

I. Green Hydrogen

Certified green hydrogen requires an emission reduction of >60-70% (depending on the certification body) below the benchmark emissions intensity threshold (= GHG emissions of grey hydrogen, for example benchmark values according to the renewable energy directive RED II). ²⁾

Production method: Green hydrogen is generated entirely by renewable energy. 'Green' hydrogen is produced by electrolysis using low- or zero-carbon electricity. ²⁾

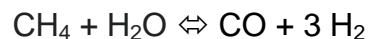
Green house gas emissions: > 0.45 kg CO₂e per kg H₂; ¹⁾

II. Grey Hydrogen

Grey hydrogen has significantly higher carbon emissions than green hydrogen. It is produced by steam reforming of commonly natural gas and represents 95% of the market. ²⁾

Methane is 86 times more powerful a greenhouse gas compared to CO₂; An average of 2,3% of the methane produced leaked to the atmosphere. ¹⁾

Production method: steam methane reformation:



1 kg Hydrogen requires 3 kg natural gas (CH₄, Methane);

The CO₂ equivalent from methane application is calculated as:

- 2.3% x 3 kg CH₄ *86 = 5,9 CO₂e/kg hydrogen;

The SMR process usually emits

- 9 - 12 kg CO₂ per kg hydrogen;
- **Total CO₂e: 15 – 18 kg CO₂ per kg grey hydrogen**

III. Blue Hydrogen

Hydrogen produced by steam methane reformation is termed "blue hydrogen" when the carbon dioxide from SMR is (mostly: 70- 85%) captured and stored geologically.

Production method: steam methane reformation + Carbon Capture and Storage (SMR + CCS);

1 kg Hydrogen requires 3 kg natural gas, equal to

- 5,9 CO₂e;

Beyond capture and storage of CO₂ emissions from the SMR process:
(70-85% from 9-12 kg CO₂ per kg hydrogen)

- 1,3 – 3,6 kg of CO₂e per kg hydrogen.
- **Total CO₂e: 7,2 – 9,5 kg CO₂ per kg blue hydrogen**

Blue hydrogen produced through more energy intensive autothermal reforming enables 98% of CO₂ emissions to be captured;

IV. White Hydrogen

Manufacturing of 1 kg white Hydrogen requires 15 – 25 kg waste. Alternatively, such waste would have to be landfilled or incinerated/gasified for electricity production – in all cases releasing CO₂e.

The Los Angeles County Greenhouse Gas Emission Report ³⁾ compares transport and disposal of 1'000 tons per day MSW in a modern sanitary landfill to the treatment in a conversion technology like THERMOSELECT. According to the report 1'000 tons of landfilled waste would emit 1'640'000 tons of CO₂e.

In other words: 1 kg waste landfilled emits 1'640 kg CO₂e , which can be avoided if the waste is used as feedstock for white hydrogen manufacturing.

Production method: Syngas produced from waste (H₂ + CO + CO₂) undergoes water-gas-shift reaction to enlarge hydrogen content:



(This is no methane reformation process !).

The shifting process creates about 1 kg CO₂ per kg waste, equal to 15-20 kg CO₂e per kg hydrogen. Beyond Carbon Capture and Storage (70-85%):

- Release of about 4 kg CO₂e per kg white hydrogen;
- Avoidance of about 24'600 – 41'000 kg CO₂e from landfilling per kg white hydrogen;
- **Net avoided Greenhouse Gas emissions as compared to landfilling of waste: average about 30'000 kg CO₂e per kg white hydrogen;**
- Comparing White Hydrogen Manufacturing to the production of electricity from waste also results in substantial avoided greenhouse gas emissions.

[White Hydrogen Manufacturing is a Negative CO₂ Emission Technology.](#)

ANITA RIEGEL



VIVERA CORPORATION LTD.

AEULESTRASSE 30

LI - 9490 VADUZ

.....
Sources:

- 1) <https://www.rechargenews.com/energy-transition/new-clean-hydrogen-production-tax-credit-of-up-to-3-kg-approved-by-us-house-paving-way-for-cheap-green-h2/2-1-1102245>
- 2) Wikipedia: Hydrogen
- 3) County of Los Angeles Greenhouse Gas Emissions Report Jan. 2016