



# THE ENVIRONMENTAL PROFILE OF PLATINUM GROUP METALS (PGMs)

A CRADLE-TO-GATE LIFE CYCLE ASSESSMENT OF THE PRODUCTION OF PGMs AND THE BENEFITS OF THEIR USE IN A SELECTED APPLICATION

Reference Year 2017 - 2022 Update



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## **DISCLAIMER:**

Within secondary production, it is common in the PGM industry to treat a mixed feed of materials, which may include automotive and industrial catalysts, electronic scrap, and by-product materials. Consequently, it is challenging for an LCA to allocate the environmental footprint of a particular process either to individual metals or to an individual feed such as autocatalysts. The IPA LCA study has adopted a pragmatic approach and has used a mixed feed to model the average footprint for the secondary production

of PGMs. Thus, while the results of the LCA study are valid as an industry average, they are not suited for the analysis of specific secondary production processes, especially for comparison purposes. Similarly, the LCA results for primary production are averaged from inputs from mining operations which vary between one another in terms of the characteristics of their ores and should not be used to analyse one particular mine or participating company, or their production processes.



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## INTRODUCTION

In 2013, the International Platinum Group Metals Association (IPA) completed its first industry-wide Life Cycle Assessment (LCA) to measure the environmental impacts of the primary and secondary production of platinum group metals (PGMs) as well as the benefits of using PGMs in catalytic converters (autocatalysts) to control vehicle exhaust pollution. The study, based on data for the year 2010, focused on quantifying the environmental impact of the production of 3E (platinum, palladium, rhodium) of PGMs, the fabrication of PGM-containing autocatalysts and the use of autocatalysts in a Euro 5 vehicle system (diesel and gasoline) over a vehicle lifetime of 160,000 km. Since then, the data has been requested and used by the PGM industry, automotive and chemicals industries, research organizations and other stakeholders in various, mostly internal studies.

In an effort to provide updated, reliable data to its stakeholders, the IPA commissioned Sphera, a consultancy and software firm, to conduct an update of the 2010 data, based on 2017 production data and reflective of the industry performance for that year. Eleven out of twelve IPA members took part in the new study, representing most primary producers of PGMs (from mining to refining), secondary producers of PGMs (recycling and refining) as well as the majority of fabricators of autocatalysts. With a

coverage of 95% of the global primary PGM supply (2010: 70%), roughly 70% of the secondary global PGM supply (2010: 60%) and around 90% of autocatalyst fabrication (2010: 90%), the study is highly representative of the global PGM industry<sup>1)</sup>.

The 2017 study achieved a greater geographical and technological representation of the industry than in the previous study in 2010, covering more regions and more types of autocatalysts. The update also follows the introduction of new emissions regulations in September 2017, Euro 6d-TEMP (the first of a two-stage introduction of the Euro 6d standard), for passenger vehicles in the European Union (EU) and Switzerland. New passenger car models will be subject to a new procedure for the measurement of fuel consumption and emissions - the Worldwide Harmonized Light Vehicles Test Procedure (WLTP) replacing the New European Driving Cycle (NEDC) procedure, in addition to on-road measurements of Real Driving Emissions (RDE) to validate emissions under real driving conditions, as opposed to previous laboratory-only measurements. RDE legislation specifically targets nitrogen oxides (NOx) and particulate emissions (PM). Hence, a further goal of the 2017 study was to understand the benefits of the use of PGMs in a catalytic converter for a vehicle that meets Euro 6d-TEMP emissions standards.

LCA Study Quick Facts			
Life cycle stage	Primary PGM Production	Secondary PGM Production	Autocatalyst fabrication
Geographical coverage	South Africa, Zimbabwe, USA, Russia	Belgium, UK, Germany, Japan, USA, China	South Africa, UK, Germany, Belgium, Poland, Macedonia, France
Industry representation	95%	> 70%	90%
Details	<ul style="list-style-type: none"> <li>• Period covered: FY 2017</li> <li>• Conducted by Sphera</li> <li>• Third party critical review according to ISO 14040, ISO 14044 and ISO/TS 14071 by Prof. Dr. Matthias Finkbeiner, Technical University Berlin</li> <li>• Data quality analysed by an independent technical expert with mining experience (William J. Middleton of WJM Environmental)</li> </ul>		

Table 1: LCA Study Quick Facts

<sup>1)</sup> Industry estimates

The LCA Study was undertaken for internal use by the IPA and its members and for communication to LCA practitioners, end-use markets (customers such as automotive OEMs) and other selected stakeholders. The results of the study are not intended for use in comparative assertions (i.e. comparing PGMs to other materials or comparison of endused applications) for public access. Any such comparisons should only be made on a product system basis and must be carried out in accordance with ISO 14040 and ISO 14044, including an additional critical review by a panel.

## WHAT IS LCA?

Life Cycle Assessment is a reliable method used across a variety of sectors for calculating the lifetime environmental impacts of a product or service. LCA identifies environmental “hot spots” in products and materials and establishes the benchmark against which improvements can be measured. LCA provides information to decision makers by giving insights into the potential environmental impact of materials and products from raw material extraction or manufacture to end of life disposal.

Companies as well as industry associations use LCA to demonstrate transparency and corporate credibility to stakeholders and customers. Industry-wide LCAs offer the benefit of providing reliable, transparent, and averaged data on a global or regional level. The growing significance of LCAs as part of life cycle thinking becomes evident in the European Union’s Circular Economy approach and related policies such as the Product Environmental Footprint (PEF) studies which involve the use of LCA data for a variety of materials.

### A typical LCA study consists of four phases:

- **Goal and Scope:** The goal and scope outline the rationale of the study, the anticipated use of the results of the study, the boundary conditions, and the assumptions used to analyze the product system under consideration.
- **Life Cycle Inventory (LCI):** The life cycle inventory stage quantifies the material and energy use and environmental releases for the product system being studied. These results can be used in isolation to understand emissions, waste, or

resource use. Additionally, the results can provide insights which may lead to product design improvements.

- **Life Cycle Impact Assessment (LCIA):** The evaluation of environmental relevance of the inputs and outputs of the system.
- **Interpretation:** Interpretation of the results of the study, including recommendations and limitations of the study as well as an analysis of the validity of the results based on those limitations.

## WHY THE LCA WAS CONDUCTED

The PGM industry faces growing demand from stakeholders for robust, credible, and independent data regarding the environmental footprint of PGMs and PGM-containing products. At the same time, publicly available data on the life cycle of PGMs is outdated and incomplete and does not reflect the latest developments in technology. Therefore, the industry commissioned the consultancy and software firm Sphera to update the industry’s LCA data set with the aim to:

- Update life cycle data on PGMs and their application in an autocatalyst under Euro 6d-TEMP legislation.
- Provide data to determine the benefits of PGMs (e.g. in applications and through recycling).
- Identify areas (in the PGM life cycle) where industry can improve performance and allow companies to benchmark their results against the industry average.

As processes and technologies used in production change and improve over time, it is recommended to update LCA data every 5-7 years. The IPA LCA 2017 update also reflects changes in data category requirements, i.e. data required by regulators and other stakeholders to assess environmental impacts.

New data categories are covered in the 2017 study. These include, e.g., land use transformation data due to its relevance for assessment of the Product Environmental Footprint (PEF) method which is being developed by the European

Commission and is currently in the transition phase. PEF requires compliant assessments to use a predefined list of 16 LCIA methods aimed at driving comparability between environmental assessments of different products and may become important for European businesses / manufacturers in future.

Freshwater scarcity is another increasingly pressing environmental issue. Hence, water use, an umbrella term for all types of anthropogenic water uses, has also been addressed in the study. The mining and metals industry is aware of the physical, regulatory, and reputational risks posed by water use. Nevertheless, collecting data on water consumption and water use remains a challenge. The 2017 study addresses, as a first step, blue water consumption defined as freshwater leaving the watershed.

## 2022 UPDATE

Following some internal benchmarking exercises that had been executed by members, it had been assumed that some secondary data had not been fully accounted for when finalising the LCA 2017. Hence, IPA asked its LCA consultancy Sphera to re-assess the data of secondary producers and to check for potential gaps. As a result, additional data from pre-processing steps within the supply chain have been added to the existing 2017 data, covering, I.g., some pyrometallurgical processes that occur when dissolving end-of-life material. In addition, waste streams have been reassessed and a more realistic approach adopted (in the LCA 2017, worst case scenarios had been used).

Finally, upstream data have been updated following the general update of the GaBi database, now featuring energy data from 2018/2019 (whereas 2016 data was used before). As a result, the data for both primary and secondary production have slightly changed, both due to the secondary data recount and due to the newer energy data. To be fully transparent, we are presenting both values from the original LCA 2017 study and the GaBi 2022 update in the tables on page 7.

The updated data is available in the GaBi database following the 2022 summer update or can be requested from IPA by submitting a data request on our website. All results published around the

autocatalyst application study have remained untouched, they still give a very good account of emissions generated during production and emissions saved through the use phase of the catalyst.

### GOAL AND SCOPE OF THE IPA LCA STUDY

The LCI carried out to collect the data presented in this Environmental Profile follows the “cradle-to-gate” approach which covers the processes from the extraction of the raw materials to the finished product. For PGMs it includes all aspects of ore extraction, the production of other raw materials, energy supply and the production of the refined PGMs themselves. The LCI also includes the production of fuel and ancillary materials and represents all resource use and emissions caused by PGM production as well as the use of PGMs in a catalytic converter application.

The functional units for the study were: 1 kg of platinum (Pt) (>99.95%), 1 kg of palladium (Pd) (>99.95%), and 1 kg of rhodium (Rh) (>99.90%).

Based on the input from the participating IPA members, this study focused on the primary and secondary production of PGMs. It also assessed the fabrication of autocatalysts using PGMs as well as the use of these catalytic converters in a vehicle system, assuming a vehicle life-time of 160,000 km.

Figure 1 shows the various processes considered in the system, including the use phase, while the system boundary of the main study is depicted by the red box, i.e. for the production of PGMs.

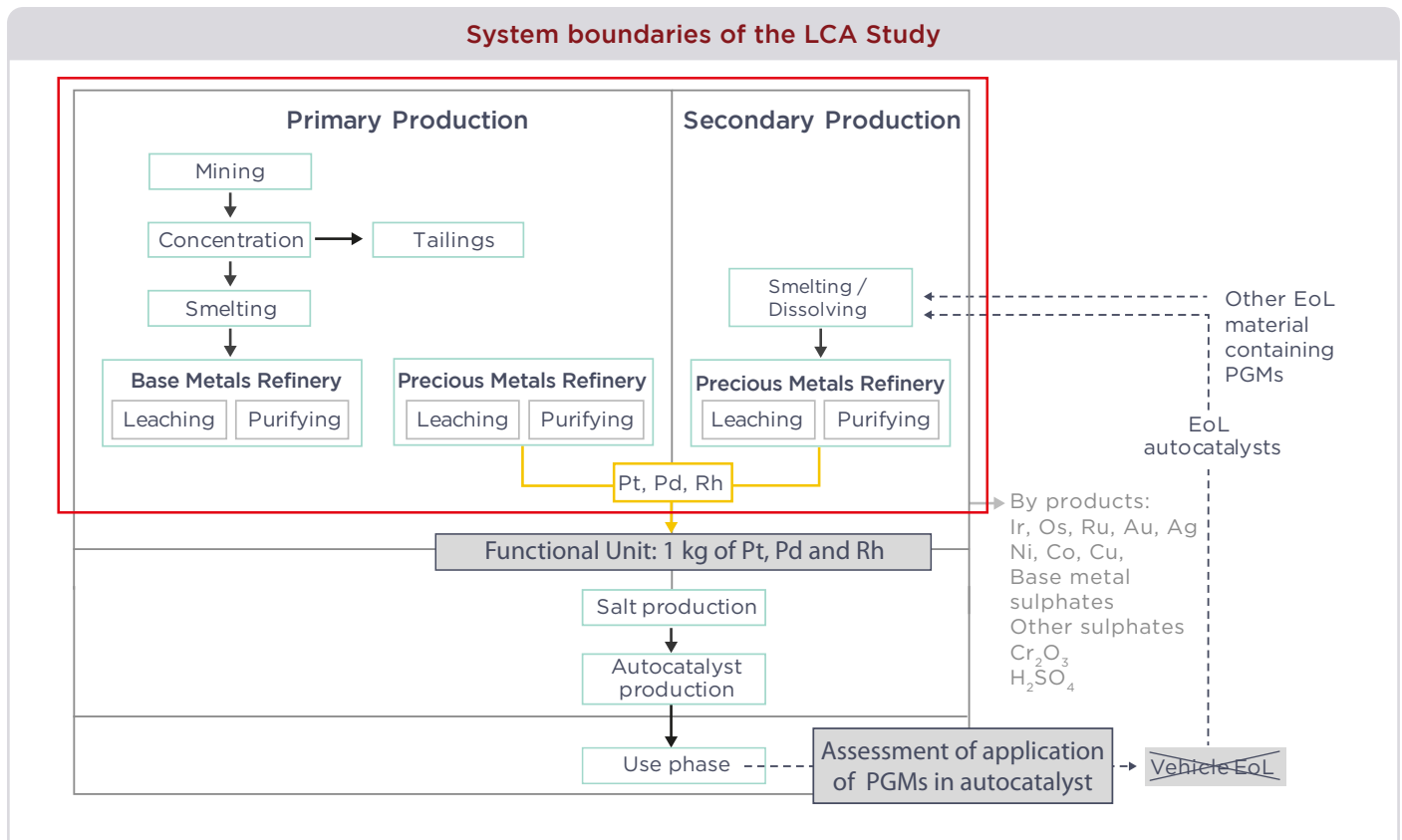


Figure 1: System boundaries of the IPA LCA Study 2017 “Life Cycle Assessment of Global Platinum Group Metals Production - Reference Year 2017”, issued by Sphera in October 2020

## KEY FINDINGS BASED ON LCI AND LCA RESULTS

The study illustrates that even though the impacts of PGM production appear to be high, from a life cycle perspective these impacts are significantly out-weighted by the in-use benefits.

### Primary Production:

- Mining, concentration, and smelting processes together make the major contribution to the impact of the primary production of PGMs on the environment. These energy-intensive processes precede the final separation of metals during refining, thereby producing not only PGMs, but also several other base metal products such as nickel, copper and cobalt, and other precious metal products such as iridium, osmium, ruthenium, gold and silver, which are not considered in this study.
- Electricity consumption in South Africa, which is more than 90% hard coal based, remains the biggest contributor to impact categories (such as Global Warming Potential) in addition to process emissions (direct activities).

The environmental impacts of PGM production have been quantified for a variety of categories; the two most requested categories Global Warming Potential (GWP) and Primary Energy Demand (PED), are presented in tables 2 and 3.

Global Warming Potential can be defined as the aggregate measure of the contribution to the greenhouse effect of some gases through their conversion into carbon dioxide equivalent (CO<sub>2</sub>-eq).

Primary Energy Demand is the quantity of energy directly taken from the environment prior to undergoing any anthropogenic changes and can be renewable (e.g. solar, hydropower) or non-renewable (e.g. coal, natural gas).

Numbers in tables 2 and 3 are presented per gram of PGMs, as the PGM loading on a passenger car autocatalyst system ranges from 3 to 9 grams.

		Primary production					
		Pt		Pd		Rh	
		LCA Study 2017	Gabi 2022	LCA Study 2017	Gabi 2022	LCA Study 2017	Gabi 2022
GWP	kg CO <sub>2</sub> -eq/g	41.8	33.3	25.3	23.7	36.9	34.9
PED	MJ/g	464.6	443	318.9	346	414.2	459

Table 2: LCIA results for the primary production of 1 gram of PGMs

### Secondary Production / Recycling:

- The smelting process is the major contributor (65%) to GWP for the secondary production of PGMs; 40% of GWP from smelting relates to the consumption of auxiliaries and raw materials and another 30% to emissions from direct activities such as electricity generated on-site and other associated process emissions. In the refining process, more than 40% of the GWP is associated with waste treatment.
- For PED, again the smelting process is the major contributor, with an average 68% share. 40% of PED from smelting arises from auxiliaries and raw materials, around 30% from purchased electricity and around 30% arises from the upstream production of fuels and reductants.
- The recycling of PGMs has a significantly lower footprint than primary production. This is expected for various reasons, including the vast difference in the concentration of PGMs in the primary versus the secondary sources.

		Secondary production					
		Pt		Pd		Rh	
		LCA Study 2017	Gabi 2022	LCA Study 2017	Gabi 2022	LCA Study 2017	Gabi 2022
GWP	kg CO <sub>2</sub> -eq/g	0.63	0.695	0.72	0.732	0.84	0.819
PED	MJ/g	10.1	10.8	11.7	11.3	12.6	12.4

Table 3: LCIA results for the secondary production of 1 gram of PGMs

**Autocatalyst in-use benefits:**

By using PGM-containing catalysts in vehicles with internal combustion engines and due to progressively more stringent emissions standards, vehicle emissions have been reduced significantly over the last 45 years.

Due to the incomplete combustion of fuel, the following emissions occur while driving:

- Carbon Monoxide (CO)
- Nitrogen Oxides (NOx)
- Hydrocarbons (HC) and
- Particulate Matter (PM)

These emissions have a negative impact on air quality and pose a risk to human health. New vehicles, however, are fitted with catalyst systems to reduce the regulated emissions from internal combustion engines. PGMs are the key materials in these reactions. Their use in autocatalysts is essential in reducing local vehicle emissions.

For the present study, the use phase performance of PGMs was represented by their application in an autocatalyst system in a Euro 6d-TEMP diesel and gasoline engine vehicle. An average system was modelled for each vehicle type.

- Our results indicate that over 2 tonnes of toxic and harmful pollutants (1180 kg CO, 162 kg HC, and 839 kg NOx) are neutralized by the catalytic converter systems in one Euro 6d-TEMP 1.4 litre gasoline and one Euro 6d-TEMP 2.0 litre diesel vehicle in use over 160,000 km.

- Based on the data collected in this study, in meeting the Euro 6d-TEMP emissions standard the conversion achieved for the modelled diesel car is 84% for CO, 98% for NOx and 66% for HC; for the gasoline vehicle, the conversion is 88% for CO, 98% for NOx and 95% for HC.
- Emissions of CO<sub>2</sub> slightly increase over the vehicle lifetime compared to an unregulated vehicle; this is due to CO<sub>2</sub> generated in the manufacture of the autocatalyst and the conversion of CO and HCs into CO<sub>2</sub> during vehicle use; however, this increase is relatively small (3% for the diesel vehicle and 11% for the gasoline vehicle) when compared to CO<sub>2</sub> emissions from the combustion of the fuel used to drive the vehicle.
- The emissions reductions because of the use of an autocatalyst outweigh the emissions generated during the production of the catalyst including PGMs and other related materials used in the wash coating process.
- The study measures the “break-even” point for emissions, which is the driving distance of the vehicle in which the additional environmental burden of producing the autocatalyst is offset by the role of the autocatalyst in reducing vehicle emissions. For all investigated Euro 6d-TEMP diesel systems the break-even point for all emissions (CO, HC, and NOx) is reached after between 2.5 km and 350 km of driving.

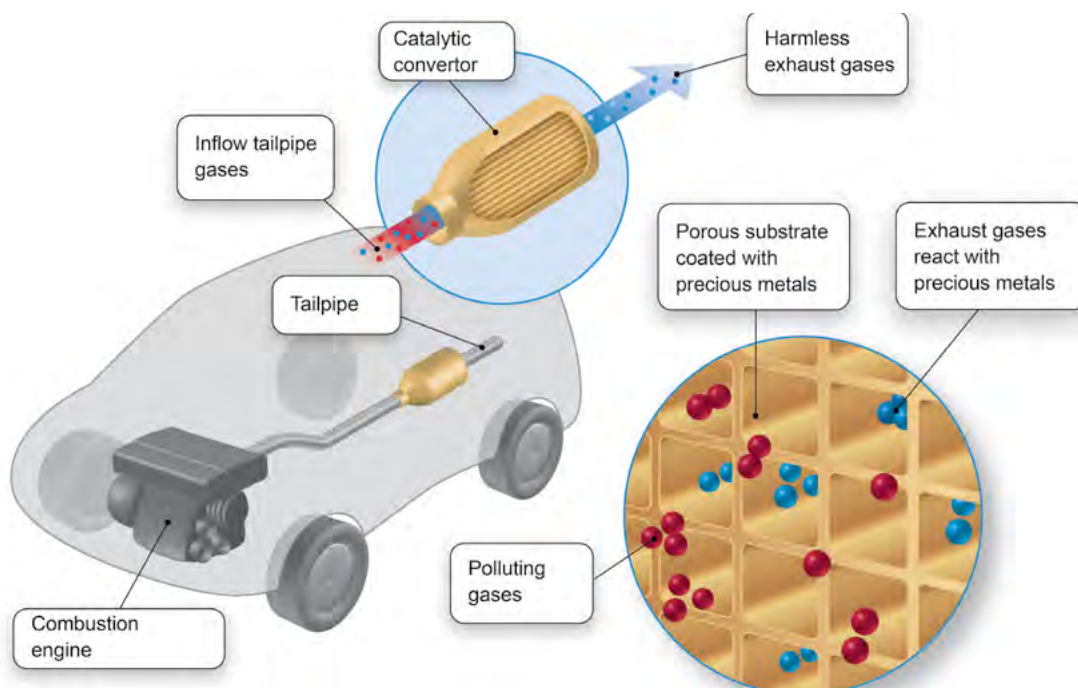


Figure 2: Source: Umicore



The break-even point for HC, for example, is reached after driving a gaso-line vehicle equipped with a catalytic system for 2.5 km. Hence, at that distance the emissions from producing the catalyst (including the PGM loading) have been cancelled out by the reduction of HC emissions from the vehicle (see figure 3):

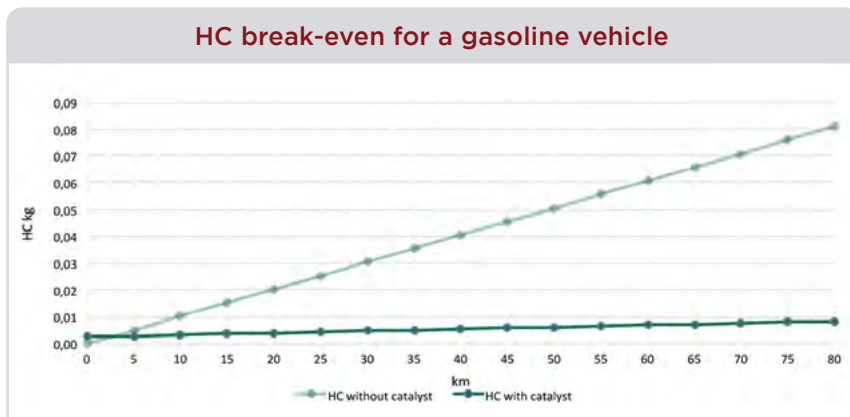


Figure 3: Cumulative HC emissions during the gasoline vehicle's lifetime.

Figure 4 on the right shows another example for use phase benefits: the benefit in countering the NOx emissions associated with the production of the autocatalyst is already achieved after driving the vehicle 350 km.

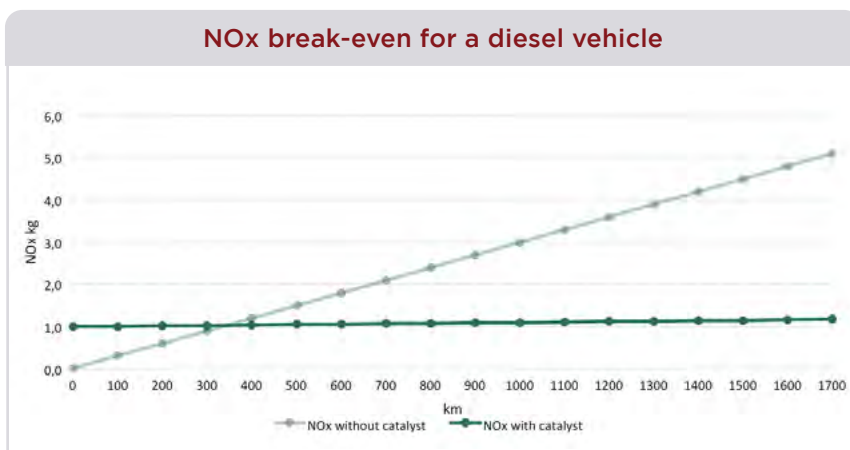


Figure 4: Cumulative NOx emissions during the diesel vehicle's lifetime;

The production of a diesel catalyst emits 0.99 kg of NOx; the benefit during the use phase, however, is that the use of the catalyst in the vehicle reduces NOx emissions by 454 kg over the vehicle's lifetime.

Similarly, the production of a gasoline catalyst emits 0.22 kg of NOx; in use, however, the catalyst in the vehicle reduces 386 kg of NOx. The break-even point for NOx emissions is achieved after driving the vehicle 100 km, as is shown in figure 5.

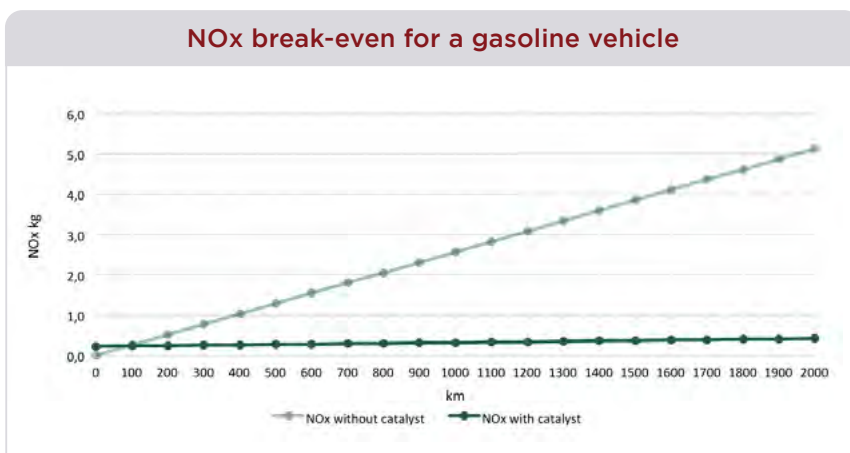


Figure 5: Cumulative NOx emissions during the gasoline vehicle's lifetime;

Another key contribution of autocatalysts to air quality and climate protection is the reduction of particulate emissions from internal combustion engines in transportation and machines. Particulate filters such as the Diesel Particulate Filter (DPF) and the Gasoline Particulate Filter (GPF) placed in the exhaust system mechanically remove the particulate from the exhaust

stream. Their removal efficiencies have proven to be in the 99% range for both PM and particulate number (PN) down into the nano size range of particulates. Although PM was not assessed separately in this study due to the lack of availability of validated data at the time of the study, the high efficiency of particulate filters has been demonstrated in previous studies.

### COMPARISON OF 2010 AND 2017 LCA DATA

Due to significant changes between the database versions (background data) and the contributing data (participants to the study), no direct conclusions can be drawn in terms of the environmental performance of the industry. For the primary production route, the PED related to the production of Pt has increased by 8%, while the PED to produce Pd has decreased by 21%, and by 3% for Rh. This can be explained by the inclusion of new participants with different power sources, such as hydro power and natural gas in Russia where a great amount of Pd is mined, and at the same time with the inclusion of deeper mines in South Africa with higher electricity demand.

The GWP for Pt has increased by 13% in 2017 compared to 2010. With purchased electricity being the major contributor to the overall GWP, it was further investigated that the GWP of the South African electricity mix (in the GaBi software system database) increased by 19% since 2010, hence the efficiency declined.

When comparing the average results of those participants who also contributed data in 2010 with the 2017 figures, a generally lower energy consumption is evident for 2017.

No comparisons can be drawn regarding the environmental performance for the secondary production of PGMs as the mix of companies represented has changed. Data collected for 2017 is more representative and comprehensive than data collected for 2010, and the volume of secondary production covered is considerably higher (increase by 130%) and more representative of the market situation.

In the 2010 LCA Study, the reported volumes of primary PGM production and secondary PGM production volumes were in a ratio of 90% to 10%, in 2017, the ratios were as follows:

- Platinum: 74% primary production, 26% secondary production.
- Palladium: 75% primary production, 25% secondary production.
- Rhodium: 67% primary production, 33% secondary production.

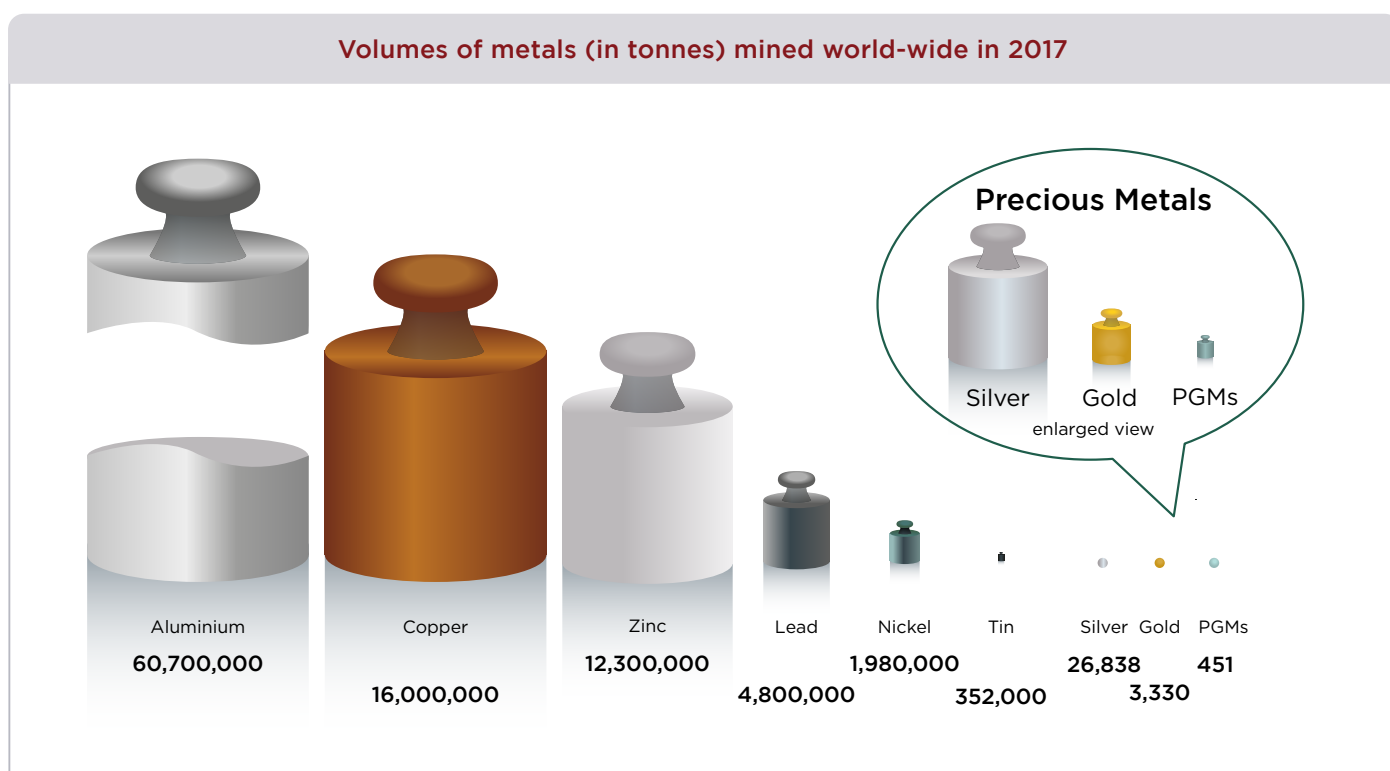


Figure 6: Source: British Geological Survey 2017; object sizes are not to scale

## WHAT ARE PGMs?

The six platinum group metals (PGMs) occur together in nature alongside nickel and copper. Along with gold and silver, PGMs are precious metals and are very rare elements in the Earth's crust. The annual primary production of PGMs amounts to around 450 tonnes, several orders of magnitude lower than many common metals.

Due to their economic values and higher quantities, platinum and palladium are the most important metals in the PGM mix and the main products. Rhodium, ruthenium, iridium and osmium are mined as co-products of platinum and palladium. PGMs are highly resistant to wear, tarnish, chemical at-



Figure 7: PGM loadings on average passenger car

tack and high temperature, and have outstanding catalytic and electrical properties. All these unique characteristics have made them indispensable in many industrial applications.

## FACTS ABOUT PGMs

- PGMs are very rare elements and most PGM-bearing ores are extremely low-grade, with typical mined ore grades ranging from 2 to 6 grams per tonne. PGM mining is a capital, energy and labour-intensive process; extraction, concentration and refining of the metals require complex processes that may take up to six months.
- Most of the largest primary producers of PGMs are in South Africa which hosts 95% of the world's known reserves. World resources of PGMs are estimated to total more than 100 thousand tonnes<sup>2)</sup>. In 2017, South Africa contributed 73% to primary supply of platinum, 40% to primary supply of palladium (Russia: 38%) and 82% to primary supply of rhodium. With a market share of 57%, South Africa was the largest PGM producer in 2017<sup>3)</sup>.
- PGMs have outstanding catalytic qualities which make them the premier choice for several industrial applications, such as petroleum refining, nitric acid manufacturing, and autocatalysts. There are two main properties that explain the widespread use of PGMs in cleaning car and other vehicle exhaust since the early 1970s: their resistance to poisoning (e.g. from fuel impurities); and their high thermal stability which means they retain their catalytic activity for a long period of time under extreme conditions.
- PGMs are used rather than consumed. The high recyclability of PGMs means they can be reused many times, thus ensuring that their impact on the environment is kept as low as possible.
- The PGM industry routinely recycles PGMs from their applications. Using state-of-the art recycling technology, more than 95% of the PGM content of spent automotive catalysts (and other PGM-containing applications) can be recovered. However, the high technical recyclability of PGMs is sometimes jeopardized by insufficient collection, especially in open-loop cycles, and inappropriate pre-treatment of PGM-bearing materials.
- In 2017, open-loop recycling contributed 24% of the total supply of platinum, 29% of the total supply of palladium and 29% of the total supply of rhodium<sup>4)</sup>.

<sup>2)</sup> U.S. Geological Survey, Mineral Commodity Summaries, January 2020.

<sup>3)</sup> Source: Johnson Matthey, PGM Market Report, May 2018.

<sup>4)</sup> Based on Johnson Matthey, PGM Market Report, May 2018.

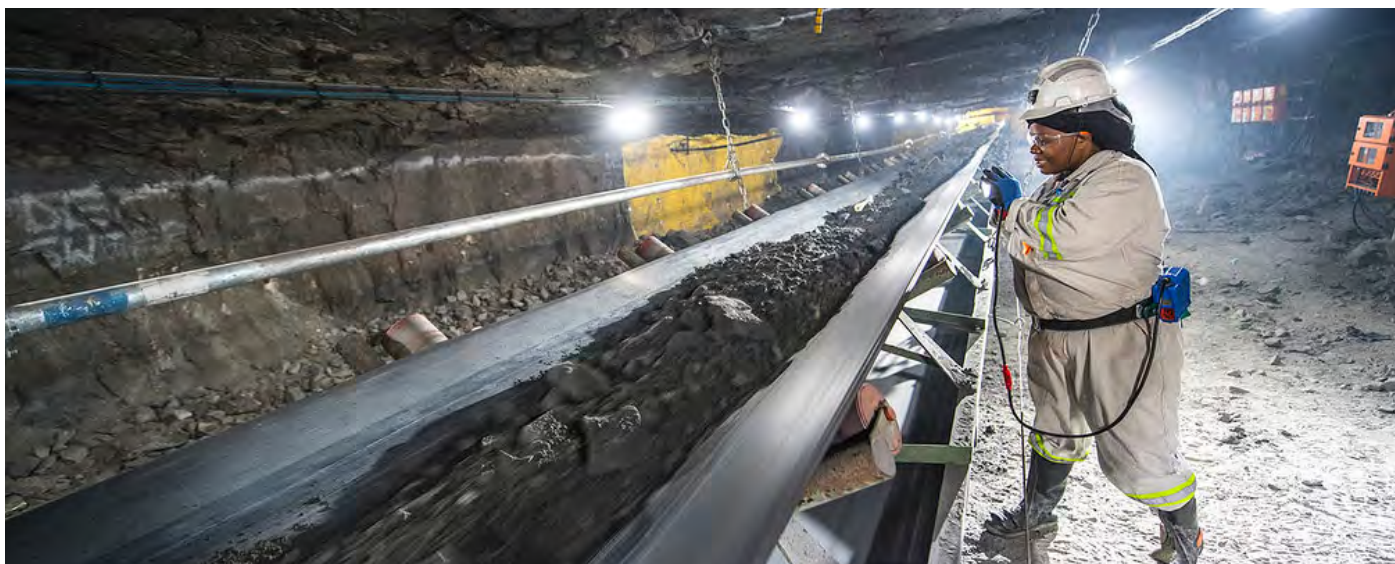


Figure 8: PGM mining in Rustenburg; source: Sibanye-Stillwater.

## HOW ARE PGMs PRODUCED?

### Primary Production

PGM-bearing ore is typically mined underground and from open pits. In South Africa, while open-pit methods are used to mine the Platreef, most parts of the Merensky and UG2 reefs are mined underground, with some mines reaching depths of more than 2 km, which require additional ventilation and cooling for the workers due to higher temperatures at these depths and increased effort in hauling the ore to the surface. Both requirements lead to an increase in electricity demand.

The ore is blasted before being transported to the surface. Crude ore is crushed, milled and concentrated into a form suitable for smelting, which takes place at temperatures that may be over 1500°C (2732°F). Unwanted minerals such as iron and sulphur are removed, leaving a matte containing the valuable metals which are separated in a series of refining processes. Nickel, copper, cobalt, chrome, gold and silver may be extracted in the refining process as co-products.

Electricity consumption is high, not only for ore haulage, but also to drive compressed air to the miners' hand-held pneumatic drills and, because the hard rock in platinum mines has a high thermal gradient, to cool the working areas. The power grid in South Africa, where the bulk of production considered in this study takes place, relies heavily on the combustion of hard coal, leading to relatively high CO<sub>2</sub> emissions: around 80%<sup>5)</sup> of electricity is generated that way. The local electricity grid mix is largely beyond the control of South African PGM producers. However, every effort is made to reduce primary energy demand.

### Secondary Production (Recycling)

PGMs can be recycled from a variety of end-of-life products (such as spent autocatalysts) and even from residues created during primary production. Secondary production processes can vary widely depending on the specific material or combination of materials treated. Some secondary producers of PGMs use a dissolving process to create a PGM-rich solution for refining, while others may use a smelting process to create a matte. In both cases, the final PGM products are identical in quality and purity to those refined from mined material.



Figure 9: Life cycle of PGMs; image credit platinum ore: Johnson Matthey; recycling numbers based on Johnson Matthey PGM Market Report, May 2018.

5) Source: Eskom Integrated Report 2020. 83% in 2017 and around 81% in 2020.

### WHAT ARE THE MAIN APPLICATIONS?

PGMs play a vital role at the heart of modern societies. They are found in numerous products, from computer hard disks to aircraft turbines, from anti-cancer drugs to mobile phones, from industrial catalysts to fuel cells. PGMs have played a role in the manufacture of many goods we use daily, with the most prominent being autocatalysts in vehicles.

The chemical industry is another key user of PGMs for various applications. Platinum, platinum alloys, and iridium are used as crucible materials for the growth of single crystals. Platinum or platinum-rhodium alloy catalysts in the form of gauze are used to catalyze the oxidation of ammonia to nitric acid, which is a raw material for fertilizers, explosives, nylon and polyurethane. PGMs have also become important as catalysts in synthetic organic chemistry. Ruthenium dioxide is used as coatings on dimensionally stable titanium anodes used in the production of chlorine and caustic soda. Platinum supported catalysts are used in the refining of crude oil, reforming, and other processes associated with the production of high-octane gasoline and aromatic compounds for the petrochemical industry.

Numerous applications in which PGMs are involved benefit the environment and our quality of life, such as water purification, N<sub>2</sub>O abatement and surgical implants, to name a few.

PGMs also play a key role in the development of advanced technologies such as hydrogen production which requires a Pt and Iridium based proton exchange membrane (PEM) for electrolysis (electrolysis is the process using electricity to split water into hydrogen and oxygen).

By far the largest use of PGMs today is for automobile catalytic converters (autocatalysts), pollution control devices fitted to cars, trucks, motorcycles, and non-road mobile machinery. As of 2017, autocatalysts accounted for over 61% of total global PGM demand (see figure 10).

In catalytic converters, PGMs are coated onto a substrate housed in the exhaust system where they act as catalysts to reduce levels of harmful emissions below legislated limits. Autocatalysts convert hydrocarbons (HC), carbon monoxide (CO) and oxides of nitrogen (NOx) from gasoline and diesel engines into less harmful carbon dioxide, nitrogen, and water vapour. Catalysed soot filters containing PGMs are used to trap and oxidise particulate matter from both diesel and gasoline vehicles.

Platinum, palladium and rhodium are the active metals in autocatalysts and for this reason these PGMs were evaluated in the LCA study.

Figure 10 shows the main usages of PGMs by industry sector in 2017 (reference year):

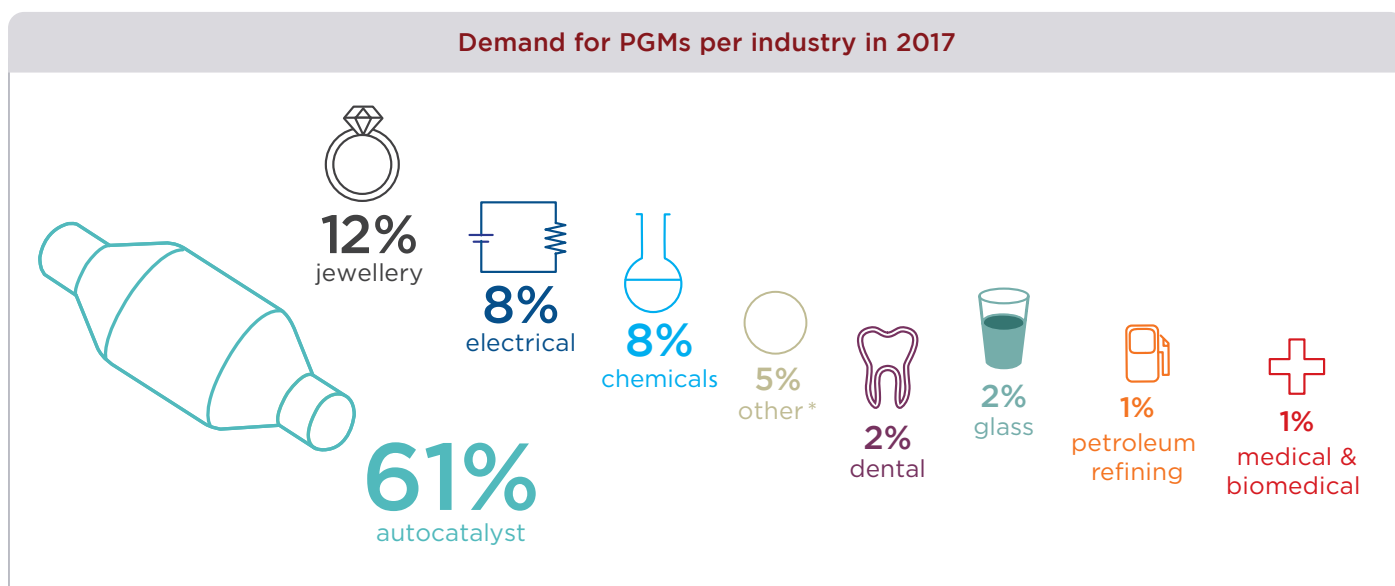


Figure 10: Source: Johnson Matthey PGM Market Report May 2018; \*includes investment

## TAKE-AWAY MESSAGES



Mineable deposits of PGMs are very rare in the Earth's crust; the extraction and refining of PGMs is a capital, energy and labour intensive process; e.g., it takes up to six months and requires between 10 and 40 tonnes of ore to produce one troy ounce (31,1035 grams) of platinum.

Like all mining activities, the extraction, processing and refining of PGMs impacts the environment. The PGM industry acknowledges its footprint and has set targets to reduce adverse environmental impacts.

PGMs are produced in low volumes; the global production of PGMs in 2017 was around 450 tonnes, several orders of magnitude lower than many common metals.



PGMs are used in relatively small quantities: The average PGM loading for a Euro 6d-TEMP European Light Duty Diesel (LDD) catalyst system, as modelled in the study, is 9.4 grams, for a Euro 6d-TEMP European Light Duty Gasoline (LDG) catalyst it is 3.2 grams. The quantity of toxic pollutants in the exhaust gas and the target reduction of these to comply with the legal emissions standards influence the quantity of PGM salts required. Due to stricter emissions regulations requiring more complex catalytic systems, the average PGM loadings on diesel cars has slightly increased compared to 2010<sup>5)</sup>.



The high and repeatable recyclability of PGMs means that the environmental burden of PGM production decreases with each recycling round. Due to its lower environmental impact, secondary production plays an important role in lowering the environmental footprint of global PGM production.

In the context of the PGM life cycle it must be understood that recycling could not occur if there had not been a primary ounce of PGMs produced beforehand. Hence, there is an industry-wide consent that secondary production is complementary to primary supply; ensuring the steady supply of PGMs to meet society's current and future needs requires both increased levels of recycling and ongoing investments in primary production.

PGMs contribute to the United Nations Sustainable Development Goals, especially SDG 3, 9 and 11, by helping to create innovative solutions to enhance the quality of life and air.



<sup>5)</sup> The 2010 LCA Study used 2-3 grams of PGMs for the modelled Euro 5 Light Duty Gasoline catalyst system and 7-8 grams of PGMs for the modelled Euro 5 Light Duty Diesel catalyst.

## COMPANIES PARTICIPATING IN THE LCA STUDY



## ABOUT THE IPA

The IPA is a non-profit organization representing 80% of the mining, production, and fabrication companies in the global platinum group metals (PGM) industry, comprising platinum, palladium, iridium, rhodium, osmium, and ruthenium.

In 2008, the IPA began to formulate an environmental strategy because of increased environmental awareness within the organization and in response to market, customer and regulator expectations.

In 2009, the membership developed the PGM industry's Sustainability Principles which include improving our understanding of the environmental, social, and economic impacts and benefits of our materials across their life cycle.

In 2013, the first industry-wide LCA was finalized and aggregated global average data was made available to selected stakeholders.

In committing itself to a life cycle approach, the industry determined that it will:

- Collaborate with suppliers, customers, and other stakeholders to understand the life cycle of its products and materials, and
- contribute to a global database of life cycle information and share best practices to reduce the overall footprint of PGM products.

The LCA study update supports the industry's commitment to understand and improve the sustainability performance of PGMs.



### **CONTACT INFORMATION**

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