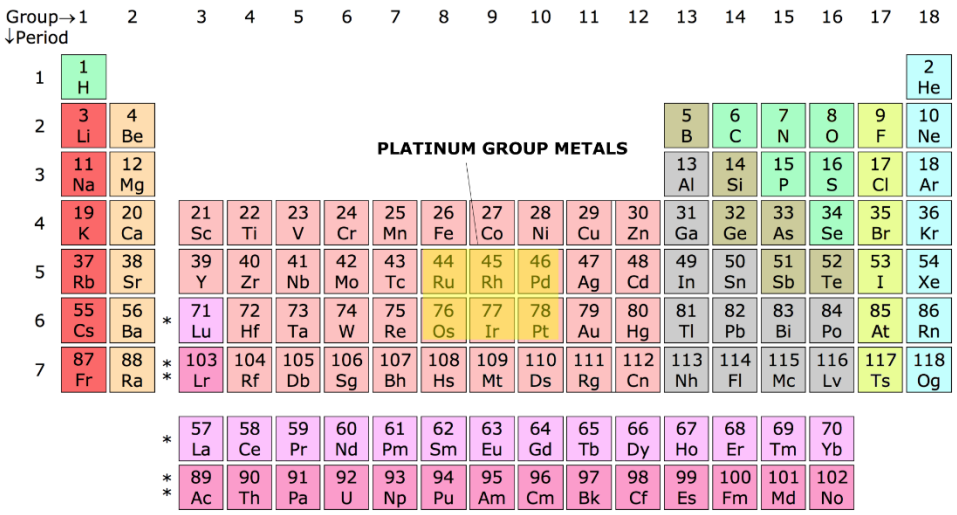
Negative Greenhouse Gas Emissions? The Curious Case of Platinum and Palladium

At over $1,800 per ounce, gold is one of the most expensive metals in the world. However, gold is not the most expensive. Members of the platinum group metals ("PGMs"), six elements near the center of the period table (See Figure 1), are perennially strong contenders for the title of "most expensive metal". Of the six, platinum and palladium are the most well-known. As of July 2021, an ounce of platinum is trading over $1,100 whereas palladium, its currently more expensive relative, is trading at $2,700 per ounce. These high prices can be attributed to rarity of the metals, a shortage of consistent supply, and their expensive production cycle.

Figure 1: Platinum Group Metals on the Periodic Table



The production of platinum and palladium is highly energy intensive, leading to the release of significant greenhouse gases (GHGs). The U.S. Environmental Protection Agency (EPA) quantifies the effect of GHGs using a measure called carbon dioxide equivalents (CO_2e), the climate effect translated into units of carbon dioxide. According to a 2017 study by the International Platinum Group Metals Association (IPA), the production of one gram of platinum emits 41.8 kilograms of CO_2e, whereas the production of one gram of palladium emits 25.3

kilograms of CO_2e [1]. The mining and separation of platinum from its ore is the largest cause of emissions; it takes up to a ton of ore to produce just one ounce of platinum. South Africa is the world's largest producer of platinum, followed by Russia. Russia is also the largest producer of palladium. Both countries largely use fossil fuels for electricity generation.

Although the production of platinum and palladium is associated with significant release of GHGs, the metals – like other industrially useful metals - can be recycled. Recycling reduces the reliance on production, which eases the burden on GHG emissions. The Government of Canada estimates that 30% of the global supply of platinum group metals are from recycling sources[2]. Recycling platinum and palladium still emits GHGs, albeit at much lower levels compared to production: recycling one gram of platinum releases 0.63 kg of CO_2e and recycling one gram of palladium releases 0.72 kg of CO_2e.

Table 1: Environmental Effects of Platinum and Palladium

	Production	Recycling	Price (July 2021)
Platinum	41.8 kg CO_2e/g	0.63 kg CO_2e/g	~ $35/g
Palladium	25.3 kg CO_2e/g	0.72 kg CO_2e /g	~ $70/g

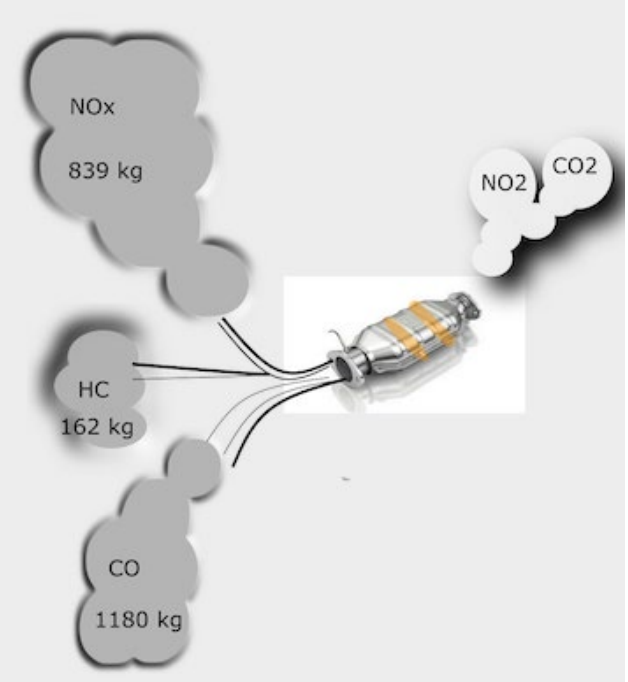
If the story were to stop here, platinum and palladium do not appear at all environmentally friendly. Environmentally-conscious commodity investors simply shun these metals, right?

Not so fast. Looking at the production and recycling GHG emissions of platinum and palladium provides only a partial picture. A full lifecycle analysis must include the environmental impact of these metals in their primary uses. Yes, platinum and palladium have large emissions during their production phase. However, the primary use of platinum and palladium is automotive catalytic converters, consuming about a half of the global supply[3]. A catalytic converter is an

[1] https://ipa-news.de/assets/sustainability/2021-04-26_IPA%20Environmental%20Profile%20of%20PGMs.pdf
[2] https://www.nrcan.gc.ca/our-natural-resources/minerals-mining/minerals-metals-facts/platinum-facts/20520
[3] https://pubs.usgs.gov/of/2004/1224/2004-1224.pdf

exhaust emission control mechanism that transforms pollutants in the exhaust gas of an internal combustion engine into less harmful material. During its normal use, an internal combustion engine produces harmful byproducts such as carbon monoxide, nitrous oxide, hydrocarbons. A catalytic converter transforms these toxic pollutants into water, nitrogen, and carbon dioxide.

Figure 2: The Function of a Catalytic Converter



Although carbon dioxide is produced by the catalytic converter, its greenhouse gas effect is mild compared to the effects of the molecules it destroys. For example, carbon monoxide has a Global Warming Potential (GWP) of two[4], meaning one kilogram of carbon monoxide has the climate effect of two kilograms of carbon dioxide. Nitrous oxide has a GWP of 265-298[5].

According to the IPA, over the lifetime of a car, the typical catalytic converter breaks down 1,180 kilograms of carbon monoxide, 439 kilograms of nitrous oxide, and 162 kilograms of

[4] https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-chapter2-1.pdf#table-2-14
[5] https://www.epa.gov/ghgemissions/understanding-global-warming-potentials

hydrocarbons. A conservative estimate of the total amount of GHGs broken down is equal to hundreds of thousands of kilograms of carbon dioxide. In a typical catalytic converter, 3-9 grams of platinum or palladium is used. If we conservatively assume 9 grams, the high-end estimate of the carbon emissions from producing these metals is no more than 360 kilograms of CO_2e. The environmental effect of breaking down nitrous oxide alone is more than 300 times larger than the production emissions (439 kg x 265 GWPs/360 kg = 323).

Considering both production and usage, where do platinum and palladium stand on the environmental scale?

Although platinum and palladium production releases GHGs, their use in catalytic converters provides such magnificent benefits from the perspective of GHG emissions that emissions during production are overwhelmingly offset. In this sense, platinum and palladium are truly negative-emission commodities!