Assessing Green Hydrogen Production Power, Natural Gas Displacement, O_2 Value, and IRS Credit Potential

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https://infinityturbine.com/heat-treating-steel-ng-hydrogen-production-savings-using-solar-pv-by-infinity-turbine.html

Calculate kWh per kg for green hydrogen electrolysis, O_2 output, NG displacement potential, savings in Illinois, and value of oxygen, in the context of the IRS hydrogen credit.

This webpage QR code

PDF Version of the webpage (maximum 10 pages)

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Introduction

To assess the financial viability of producing green hydrogen (and claiming the IRS credit), it is helpful to run through a back-of-envelope engineering and economic model. Below I walk through the key conversions and assumptions you'd need, estimate the magnitude of savings from displacing natural gas (NG) in a steel heat-treating facility, and estimate the possible credit from the IRS.

Electrolysis: Power Required and O_2 Production

Theoretical and practical energy need for H_2

The thermodynamic (ideal) enthalpy input required to split water into H_2 and O_2 corresponds to about 39.4 kWh per kg H_2 (based on 141.9 MJ/kg HHV) ([National Academies Press][1])
In practice, due to inefficiencies, real electrolyzers consume more. Many commercial systems today operate in the range of 50 to 55 kWh per kg H_2 ([Hydrogen Program][2])
Some advanced systems or pilot units claim somewhat lower consumption (e.g. ~ 37–42 kWh/kg) under favorable conditions, but that is optimistic and may exclude balance-of-plant losses. ([Bloom Energy][3])
Thus, a reasonable assumption for a full-system baseline is ~ 50 kWh per kg H_2 (or in a well-optimized plant perhaps slightly lower).

Hence, for each kg H_2 produced, you'd need on the order of 50 kWh of electricity from solar PV (or other source).

Mass of O_2 produced

From the balanced reaction:

[$2 H_2O \rightarrow 2 H_2 + O_2$]

Molecular weights:

H_2O: 18,
H_2: 2,
O_2: 32.

For every 2 moles (≈36 g) of water, you get 2 moles (≈4 g) hydrogen and 1 mole (≈32 g) oxygen.

Thus, per mass of hydrogen:

If you produce 1 kg (1000 g) of H_2, that's 500 moles of H_2. That came from 500 moles of water input (each yields one H_2 and ½ O_2). The corresponding O_2 is 250 moles, i.e. 250 × 32 = 8,000 g = 8 kg of O_2.

In short: 1 kg H_2 yields about 8 kg O_2 (assuming pure separation, ideal stoichiometry).

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