usage (autocatalysts and electrical applications) with the remainder, mainly the jewellery and petroleum and chemical demand sectors, involved in closed-loop systems. The recycling challenge is to transform the open-ended applications and move towards closed-loop recycling. Progress, though, is slow given the numerous and significant challenges involved.

Recycled volumes of PGMs make a significant contribution to global PGM supply with more than 2 moz recycled in 2009 (equivalent to 15% of global PGM consumption). However, the gap between PGM supply and end-use demand is forecast to widen significantly out to 2020 and this will place growing pressure on recycling to fill the gap. PGM mining is getting deeper, more challenging and more expensive and is unlikely to provide any real growth in supply over the next 10 years. Indeed, the reserves are more likely to begin depleting from 2015 onwards. Furthermore, above-ground stocks are either severely depleted (Russian) or are stable (Swiss) and offer little support against a widening market deficit.

Recycling has historically made up the market deficit and this reliance on secondary metal to close the gap is forecast to grow significantly in the future.

Legislation and economics are the key drivers of PGM recycling

Recycling legislation is spreading globally—firstly, in response to the growing awareness worldwide of the scarcity and limitations of natural resources and the desire to reduce dependency on primary (in the ground) resources and move towards sustainable methods in order to meet mounting global demand in the future.

Secondly, awareness of the need to reduce waste generation and reliance on the use of landfills is growing

significantly. At one level or another, all countries around the world are seeking to recycle greater quantities of the components and materials currently being discarded to waste dumps. In the EU, for example, waste directives require that by 2015 90% of scrapped motor vehicles and waste electrical and electronic equipment (WEEE) must be recycled (passed through accredited recycling centres), and that some 80% of the component materials be recovered for reuse. Similar stringent legislation exists in the USA and will in time be applied, to a lesser or even greater degree, in other economic regions of the world.

Interestingly, it is legislation once again that is the driver behind the largest PGM demand sector, autocatalysts, which are used to control and reduce tailpipe emissions. As the trend of ever tightening emission control legislation continues, coupled with a growing global vehicle fleet, so PGM demand will continue to grow. This will place more pressure on primary PGM production and increasingly on recycling activities to meet rising global demand. See Figure 1.

However, legislation alone is insufficient to bring about effective and enduring recycling activity if the economics of recycling do not stack up. The business case for recycling is therefore closely linked to legislation (both recycling and environmental) and the global supply-demand balance.

PGM recycling is characterized by two stages, collection and processing, in which competitors in the latter compete against one another for supply of feedstock from the former. The economics of collection and processing are complex and are governed largely by the PGM metal prices, which impact directly on attractiveness and profitability.

Whereas the metal price determines the value of a unit of scrap (spent autocatalyst, scrapped mobile telephone, etc.), each collector in the collection chain has its own required price to meet individual operating costs (those of physical collection and storage) and provide sufficient return to ensure a profit margin. Over and above these costs, however, collectors face a range of other 'costs' from the processing stage which detract from the profit margin. These include:

- Assay and laboratory charges for determining the metal content of the scrap delivered
- Smelting and refining charges to cover the operating

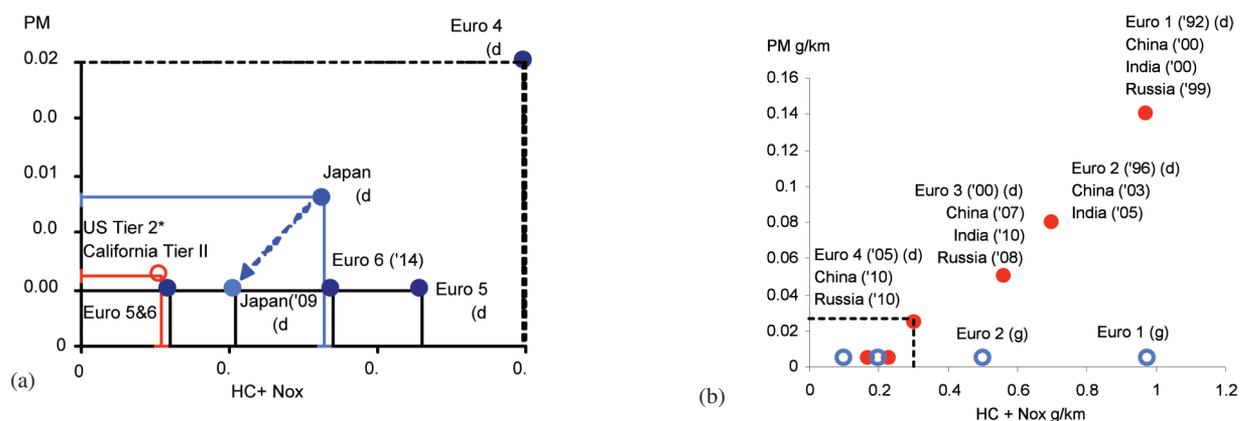


Figure 1. (a) Emission standards: western world. (b) Emission standards: emerging economies. Source: SFA (Oxford)

costs of the processors

- The potential cost of metal price fluctuations (smelting and refining can take up to 20 weeks to produce pure metal)
- The cost of processing losses (metal recovery is not 100%).

Additionally, processors typically offer metal recoveries that are slightly lower than those which are achievable. This difference is to cater for potential unexpected losses in the processes, and any additional metal recovered accrues to the processor.

Furthermore, sometimes processors do not pay for all the metals they receive, particularly minor PGMs, base metals and/or trace metals. If these can be recovered they usually accrue to the smelter/refiner.

A final challenge to both collectors and smelter/refiners is the availability of credit, which is essential to cover the cost of metal price hedging over the processing period (between the time of scrap metal receipt and final metal recovery) and can have a considerable impact on the viability of collection operations.

Processors compete on the basis of the terms (see bullet points above) and services offered to suppliers in order to attract and secure supplies of feedstock. OPEX charges are a function of technology and efficiencies, as are laboratory and assay charges. Restitution times vary significantly between processors and are exacerbated if the smelting and refining stages are carried out by separate parties (this also increases costs). As an alternative offering many processors provide a metal offtake option (purchase of the metal), which significantly reduces the time between metal delivery and receipt of payment but places further hedging requirements on the processors. Furthermore, competitive advantage is also achieved through the provision of regional/country collection centres (integrating processors into the collection chain) in order to improve access to the collection base and further strengthen security of supply.

Two final factors play a significant role in the recycling industry: economies of scale to achieve and maintain profitability and the reliance of the industry on trust and reputation between processors and collectors.

Sources of secondary PGMs

Secondary PGMs derive from the recycling of spent autocatalysts, jewellery, petroleum and chemical catalysts, WEEE, and pharmaceutical and other industrial equipment.

Autocatalysts are the single largest PGM demand sector (more than 50%). Taking into account the recycling lag-period, regional vehicle production rates, vehicle exports, recycling rates and metal recoveries, spent autocatalysts are projected to contribute more than 2 moz (3E) PGMs to the secondary PGM supply in 2010. This is forecast to increase significantly to more than 3.5 moz by 2020. However, global recycling rates are less than 50%, which means that a significant volume of PGMs contained in spent autocatalysts will remain unrecycled. This presents a huge recycling opportunity, but not without commensurately large challenges.

Electrical and electronic equipment (EEE) is the third-largest demand sector for PGMs, but with its low recovery rates it is only expected to deliver in the region of 450 koz (Pt and Pd) to the recycling stream.

The following demand sectors are traditionally reported net of recycling volumes as a result of the almost closed-loop nature of their respective recycling systems:

Jewellery, the second-largest end use of PGMs (Pt and Pd), accounts for about one-fifth of global demand. Volumes of recycled PGMs from jewellery are, however, fairly small (~300 koz) when compared to spent autocatalysts, are basically closed loop, and derive from sweeps (produced during manufacturing) and the return of unwanted jewellery (old-for-new).

Chemical, petroleum, pharmaceutical and other industrial applications account for the remainder of PGM demand (some 17%). Many of these sectors involve closed-loop recycling whereby end-users return the expended PGMs to the original equipment manufacturers (OEMs) for recycling or in exchange for replacement units. However, a small portion of these end uses (mainly the silicone applications) actually consume the PGMs in the production process. See Figure 2.

Feedstock availability

The availability of feedstock in any country or region is reliant on the level of recycling awareness, the extent of recycling legislation and the level of recycling infrastructure in place. The size of recycled volumes further relies on the level of consumption of PGM-related products and components in a specific region. With few exceptions, all the countries of the world consume PGMs through the use of motor vehicles (with some form of emission control catalyst in place) and EEE (typified by short life cycles of

2–5 years). Additionally, many countries participate in oil and petroleum refining activities which, along with chemical manufacturing (nitric acid production), require PGM-loaded catalysts and other PGM-linked equipment. All of these end uses are potential sources of feedstock, with the latter sources largely tied up in existing closed-loop recycling systems.

However, the tracking of autocatalysts and EEE is complicated by the international second markets for these goods. Many developed economies export second-hand motor vehicles to emerging economies and, similarly, large quantities of refurbished or unwanted EEE are sold or donated to these developing economies.

Regardless of where final scrapping takes place, feedstock availability relies on a number of factors:

- The existence of incentives to support the collection of scrapped goods.
- Collection and recycling infrastructure. For example, a car scrapped in the UK must (by law) go through a certified scrapping process to ensure that all recyclable parts enter the recycling stream. However, a vehicle in an emerging economy (and perhaps imported second-hand from the EU or Japan) will typically be driven until its end of life and then simply be abandoned or consigned to a scrap heap with little chance of recycling taking place (remoteness and lack of infrastructure).
- Recycling networks are also essential to ensure the economies of scale required to make a meaningful recycling impact. Typically, recycling is a low margin, high volume business.
- Levels of recycling awareness and legislation—the higher these are, the greater the proportion of recyclable material that is actually recycled.

Metal flows

PGMs are a part of many global commodities (from autocatalysts to mobile phone handsets). They are mined in primarily only five countries, refined and exported to a range of manufacturers located around the world, sold and exported to all the regions of the world, and then either scrapped or once again sold and/or exported. Metal tracking becomes almost impossible, with only those PGMs involved in closed-loop applications being almost 100% accounted for throughout the product life cycle.

From the outset, therefore, metal flows are complex and once recycling begins an entire new set of interconnected flows comes into the equation. There are some 15 major refiners of secondary PGMs located in the USA, EU, Asia and Africa, which process more than 90% of globally recycled PGMs.

On a local scale, flows are from dismantlers (garages and scrap yards) to small and then to intermediate collectors, typically all within the same urban area/city. Larger collectors act as hubs for the smaller ones, covering local regions and, in some cases, entire countries. These then feed into major collection centres which, in turn, feed the smelter/refiners. Some of the smelter/refiners own/operate their own international collection networks and others rely purely on a single large collector to supply the majority of their feedstock.

In many cases, the metal flows of closed-loop PGMs are international with, for example, a petroleum catalyst produced in the USA being used in a South African refinery and then returned to the OEMs nearest refinery (USA, EU

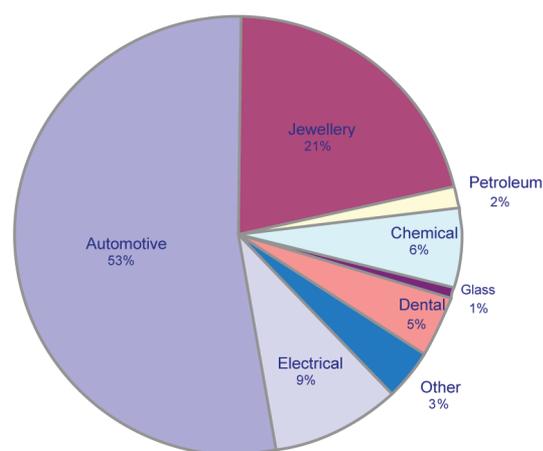


Figure 2. Global PGM demand. Source: SFA (Oxford)

or Asia) for PGM recovery. Other metal flows, such as that of jewellery, tend to be more regional or country specific. However, ultimately the flow is typically back to one of the major refiners in order to achieve the required purity levels.

WEEE flows are further complicated by the stringent environmental legislation to which they are subjected (this is because of the toxic emissions that result during the incineration stage of this waste stream), which places limitations on the processing of the waste as well as imports of it and exports to countries that do not have suitably strict environmental legislation in place. Illegal flows are rife, however.

Impacts of recycling on total PGM supply, 2010 to 2020

Historically, PGM supply from primary production, coupled with metal releases from stockpiles and the contribution of recycled metal, has been sufficient to more or less keep the PGM market in balance, i.e. able to meet demand. However, a supply gap is looming. Primary production in South Africa faces growing challenges and is potentially able to maintain only current levels for another five to eight years before depletion rates of current operations exceed supply from projects and expansions. Russian and Canadian PGM production is reliant on the economics of Cu and Ni supply and again is unlikely to increase in the future. Similarly, Stillwater (USA) is unable to raise output 4

levels given the environmental constraints on its mining rates. PGM stockpiles too are depleting: Russian stocks are now estimated to be *circa* 3 moz, and levels of PGMs held in Swiss vaults are fairly stable and again are unlikely to be completely sold off.

For years secondary PGMs have filled the supply gap but this is unlikely to be the case going forward, as illustrated in Figure 3.

Traditionally, recycled PGMs have made a growing contribution to global PGM supply, up from around 4% in 1990 to nearly 18.5% in 2009. Going forward, recycling volumes are expected to continue to rise as a result of legislative pressures (recycling directives and emission control requirements) which will both drive demand for PGMs and encourage their recycling. Additionally, WEEE is a growing contributor to secondary PGM supply, albeit that it significantly favours Pd over Pt.

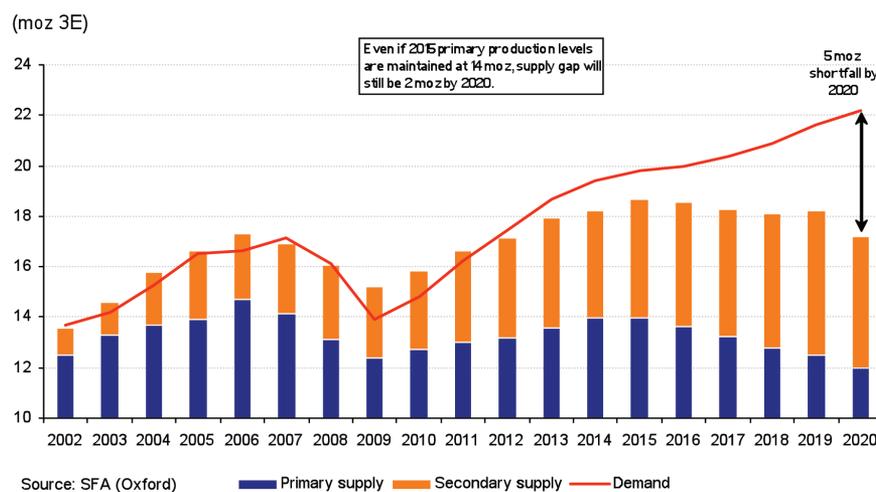


Figure 3. Global PGM supply and demand

The supply-demand balance indicates that secondary metal provision would need to increase significantly in order to keep the market in balance out to 2020. SFA models of secondary PGM supply indicate that the volume of PGMs becoming available for recycling are set to increase as global demand for end-use PGMs continues to grow. However, global recycling rates are low (less than 50%) and face challenges arising from regional disparities in awareness of recycling and levels of installed recycling infrastructure. Furthermore, the collection of spent autocatalysts is in itself a significant challenge to would-be collectors, particularly in the less developed regions of the world. Volumes of unrecycled PGMs from spent autocatalysts are forecast to exceed 4 moz as demand growth rates continue to exceed the increase in recycling rates. Even if all the spent catalysts were to be recycled (highly improbable given the collection challenges and the limit of current recycling refining capacity), it is unlikely that secondary PGMs would be sufficient to fill the supply gap.

Lastly, the changing basket of recycled metal is having, and will continue to have, an impact on the supply of secondary PGMs. In the late 1980s and early 1990s, when the majority of the world's PGM refineries were either built or last expanded, the cocktail of PGMs in spent autocatalysts was dominated by Pt. The refineries were designed accordingly. Today, however, following the

advent of significant penetration of Pd into gasoline catalysts in the late 1990s, the Pd:Pt metal ratio has changed dramatically towards 1.5:1. Furthermore, the more recent boom in diesel automobile uptake in Western Europe (favouring Pt-rich catalysts) is only likely to reduce this figure from around 2014. Refineries are under pressure to source a blend of diesel and gasoline catalysts in order to keep the feed mix in line with refinery capacities and this is proving difficult, with a resultant negative impact on throughput volumes that could exacerbate the supply gap.

Conclusions

The world needs secondary PGMs and will continue to need them at an ever increasing rate in order to meet the demand for PGMs, as primary production reserves begin to deplete and stockpiles are drawn down.

Secondary PGM processing is not without its challenges, particularly in the collection of PGM-bearing waste. On a global scale, recycling infrastructure, awareness and incentives are not nearly as well established as they need to be.

Competition is high and new players are needed to bolster and bring on line more efficient refining capacity as well as address the new cocktail of metals in the recycling streams.



Alex Ryan

Analyst, SFA Oxford Ltd

Alex Ryan has several years operational and management experience at a senior level in the minerals processing environment. He is familiar with project finance and evaluation methods for process improvements and expansions, and has a detailed understanding of the potential implications of climate change on platinum mining operations. Alex holds a BSc in Metallurgical Engineering and an MBA.