Supplementary Materials: Earth-Abundant Electrocatalysts in Proton Exchange Membrane Electrolyzers

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Calculations

We chose the Pt-Ir proton exchange membrane electrolyzer and calculated how many years of precious metal annual production would be required.

If we choose Pt-Ir$_{0.6}$Ru$_{0.4}$O$_2$ based as the state-of-the-art electrolyzer (see [79])

Pt at the cathode: 0.4 mg$_{Pt}$/cm^2

Ir at the anode: 1.54 mg$_{Ir}$/cm^2

Ru at the anode: 0.54 mg$_{Ru}$/cm^2

Equilibrium potential at 80 °C is 1.18 V

At current 1 A/cm^2 (1.567 V)

Annual Pt production (including recycled): 2.2×10^5 kg (USGS 2016 Mineral Years Report)

Annual Ir production (including recycled): 7.2×10^3 kg (Johnson Matthey 2018 PGM market report)

Annual Ru production (including recycled): 3.8×10^4 kg (Johnson Matthey 2018 PGM market report)

Power stored: P_{stored} = 1.18 W/cm^2

Total area needed for TW hydrogen production: $A = 8.4 \times 10^{11}$ cm^2

Amount of Pt needed:

$$W_{Pt} = 8.4 \times 10^{11} \times 0.4 \text{ mg} = 3.36 \times 10^5 \text{ kg} \approx 1.5 \text{ years of annual Pt production}$$

Amount of Ir needed:

$$W_{Ir} = 8.4 \times 10^{11} \times 1.54 \text{ mg} = 1.29 \times 10^6 \text{ kg} \approx 180 \text{ years of annual Ir production}$$

Amount of Ru needed:

$$W_{Ru} = 8.4 \times 10^{11} \times 0.54 \text{ mg} = 4.54 \times 10^5 \text{ kg} \approx 12 \text{ years of annual Ru production}$$

The authors of this article are based in Norway, and a report (27 November 2018) from the National Transport Plan states:

"*The National Transport Plan (NTP) has stated that by 2025, no more fossil cars should be sold. With a yearly sale of roughly 150,000 cars in Norway and assuming that hydrogen cars will have a rising market share from 30% to 50% in the years from 2025 to 2030, the number of hydrogen cars will accumulate to roughly 500,000 by 2030. These cars will then consume around 75,000 tons of hydrogen, which in turn, will require 4 TWh of renewable electric energy*."

Source: https://www.openaccessgovernment.org/hydrogen-is-finally-getting-attention-from-norwegian-politicians/47244/