

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 strong contenders for the title of “most expensive metal”. Of the six, platinum and palladium are the most well-known. As of July 2021, one 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 supply, and their expensive production cycle.

Figure 1: Platinum Group Metals on the Periodic Table

Group→	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
↓Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	* 71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	* 103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
			* 57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb		
			* 89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No		

The production of platinum and palladium can be 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 (CO₂e), 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 CO₂e, whereas the production of one gram of palladium emits 25.3 of

CO₂e¹. 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 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 sources². 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 CO₂e and recycling one gram of palladium releases 0.72 kg of CO₂e.

Table 1: Environmental Effects of Platinum and Palladium

	Production	Recycling	Price (July 2021)
Platinum	41.8 kg CO ₂ e/g	0.63 kg CO ₂ e/g	~ \$35/g
Palladium	25.3 kg CO ₂ e/g	0.72 kg CO ₂ e /g	~ \$70/g

Platinum and palladium do not appear at all environmentally friendly. Should environmentally-oriented commodity investors simply shun these metals?

Looking at the production and recycling GHG emissions of platinum and palladium only provide a partial picture. A full lifecycle analysis must also include the impact of these metals in their uses. From a lifecycle point of view, indeed, platinum and palladium have the largest emissions during their production phase. However, the primary use of platinum and palladium is automotive catalytic converters, which consumes about a half of the global supply³. A catalytic converter is an exhaust emission control mechanism that transforms pollutants in the exhaust

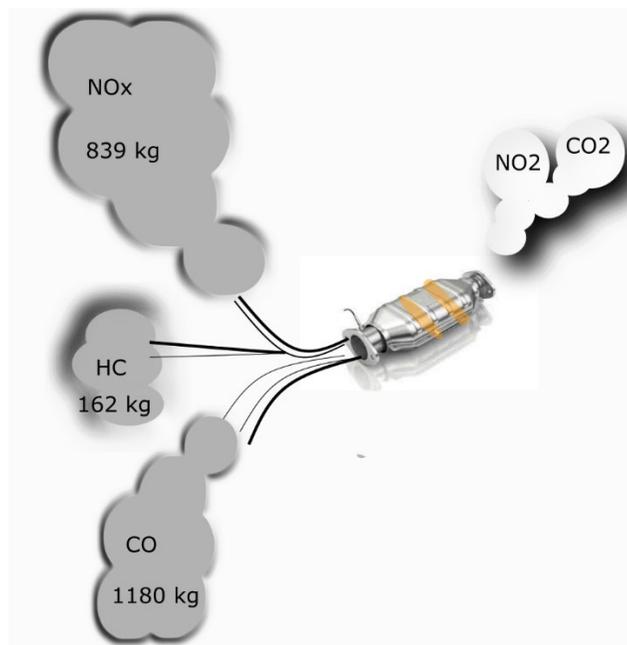
¹ https://ipa-news.de/assets/sustainability/2021-04-26_IPA%20Environmental%20Profile%20of%20PGMs.pdf

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>

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, and other particulates. 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 two⁴, meaning one kilogram of carbon monoxide has the climate effect of two kilograms of carbon dioxide. Nitrous oxide has a GWP of 265-298⁵.

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 hydrocarbons. A conservative estimate of the total amount of GHGs broken down is equal to

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>

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 CO₂e. Just the environmental effect of breaking down nitrous oxide is more than 300 times larger than the production emissions ($439 \text{ kg} \times 265 \text{ GWPs} / 360 \text{ kg} = 323$).

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

Although platinum and palladium production releases GHGs, their subsequent use in catalytic converters provide extraordinary benefits from the perspective of GHG emissions to more than offset emissions during production. In this sense, platinum and palladium are truly negative-emission commodities.