LCA

LCA FACT SHEET ON IRIDIUM AND RUTHENIUM

Annex to the IPA LCA 2017 Study on Platinum, Palladium, and Rhodium

April 2023

IPA
INTERNATIONAL PLATINUM GROUP METALS ASSOCIATION

LCA FACT SHEET ON IRIDIUM AND RUTHENIUM

Annex to the IPA LCA 2017 Study on Platinum, Palladium, and Rhodium

BACKGROUND

The Iridium (Ir) and Ruthenium (Ru) Study, conducted in 2022, represents an Annex to the Life Cycle Assessment Study that the International Platinum Group Metals Association (IPA) had commissioned with the consultancy firm Sphera in 2017 for platinum, palladium, and rhodium. Both the original study as well as the Annex reflect the PGM industry's environmental performance for the year 2017.

The study extension (Annex) on iridium and ruthenium has been performed in response to increasing stakeholder demand for LCA data on these two metals, especially for iridium as a key metal for the hydrogen economy. It is the first time that an average industry LCA data set for primary production has been compiled on these two metals. Secondary production (recycling) of iridium and ruthenium is not in the scope of the Annex due to a lack of available data at the time of completion. Studies on platinum, palladium, and rhodium haven been performed in the past for the production years 2010 and 2017, for both the primary and secondary production routes, and with an application study on autocatalysts.

GOAL AND SCOPE OF OF THE ANNEX

The main goal of the Annex is to assess the potential environmental impact of the primary production of iridium and ruthenium and to generate a cradle-to-gate LCA profile based on the primary production data collection of 2017. The 2017 GaBi background database has been updated to the newest background database of CUP 2022.2. This includes the 2019 released electricity grid mix data of the International Energy Agency (IEA) and all new upstream data within the background database. As a side result, the Annex has also generated updated data using the newest background data for the other three PGMs (Pt, Pd, and Rh) which are presented in tables 3-5 at the end of this fact sheet.

The Annex considers the cradle-to-gate primary production of iridium and ruthenium. It covers impacts associated with the extraction of resources from nature up to the point at which the refined product leaves the factory gate. For primary produced metal the impact associated with the mining of the PGM ore is considered. The cradle-to-gate Life Cycle Inventory (LCI) includes the associated use of resources and the emissions of all electricity, energy, and materials inputs to PGM production.

The Annex focuses on the primary production of Ir and Ru, based on the input from five primary producers. The study has been carried out in accordance with ISO 14040 (2006), ISO 14044 (2006) and ISO/TS 14071 (2014). The defined and achieved scope of the original LCA 2017 Study had been ISO reviewed and confirmed appropriate to achieve the stated goal in the ISO reviewer's statement. The Annex is following the same goal and scope, and methodology, but has, however, not been separately assessed. The methodology and procedures used in 2010 and 2017 have reached a high level of maturity.

LCA Annex Quick Facts	
Life cycle stage	**Primary production**
Geographical coverage	South Africa, Zimbabwe, Russia
Industry coverage	Over 95% of global production
Overall industry representation	5 out of 6 primary producer members of IPA[1]
Time coverage	• Production data fiscal year 2017 • GaBi 2022 database for upstream process data (non-primary data such as consumed material, energy carriers etc.)
Methodology	• Cradle-to-gate LCI • LCA model created using GaBi (2022) software system (Sphera) • Combination of mass and economic allocation for PGM production
Functional unit	• 1 kg of iridium (>99,90%) • 1 kg of ruthenium (>99,90%)
Impact categories and indicators used	• Primary Energy Demand • Global Warming Potential • Acidification Potential • Eutrophication Potential • Photochemical Ozone Creation Potential • Blue Water Consumption
Quality	• Conducted by renowned consultancy (Sphera) according to ISO 14040 (2006) & 14044 (2006) and ISO/TS 14071 (2014) • Data reviewed for quality and accuracy (when first set of data was submitted in 2017) by independent technical expert William J. Middleton of WJM Environmental, Canada • Original LCA 2017 Report had been ISO reviewed by Prof. Dr. Matthias Finkbeiner, Technical University Berlin[2]

Table 1: LCA Quick Facts for the Annex Iridium and Ruthenium to the IPA LCA 2017 Report

The data submitted in 2017 by five primary producers had undergone a technical review conducted by William Middleton of WJM Environmental in Canada, hence, the review's validation can be expanded to iridium and ruthenium data submissions. Only one allocation has been applied to iridium and ruthenium, following the methodology already used in the 2010 and 2017 LCA studies.

For the Annex, the following mass-based functional units, equal to reference flow, have been used:

- 1 kg of Platinum (Pt) (>99,95%),
- 1 kg of Palladium (Pd) (>99,95%)
- 1 kg of Rhodium (Rh) (>99,90%)
- 1 kg of Iridium (Ir) (99,90%) and
- 1 kg of Ruthenium (Ru) (99,90%).

The functional unit is consistent with the main study's goal to calculate the environmental impact for the primary production of PGMs. This functional unit is also consistent with the goal of providing data to LCA practitioners and other stakeholders, which is often provided on a mass basis with a cradle-to-gate system boundary. In our general LCA communications, the impact results are presented per gram of respective PGM as PGMs are normally used in very tiny quantities of just a few grams.[3]

[1] The sixth primary producer member, Royal Bafokeng Platinum, does not produce iridium and ruthenium on its own.
[2] The Annex is in line with the methodology used in the LCA 2017 Report but has not undergone a formal separate review since the methodology has remained unchanged. The other six members of IPA are secondary producers.
[3] For example, the average amount of PGMs used in a passenger car ranges from 3-9 grams.

LCA SYSTEM BOUNDARIES

This study considers the cradle-to-gate primary production of iridium and ruthenium. It considers impacts associated with the extraction of resources from nature through to the point at which the refined product leaves the factory gate. Data included or excluded from the study is dependent on the system boundaries identified during goal and scope definition.

updated numbers for platinum, palladium and rhodium are presented in six categories detailed in table 2, on page 5.

Global Warming Potential (GWP) and non-renewable Primary Energy Demand (PED) were chosen because of their relevance to climate change and energy efficiency, which are strongly interlinked, and due to high public and institutional interest. Acidification Potential (AP), Eutrophication Potential (EP), and

System boundary for the LCA Study

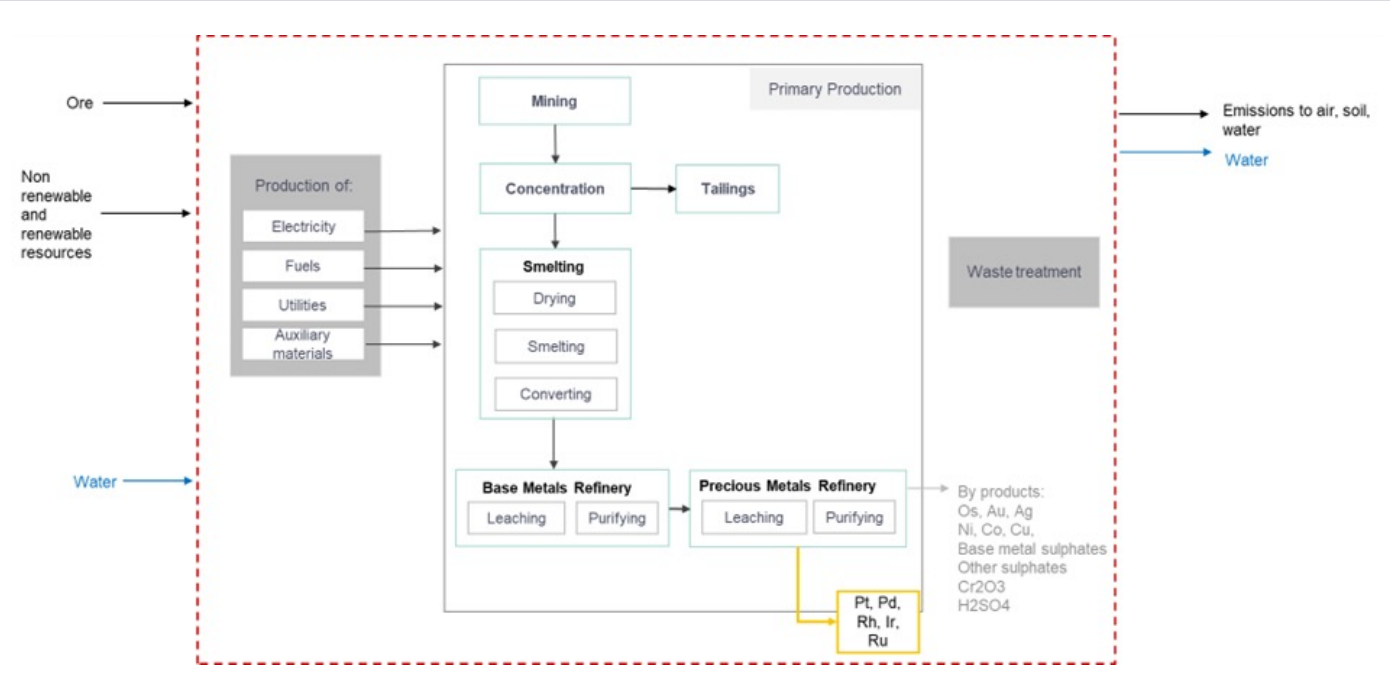

Figure 1: System Boundary (including all five PGMs)

Figure 1 shows the system boundary (depicted by the red border) considered in this study, including all five PGMs (platinum, palladium, rhodium, iridium, and ruthenium).

By-products of the primary production of PGMs such as base metals, their salts and other precious metals are part of the scope of the study. These by-products have been allocated using the approach described under “Allocation” on page 5.

IMPACT CATEGORIES

The impact potentials for the primary production of 1 gram of iridium and 1 gram of ruthenium as well as

Photochemical Ozone Creation Potentials (POCP) were chosen because they are closely connected to air, soil, and water quality, and capture the environmental burdens. Water use has also been addressed in the Annex due to the increasingly pressing issue of water scarcity in many producing countries. However, collecting data on water consumption and water use remains a challenge for the industry. Hence, the Annex as well as the 2017 Study address, as a first step, Blue Water Consumption defined as freshwater leaving the watershed.

Summary results of the LCA for the primary production of 1 gram of PGMs						
Impact Category	**Unit**	**Platinum**	**Palladium**	**Rhodium**	**Iridium**	**Ruthenium**
Global Warming Potential	kg CO_2 eq./g	31.7	22.4	34.3	27.5	33.9
Primary Energy Demand	MJ/g	421.9	329.7	450.7	350.2	434.3
Acidification Potential	kg SO_2 eq./g	0.871	1.601	0.445	0.508	0.586
Eutrophication Potential	kg PO_4 eq./g	0.018	0.011	0.019	0.016	0.019
Photochemical Ozone Creation Potential	kg Ethene eq./g	0.037	0.065	0.020	0.023	0.026
Blue Water Consumption	kg/g	278.9	207.2	316.4	208.5	310.1

Table 2: Impact categories for 1 gram of respective PGM; production year 2017, GaBi database 2022

METHODOLOGICAL BACKGROUND

The Annex to the LCA 2017 Study was conducted according to the requirements of the International Standard Organization ISO 14040 (2006), ISO 14044 (2006) and ISO/TS 14071 (2014). The original 2017 Report has received ISO verification, the Annex has not undergone a separate verification, but remains fully in line with the original methodology.

The iridium and ruthenium study is based on the CML[4] impact assessment methodology as CML characterisation factors are applicable for use in the European context and are widely used and respected in the LCA community. They are also favoured by the metals industry and were used in the 2010 and 2017 LCA studies.

ALLOCATION

The primary production of PGMs typically yields several other base metal products such as nickel, copper and cobalt due to these metals being a component of the PGM ore body. In South Africa, mining the UG2 Reef delivers a chromium concentrate (Cr2 O3) by-product. The precious metals osmium, silver, and gold are also by-products. These metal products were included within the scope of the study and were therefore treated as by-products by means of an allocation.

Multi-output allocation generally follows the requirements of ISO 14044, section 4.3.4.2, with the allocation rule most suitable for the respective process step applied within the process. No foreground processes required multi-input allocation; however, multi-input allocation was applied to waste processes including energy recovery, landfill, and wastewater treatment.

In the precious metals industry, a combination of economic allocation (by value) and mass allocation (by weight) is used. This approach was defined and used in both the 2010 and 2017 LCA studies and is consistent with the methodology adopted and recommended by the metals industry in general and set out in the metals LCA harmonization paper.[5]

Economic allocation is used between the processes upstream from the precious metal refinery where precious metals and base metals occur together due to the vast differences in the economic values between these metals. They have very different economic values and production volumes (e.g., platinum – low production volume, high market value vs. copper – high production volume, lower market value). Therefore, a mass allocation would not represent the value of the products and the rationale for producing different metals.

Where only precious metals occur together, in the precious metal refinery, a mass allocation is used to define the environmental profile since the precious metals spend broadly the same amount of time

[4] Centre of Environmental Science at Leiden.
[5] Santero, N., Hendry, J., Harmonization of LCA methodologies for the metal and mining industry. Int J Life Cycle Assess (2016) 21, 1543-1553, https://doi.org/10.1007/s11367-015-1022-4

circulating in the precious metal refinery, and therefore use the same amount of energy and consumables, to achieve maximum recovery. This allocation method was considered the best approach for the system under study as opposed to, for example, system expansion allocation which considers the existence of an alternative route to produce the by-product(s). The prices used in the assessment were averaged over three years (2015-2017).

The main non-metal by-products occurring in the production of PGMs are sulphuric acid and ammonium or sodium sulphate.[6] Sulphuric acid is produced at those sites which capture sulphur dioxide and treat it in an acid plant to produce saleable sulphuric acid, while some sites capture sulphur in the form of gypsum which could be sold or treated as waste. Ammonium or sodium sulphate are produced in the refining process. To account for this, system expansion is used to apply an environmental credit for the avoided environmental burden of the production of these virgin materials.

UPDATED FIGURES FOR PLATINUM, PALLADIUM, AND RHODIUM

In addition to generating first industry wide results for the primary production of iridium and ruthenium, this Annex also presents updated results for the primary production of platinum, palladium, and rhodium, and a comparison of 2017 and 2022 results.

Table 3, 4, and 5 compare the results from the 2017 Study using the GaBi database version SP37, with the results based on the same production year (2017), but with upstream data from the GaBi database version 2022.2. The main difference seen is based on the use of electricity: more energy was sourced from renewables in 2022. The higher impacts for rhodium and palladium in 2022 for Acidification Potential and Primary Energy Demand are linked to a wrong production amount submitted by one company in the 2017 submission which has now been corrected in 2022. In the case of platinum, the platinum model of 2017 was correct, and no adjustment was needed.

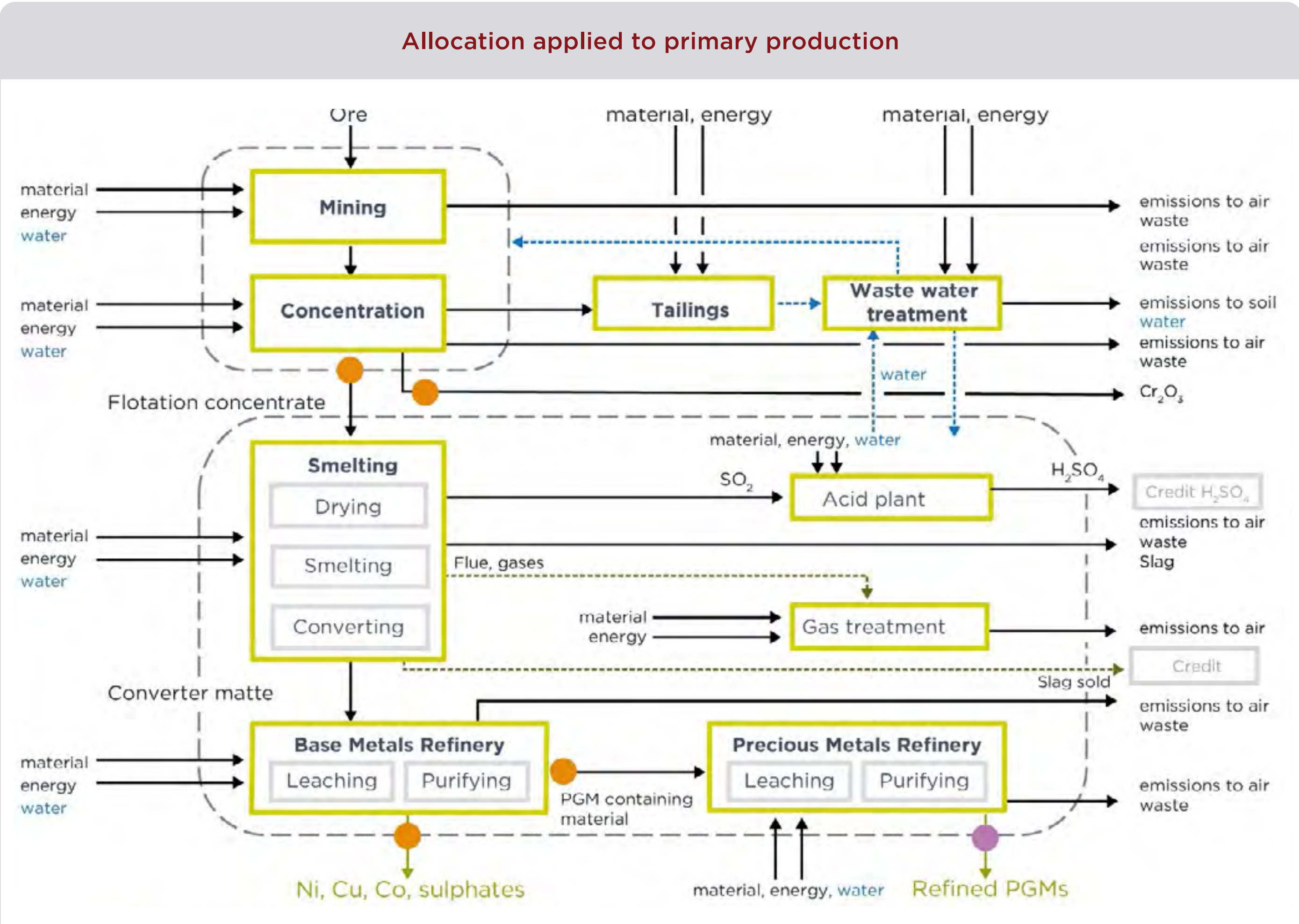

Figure 2: Allocation for the primary production route

[6] Either ammonium or sodium sulphate is produced, not both.

Comparison of the results for 1 gram of platinum 2017 to 2022, primary production				
Impact Category	**Unit**	**Platinum 2017**	**Platinum 2022**	**Change in %**
Global Warming Potential	kg CO_2 eq./g	41.8	31.7	-24%
Acidification Potential	kg SO_2 eq./g	0.934	0.871	-7%
Eutrophication Potential	kg Phosphate eq./g	0.025	0.018	-29%
Photochemical Ozone Creation Potential	kg Ethene eq./g	0.041	0.037	-10%
Primary Energy Demand	MJ/g	464.6	421.9	-9%

Table 3: Comparison of 1 gram of platinum primary production 2017 to 2022

Comparison of the results for 1 gram of palladium 2017 to 2022, primary production				
Impact Category	**Unit**	**Palladium 2017**	**Palladium 2022**	**Change in %**
Global Warming Potential	kg CO_2 eq./g	25.3	22.4	-12%
Acidification Potential	kg SO_2 eq./g	1.595	1.601	+0,4%
Eutrophication Potential	kg Phosphate eq./g	0.013	0.011	-17%
Photochemical Ozone Creation Potential	kg Ethene eq./g	0.066	0.065	-1%
Primary Energy Demand	MJ/g	318.9	329.7	+3.4%

Table 4: Comparison of 1 gram of palladium primary production 2017 to 2022

Comparison of the results for 1 gram of rhodium 2017 to 2022, primary production				
Impact Category	**Unit**	**Rhodium 2017**	**Rhodium 2022**	**Change in %**
Global Warming Potential	kg CO_2 eq./g	36.9	34.3	-7%
Acidification Potential	kg SO_2 eq./g	0.412	0.445	+8%
Eutrophication Potential	kg Phosphate eq./g	0.020	0.019	-7%
Photochemical Ozone Creation Potential	kg Ethene eq./g	0.020	0.020	+1%
Primary Energy Demand	MJ/g	414.2	450.7	+9%

Table 5: Comparison of 1 gram of rhodium primary production 2017 to 2022

COMPANIES CONTRIBUTING DATA TO THE ANNEX IRIDIUM AND RUTHENIUM

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.

The PGM industry routinely conducts life cycle assessment studies to monitor and document the potential environmental impacts of their products.

The Annex on Iridium and Ruthenium supports the industry's commitment to understand and improve the sustainability performance of PGMs. An update on the LCA dataset has started in 2023.

CONTACT INFORMATION

International Platinum Group Metals Association e.V.
Schiess-Staett-Str. 30, 80339 Munich – Germany

Phone +49-89-5199-6770
Fax +49-89-5199-6719
info@ipa-news.com
LCA@ipa-news.com