Life cycle cost and emission analysis of different hydrogen production methods

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Abstract

Hydrogen is considered a vital component in the transition towards a sustainable world. However, a majority of the hydrogen produced globally is not environmentally friendly, and it generates even more emissions than burning fossil fuels alone. Therefore, it is crucial to differentiate between different types of hydrogen and analyze their life cycle to obtain a comprehensive understanding of their cost and emissions. This study aims to provide representative estimates of the cost and emissions associated with various hydrogen production methods. The findings reveal that the lowest emissions were observed in hydrogen produced from electricity generated by wind turbines, at 0.67 [kg of CO_2 eq per kg H_2], and hydrogen produced from electricity generated by nuclear power, at 0.73 [kg of CO_2 eq per kg H_2]. However, these methods were considerably more expensive compared to hydrogen produced through steam methane reforming, which costs 2.28 [USD/kg]. The price of hydrogen produced from nuclear energy is around 6 [USD/kg], while hydrogen from wind turbines is priced at approximately 5.1 [USD/kg].

Different Hydrogen Production Methods

Hydrogen can be obtained from a variety of sources, and it has a massive impact on its life cycle assessment. It can be made from fossil fuels or electricity or even from methane directly.

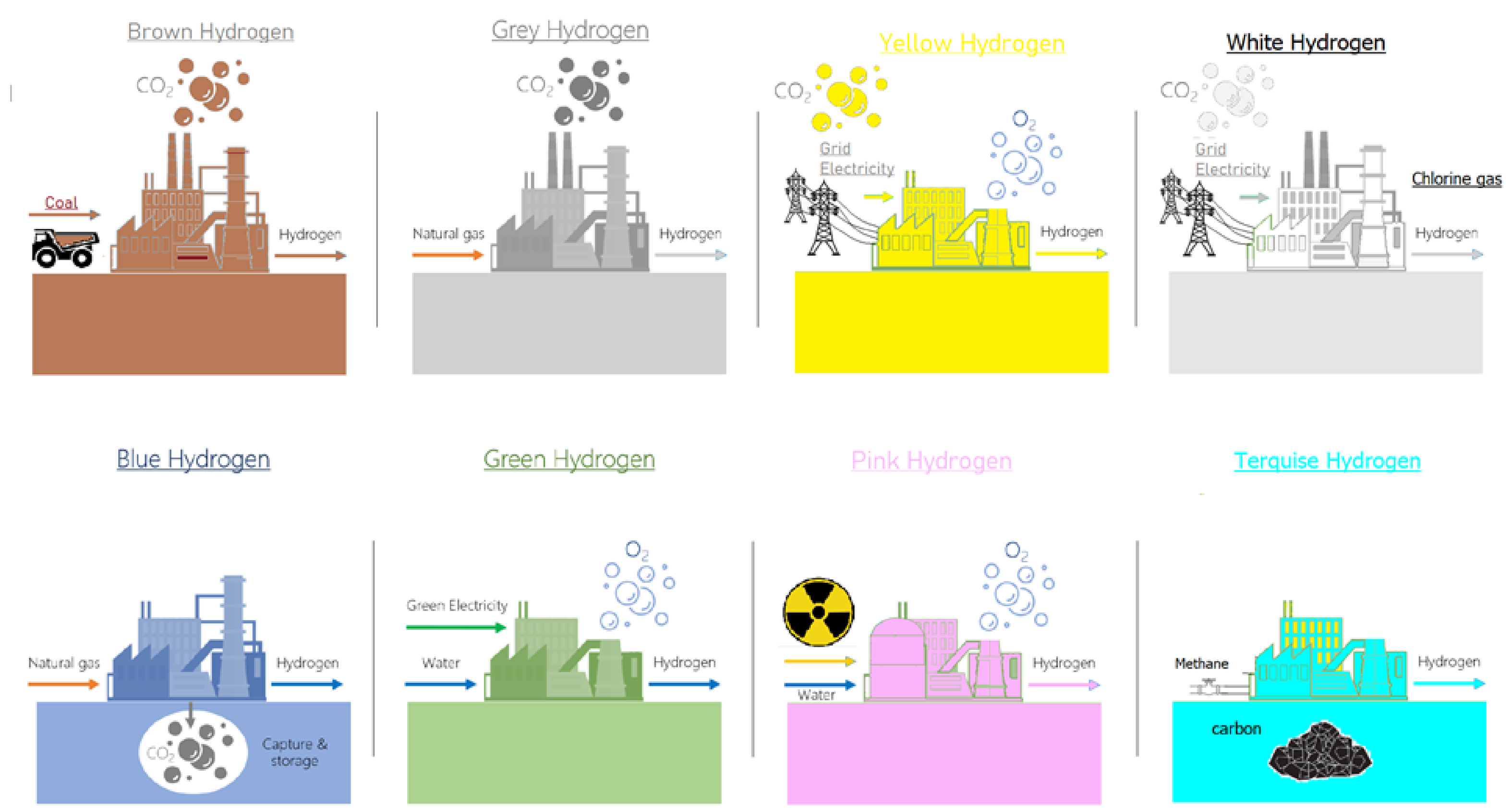


Figure 1. Colors of Hydrogen Production

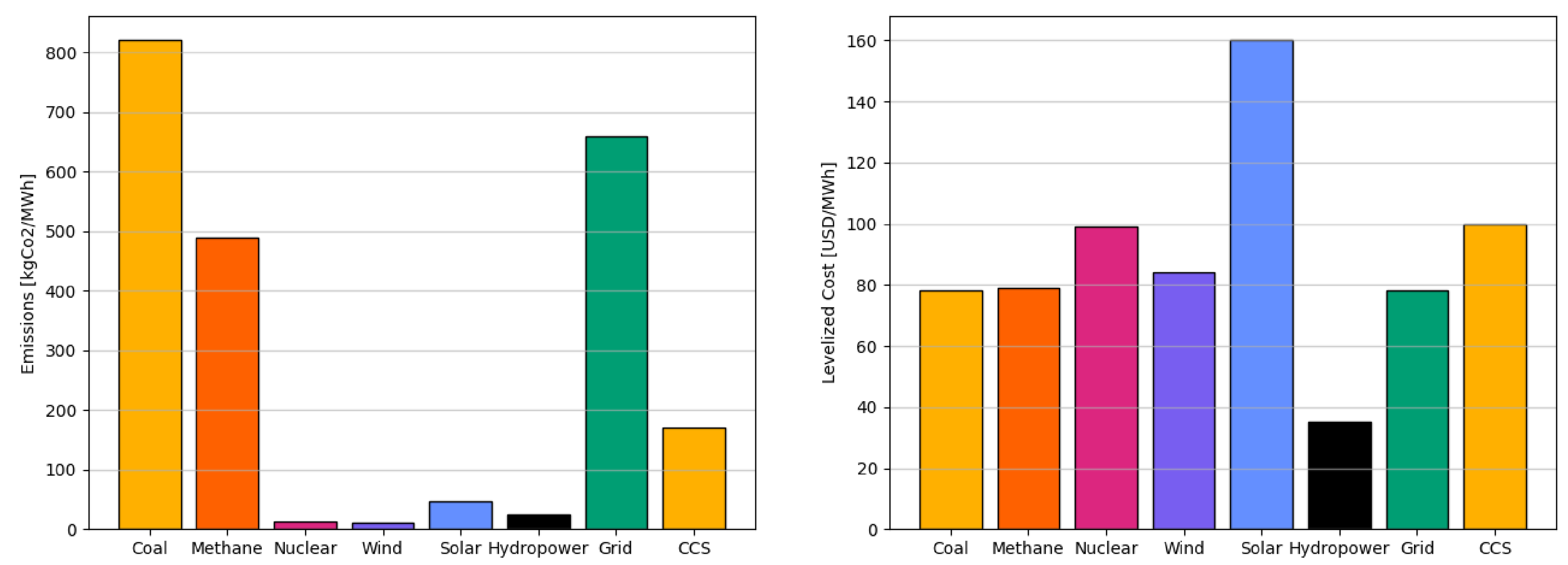
Methodology

To calculate the life cycle emissions and costs first each power source needs to be evaluated based on its own life cycle costs and emissions which can then be further evaluated with following formula:

$$Cost = Cost\ per\ kWh * \text{efficiency} * kWh\ per\ kg\ H_2$$

$$CO_{2eq} = CO_{2eq}\ per\ kWh * \text{efficiency} * kWh\ per\ kg\ H_2$$

the carbon emissions and levelized cost can be found from IPCC WP3



(a) Emissions per power source (b) Cost per power source

Figure 2. Cost and emission data collected from IPCC [1]

Process Efficiencies

Efficiencies were calculated using exergy analysis, they were grouped by process rather than power source:

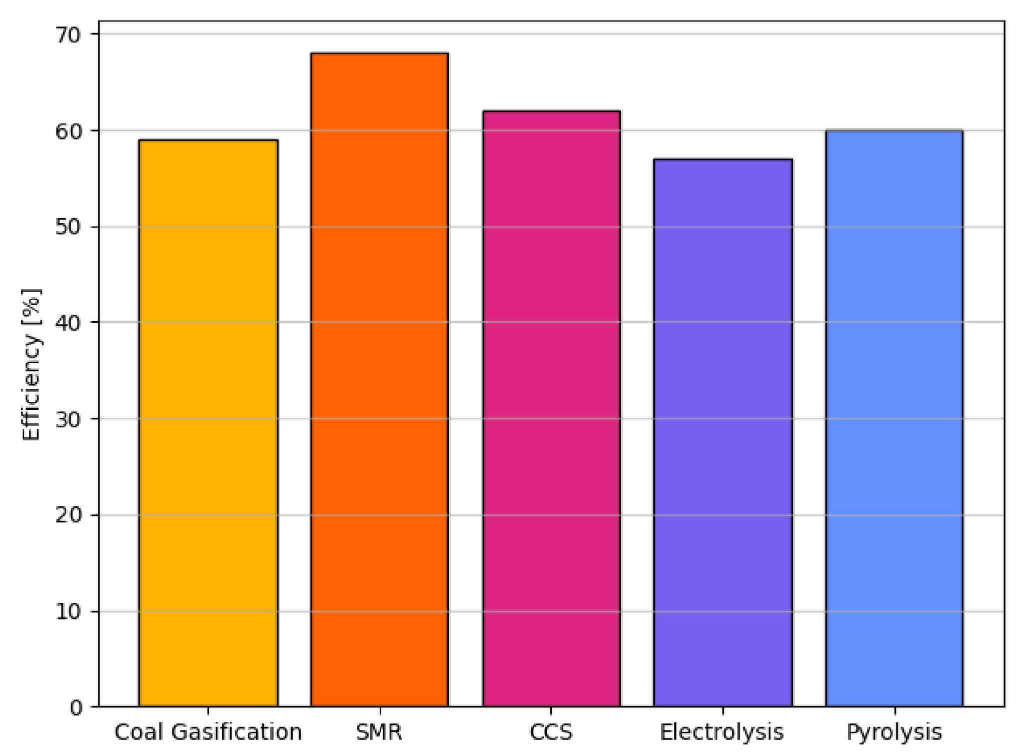


Figure 3. Hydrogen Efficiency for different Prodcution Methods

Results

The resulting costs and emissions including production, compression and transport is shown below:

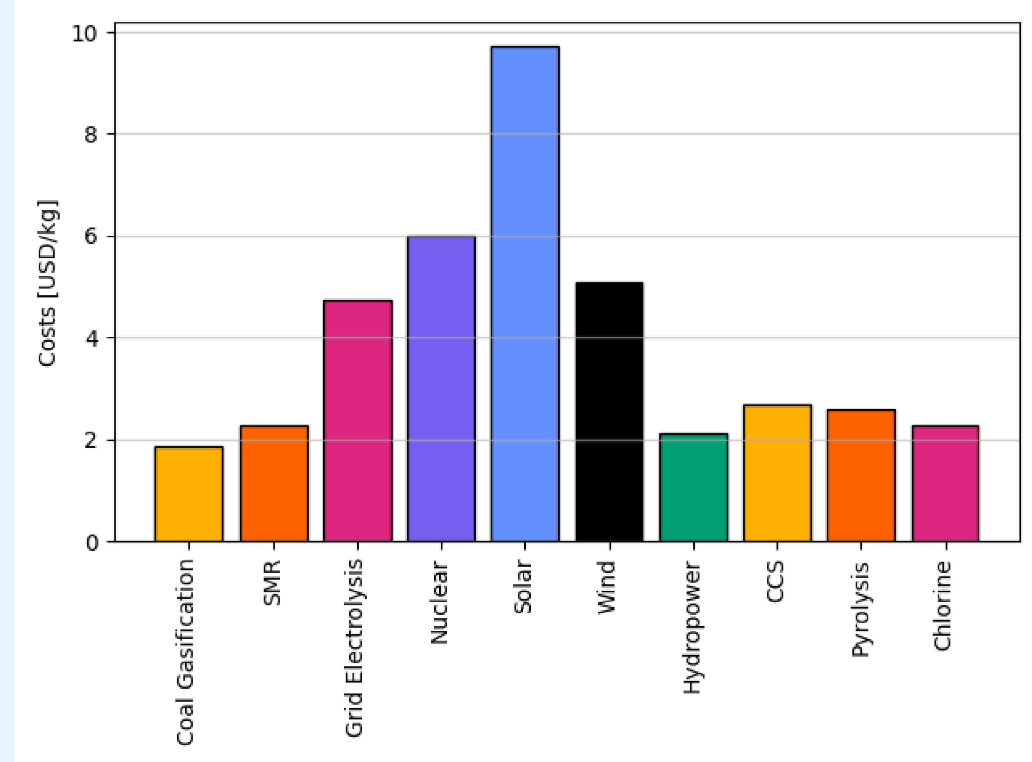


Figure 4. Cost of each Production Method

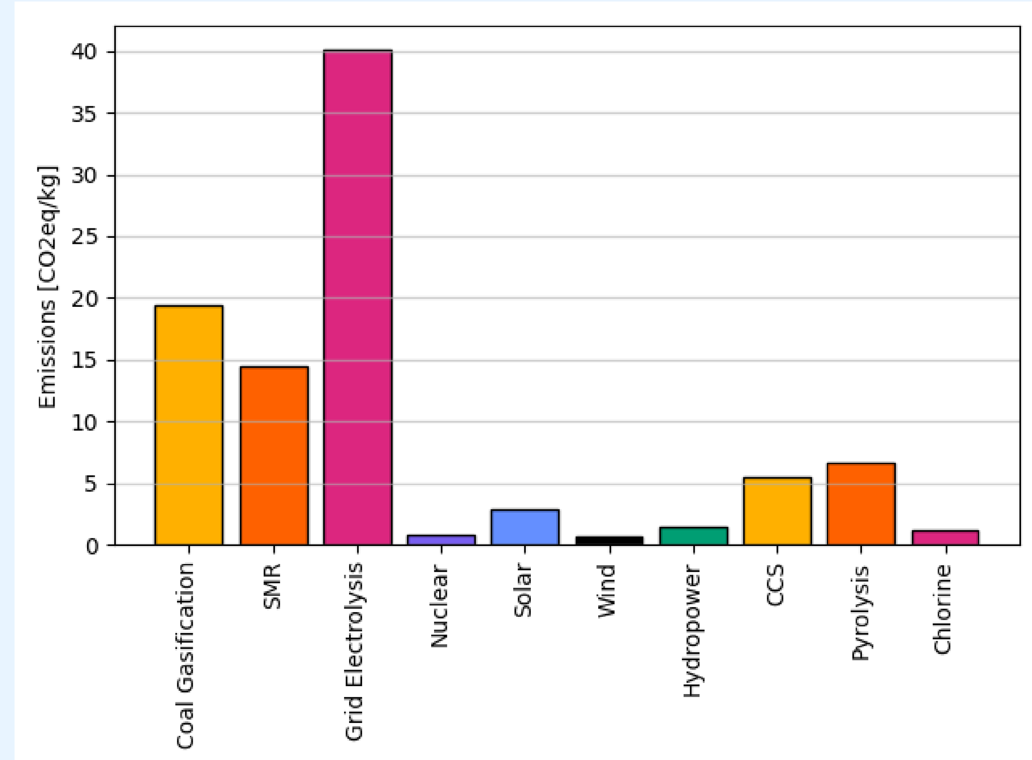


Figure 5. Emission of each Production Method

References

[1] T. Bruckner, D. Perczyk, A. McKinnon, E. Hertwich, and L. Fulton, "Technology-specific cost and performance parameters," *Climate Change 2014: Mitigation of Climate Change*, pp. 1329–1356, 2015. DOI: 10.1017/cbo9781107415416.025.