Methodology for Hydrogen production for Fuel switching from Fossil fuels to renewable hydrogen

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1 Methodology Overview

This methodology outlines a framework for calculating emission reductions in fuel switching from fossil fuel usage to hydrogen (produced from renewable energy). A green hydrogen credit framework is proposed that quantifies and monetizes the net CO_2 emission reductions achieved by replacing fossil fuels with green hydrogen, integrating these credits into existing carbon credit markets to financially incentivize the adoption of green hydrogen worldwide [2]. GHG emission reductions are achieved through fuel-switching of traditional hydrocarbon fuel with crude hydrogen.

- Additionality is taken into account.
- Leakage accounted for

Net removal of emissions CO_2 results from the production of end hydrogen derived from CO_2.

2 Baseline Emissions

Baseline emissions are calculated on the basis of conventional fossil fuel emissions

Substitution of this makeup with the proportion of hydrogen energy into the grid would be calculated for the project emissions.

The net savings of CO2-eq is derived by calculating how much carbon emission is avoided while producing the same amount of heat [1]

- Baseline situation for the production of hydrogen

Emissions calculated as the summation of CO2 generated in the natural gas combustion process, displaced by methane extracted in the project scenario).

The CO2 emissions of the combusted natural gas, as fuel in the reactors in the baseline (displaced by the methane extracted from the system in the project scenario) shall be calculated based on: CO2 from the burning of natural gas for electricity / energy

Calculation of emission reduction:

$$ER = EM_{BL} - EM_{PJ}$$

ER Emissions reductions tCO2 /year EMBL = Baseline emissions tCO2 /year EMPJ = Emissions after project implementation [3] if the baseline runs on fossil fuel

$$EM_{BL} = Q_{BLheatInput} \times CEF_{BLFUEL}$$

[3]

Symbol	Definition
ER	Emissions reductions
EM_{pJ}	Emissions after project implementation if the baseline runs on fossil fuel
EM_{BL}	Baseline emissions
$Q_{B_{L\,\text{heat\_input}}}$	Heat used in the baseline relevant equipment (input heat)
CEF_{BLFUEL}	CO_2 emissions factor per unit calorific value of fuel used in the baseline relevant equipment

Table 1: Summary of Emissions and Heat Input Symbols.[3]

If the baseline relevant equipment runs on electricity (The potential for renewables)

$$EM_{BL} = EL_{BL} \times CEF_{electricityt}$$

Symbol	Definition
EM_{BL}	Baseline emissions
$Q_{B_{L\,\text{heat\_input}}}$	Heat used in the baseline relevant equipment (input heat)
$\mathrm{CEF}_{electricityt}$	CO_2 emissions factor for electric power

Table 2: Summary of Emissions and Heat Input Symbols.

3 Project Emissions

Project emissions account for the significantly reduced emissions from producing green hydrogen using renewable energy sources instead of utilising fossil fuels as a energy source. With renewable energy sourced (e.g., wind, solar), hydrogen produced is green. This means zero emission.

Here, the emissions from the use of the captured methane was important if it was used on site for power or heat generation via hydrogen.

baseline hydrogen:

$$CEF_{BLFUELH} = EM_BL \div (F_{BLH} \times H_{VBLH})$$

where:

$$EM_{BL}$$

= Emissions from hydrogen production used prior to project implementation (take into account all incidental emissions listed in the methodology)

$$F_{PJH}$$

= Amount of hydrogen/ammonia fuel in the relevant equipment after project implementation (t/year)

$$HV_{PJH}$$

= Unit calorific value of hydrogen/ammonia fuel used in the relevant equipment after project implementation (GJ/t)

Hydrogen/ammonia fuel replaces the use of fossil fuel or grid power

4 Emissions reductions

$$ER_y = BE_y - PE_y - LE_y$$

ERy= Emission reductions in the year y (t CO2e) BEy= Project activity emissions in year y (t CO2e) LEy Leakage in year y (t CO2e)

5 Leakage

If the project equipment is transferred from another activity, or if the displaced equipment is transferred to another activity, leakage is to be considered. [3]

6 Accreditation Framework

$$r^{vHC} = (Creduce - Cprod - Ctrans)r^{CC}$$

the net savings of CO2-eq in H2 utilization, this research proposes to use a heat value-based method. The net savings of CO2-eq is derived by calculating how much carbon emission is avoided while producing the same amount of heat [2] .

$$Creduce = (Hhydr/Hfuel)Efuel^{f}$$

where:

$$Hhydr(MJ/kgH2)$$

= the heat value of H2

$$Hfuel(MJ/kgfuel)$$

= a specific fuel replaced by H2.

$$Efuel, f$$

(kg CO2-eq/kg fuel) = the emission factor of the replaced fuel.

$$rtax = f(Cprod)r^{CC}$$

$$rtazt, trans - g(Ctrans)r^{CC}$$

rtax, prod (/ton H2) and rtax, trans (/ton H2) denote the H2 taxes for production and transportation, f() and g() is determined by the H2 market operator

- f(Cprod) = Cprod and g(Cprod) = Ctrans

- g(Cprod) = Ctrans

where

$$rprice, H_C(/tonH_2)$$

is the price of HCs.

$$rv_{HC}$$

is the value of

$$H_Cs$$

which is defined from the perspective of CO2-eq savings. The price of HCs can be derived as follows:

$$rprice = (Creduce - Cprod - Ctrans + f(Cprod) + g(Ctrans)r^{CC}$$

References

[1] UNFCCC. (2015). *AMS-III.O.: Hydrogen production using methane extracted from biogas.* Available at: https://cdm.unfccc.int/methodologies/DB/XC2DTEAI88T9TTB3HK 42GWRFOQ63GD.

[2] Dong, Z.Y., Yang, J., Yu, L., Daiyan, R., and Amal, R., 2022. *A green hydrogen credit framework for international green hydrogen trading towards a carbon neutral future.* International Journal of Hydrogen Energy, 47(2), pp.728-734. ISSN 0360-3199. Available at: https://doi.org/10.1016/j.ijhydene.2021.10.084

[3] Japan Credit System (n.d.) *Methodologies for the J-Credit System.* Available at: https://japancredit.go.jp/english/pdf/methodologies/EN-R-010_methodologies_english.pdf.

[4] Verra. (2023). *Methodology for Hydrogen Fuel Switch in Process Heaters.* Available at: https://verra.org/methodologies/methodology-for-hydrogen-fuel-switch-in-process-heaters/ [Accessed 8 December 2023].