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ADVANCING GLOBAL 2050 NET ZERO GOALS THROUGH SUSTAINABLE EXTRACTION OF PLATINUM GROUP METALS AND PRECIOUS METAL RECYCLING.

PAVING THE WAY TO GLOBAL NET ZERO.

The past decade has seen a global shift in momentum toward combating climate change. Perhaps the most pivotal catalysts for this shift have been the historic signing of the Paris Agreement in 2015, closely followed by the establishment of "Net Zero" 2050 emissions targets set by the International Energy Agency (IEA)[1]. This both reinvigorated ongoing developments and inspired new efforts in clean technologies ranging from solar power and wind energy to carbon capture technology and hydrogen fuel – all in the pursuit of a comprehensively green energy transition.

One of the most promising pathways to such transition is hydrogen fuel, which, in addition to being the most abundant element in the universe, also has excellent energy density properties (140 MJ/kg compared to petroleum gasoline at 44 MJ/kg)[2]. It also may be the only high energy density fuel source that can be generated sustainably, in this case, production through electrolysis powered by sustainable energy sources like solar or hydropower, which generates no carbon-based emissions. However, for hydrogen to be a viable fuel for widespread adoption, and help pave the way for global net zero, the key challenge to overcome is prohibitive cost. The cost is primarily due to the expensive materials required for operation, mainly platinum group metals (PGMs).

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Role of PGMs on the Way to Net Zero 2050.

With green hydrogen as a pathway, the core of the energy transition problem is then a problem of precious metal supply – crucial among them PGMs like platinum, rhodium, and iridium. PGMs serve a key role in a range of clean energy technologies both as high-performance coating materials and as catalysts in underlying chemical reactions. This includes catalytic converters in the operation of both hydrogen electrolyzers and hydrogen fuel cells. The problem is PGM prices have been and continue to skyrocket as global supply is less and less able to keep pace with demand.

The State of the Current PGM Market

The PGM market of the past few years has been one of consistently high prices driven by both economic supply and geopolitical turmoil. Palladium peaked at almost $3,500 per oz in March 2022, rhodium at nearly $30,00 per oz in May 2021, while platinum has held steady above $1,000 per oz since January 20214. The total market value of approximately is speculated to be worth more than $60 billion[3].

Figure 1. PGM material prices tracked from January 2021 to April 2023

The high prices of these materials represent something of a bottleneck on innovation in the hydrogen industry. Regardless of innovation in high efficiency electrolysis, reduction in price is limited by the need of these material for operation. Most raw materials are mined in either South Africa or Russia, with a finite capability for production. This disproportion in global resource allocation leads to natural supply chain disparity subject to both logistic concern and fluctuating geopolitics. For example, while platinum prices maintained about around $1,000 per oz, China saw a surplus[4] in supply while North America and Europe experienced a decrease in availability – a decrease expects to lead to a deficit of almost 16% by 2030[5].

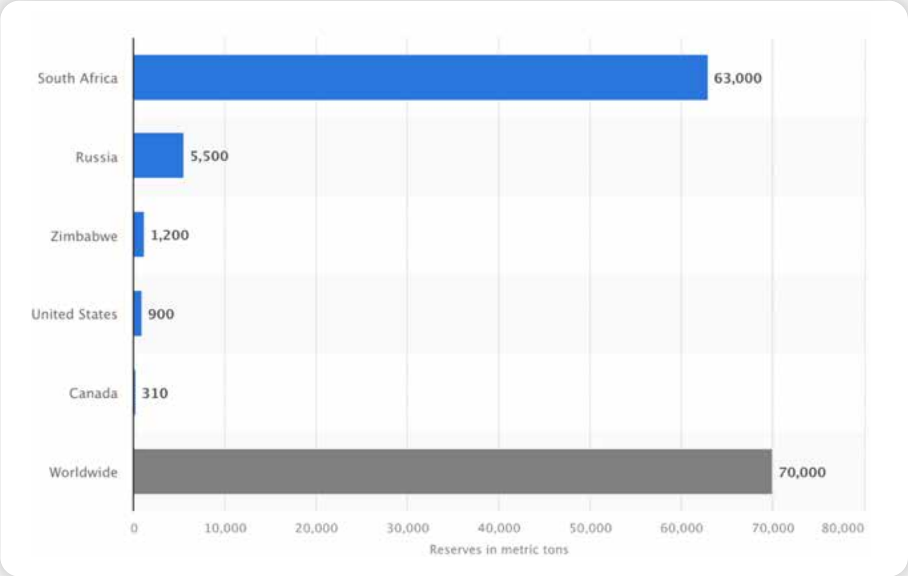

Figure 2. Distribution of PGM mine production worldwide. Source: Statista PGM reserves worldwide[6]

Challenges & Opportunity: Supply Deficit, Economy, & Environment

The state of the PGM market represents several key challenges to energy transition, but also helps shape possible opportunities for innovation. The most critical issue is the supply deficit of PGMs causing increased costs due to:

- **Limited supply,**
- **Disparate global distribution**
- **Increasing demand in the cleantech market**

The most straightforward solution would initially appear to be simply to increase production. However, from a sustainability perspective, this is not the case. The process of mining in and of itself is difficult and requires costly, carbon-driven, infrastructure on a large scale, and to increase production would only require more so. So, in truth one challenge of the PGM deficit really hides there – a deficit of PGM materials used in energy transition technologies, the cost associated with the rarity of those materials, and the sustainability risks associated with their production. Innovations that would most benefit the market mirror these challenges and would have characteristics such that they:

1. **Address the supply deficit of PGM materials for the use of clean technology solutions.**
2. **Do so in such a way that the overall cost of energy transition – centralized around green hydrogen - is reduced, preferably to the degree that widespread adoption of green hydrogen as a fuel is viable.**
3. **The process by which the deficit and costs are reduced is in and of itself sustainable and therefore not mitigating net zero contributions.**

RECYCLING TO SECURE PGMS FOR A GREEN ENERGY TRANSITION

If the process of PGM recycling could be executed in a sustainable way, the circular economy of PGMs could supplement the supply deficit in such a way that further increases in production could be less vital, the increase in availability could drive down cost, and no other negative net zero contributors would be introduced.

Based on the desired characteristics discussed above, perhaps the only worthwhile solution is to somehow reuse PGMs already mined, whether that be to capitalize on mining waste products or to refine and repurpose materials following their first life use. In other words, the best solution in alignment with the three metrics previously discussed is recycling, or rather more comprehensively, a shift to a circular economy in the use of PGM materials. In 2019 alone, more than 50 million metric tonnes of electronic waste (e-waste) were generated. That amount represents a lost total material value of almost $50 billion that could have been recycled and repurposed[7]. Approximately $2.5 billion of that value was PGMs, and that accounts for just a single year[8]. The proper recycling of PGMs could bring that same value back into the clean technologies market and provide a sustainable and consistent supply reserve for continued energy transition – however, to maintain a positive contribution to net zero goals, recycling must be executed in a green way.

Unfortunately, PGM recycling is not always innately green in the process. Typical solutions require taking the electronic waste (e-waste) and initially separating metal from non-metal subcomponents, and then either using:

1. **Pyrometallurgy (a.k.a. smelting) to melt down and isolate precious metals.**
2. **Hydrometallurgy to isolate metals through the use of corrosive acids.**

Both approaches have significant environmental implications. Smelting requires significant energy which increases its own innate carbon footprint, while hydrometallurgy uses and generates toxic chemicals as well as significant volumes of wasted water used for dilution.

pH7'S SOLUTION: PROVEN CLEANTECH FOR THE EXTRACTION OF PLATINUM GROUP METALS.

The team at pH7 Technologies has worked diligently to develop a solution to address exactly such needs, in the hopes of contributing to the energy transition by making hydrogen fuel viable via PGM metal recycling – specifically making the extraction of Platinum Group Metals such that it may be recycled sustainably. The result is our proprietary green solvent formulation which we employ in our variant of the hydrometallurgy process. The industry standard leverages highly corrosive and toxic chemicals in addition to requiring substantial power for operation. The pH7 Technologies approach has proven to be a clean technology using absolutely no toxic chemicals, reduces wastewater by 98%, has a 100% reduction in NOx and SOx emissions, and requires 84% less power than alternative processes. From a performance perspective, the pH7 approach to PGM extraction delivers a recovery rate of 99% with 75% purity (compared to 25% in alternatives). Moreover, the process is seamlessly closed-loop, generating almost no waste, enhancing both sustainability and efficiency attributes – and already being demonstrated at scale at the pH7 pilot plant.

Through the combination of increased performance and comprehensive sustainability, the widespread use of such green PGM extraction provides a viable potential methodology by which to encourage a circular recycling economy in PGM materials and in so doing address the supply deficit, cost concerns, and usher in green transition through adoption of affordable green hydrogen fuel.

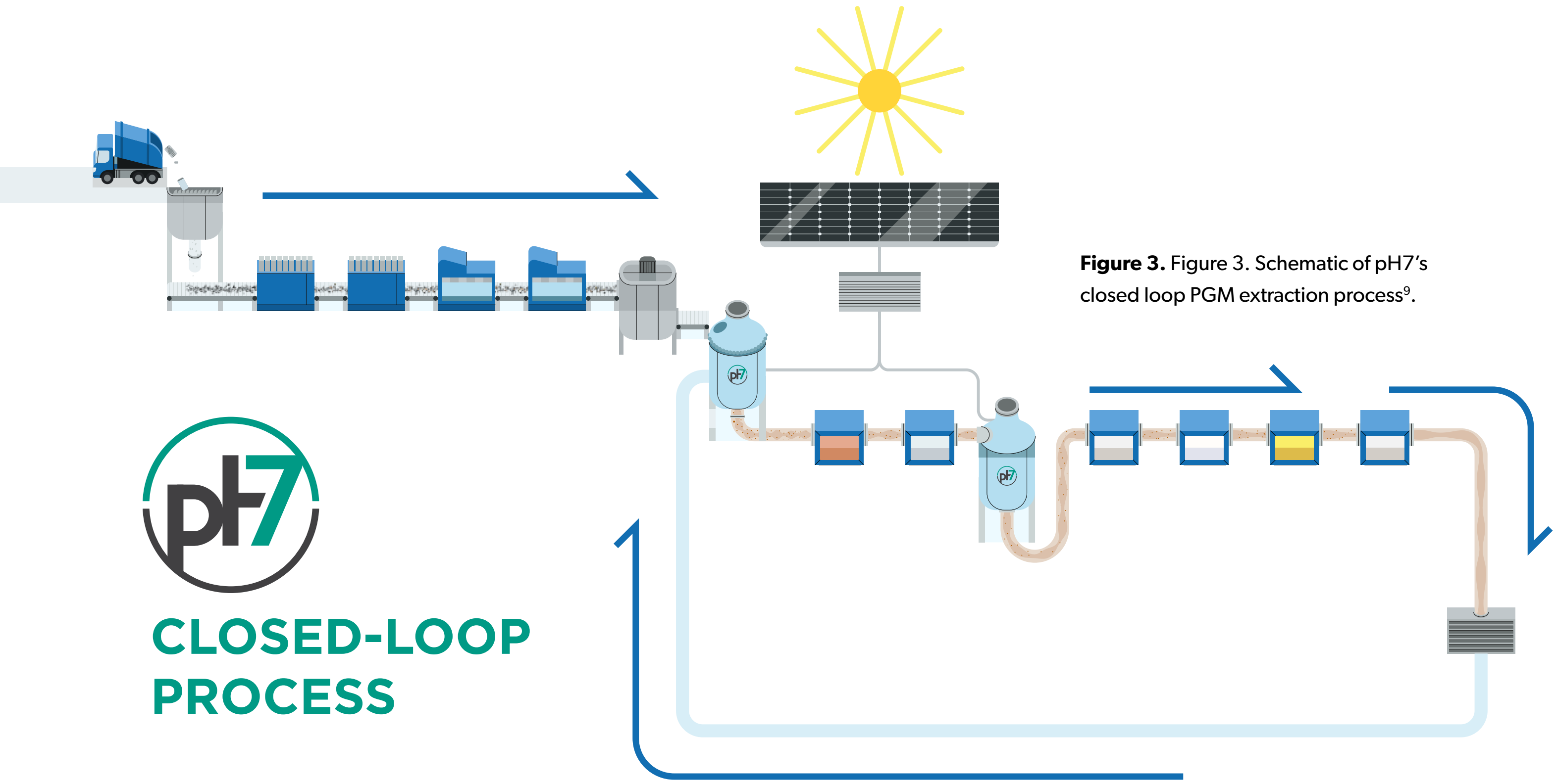

Figure 3. Figure 3. Schematic of pH7's closed loop PGM extraction process[9].

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pH7 Technologies Inc.
311-1930 Pandora Street,
Vancouver, BC, V5L 0C7