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Hydrogen technologies — Methodology for determining the greenhouse gas emissions associated with the production, conditioning and transport of hydrogen to consumption gate

Annex A

Hydrogen Production Pathway – Electrolysis

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Annex A
(informative)

A Hydrogen Production Pathway – Electrolysis

There are currently three main electrolyser technologies, distinguished by the electrolyte (and associated production temperatures): alkaline electrolyser (ALK), polymer electrolyte membrane (PEM) electrolyser and solid oxide electrolysis cell (SOEC). This methodology may be applied to any other electrolysis technologies.

A.1 Electrolysis process description and overview

Sections A.1.1 and A.1.2 provide a description and an overview for hydrogen produced from electrolysis.

A.1.1 Description

A water electrolysis cell consists of an anode and a cathode separated by a membrane immerged in an electrolyte (a conductive solution). When connected to a direct current power supply, electricity flows through the electrolyte and causes the water to split into hydrogen and oxygen. Each electrolyser system consists of a stack of electrolysis units, a gas purifier and dryer and an apparatus for heat removal.

Hydrogen and oxygen gas products must be purified, dried and cooled prior to storage and/or delivery to market, subject to required product specifications.

The oxygen gas must be safely vented to the atmosphere. Alternatively, pending availability of appropriate markets, this oxygen may be sold as a co-product.

The functional unit for life cycle analysis of hydrogen production is established as 1 kilogram of Hydrogen at a pressure and a purity that corresponds to the inlet requirements of the subsequent stage. For hydrogen purity lower than 99 mol%, refer to Annex K, reflecting the impact on GHG emissions at usage (e.g. if balance is 1% CO_2, this leads to 0.22 $kgCO_2e/kgH2$).

A.1.2 Overview

An example of a process diagram for hydrogen produced from electrolysis is presented in Figure A.1 —.

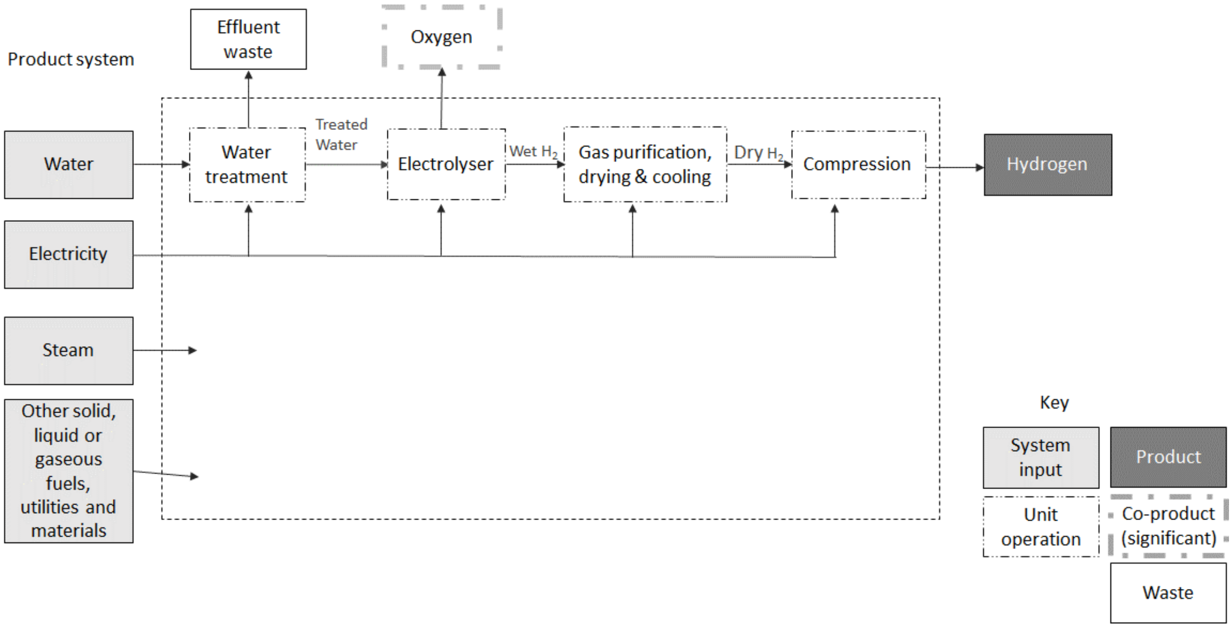

Figure A.1 — Example of process diagram for hydrogen produced from electrolysis

A.2 Emission sources and inventory

GHG emissions associated with electrolysis are subject to the nature of electricity supply for electrolysis as electricity can be sourced from the grid (noting that this may be impacted by contracting of electricity supply and associated instruments), generated on-site via the combustion of liquid, gaseous and/or solid fuels (in this case, this would be the key emissions source) or supplied from an off-grid on-site system.

Each process unit or stage in the electrolysis process contains emissions sources outlined in Table A.1 —.

Table A.1 — GHG emissions summary for electrolysis

Process unit/stage	Key emissions sources	Other emissions sources
Water supply and treatment	• Electricity for purification and filtration	
Hydrogen production	• Electricity for electrolyser units	• Steam (where purchased)[1] • Liquid, solid and/or gaseous fuel combustion for steam generation[1] • Liquid, solid and/or gaseous fuel combustion for electricity generation
Hydrogen purification, drying & cooling and compression	• Electricity for relevant units	• Steam (where purchased) • Solid, liquid and/or gaseous fuel combustion for relevant units and/or steam generation

A.3 Emission Allocation

Electrolysis system can be analysed as a single module (see Figure A.1 —) with one co-product, oxygen that can be readily handled using prioritised coproduct management strategies (i.e. system expansion).

[1] Where high temperature SOEC are utilized

Energy allocation is not appropriate for this co-product, as oxygen does not have an energy content (LHV) and zero emissions would be allocated to it using this method. Therefore, there are two options in this regard to this co-product.

Option 1 is the use of system expansion. Cryogenic distillation system can be used as a substitute system for producing oxygen (the most common process for producing oxygen). This system separates air into oxygen, nitrogen and argon. Emissions associated with the oxygen product stream can be estimated referring to relevant air separation model established within LCA databases or by LCA of oxygen production by cryogenic distillation system. Option 1 has to be used for consequential modelling.

Option 2 is the economic value allocation method, which is a direct attribution of emissions in proportion to the monetary value of the valorised oxygen as a co-product.

These emissions may then be readily removed from the inventory if oxygen is sold to the market.

A.4 Information to be reported

Table A.2 —presents the information to be reported for hydrogen produced from electrolysis.

Table A.2 — Information to be reported for electrolysis

Category	Matters to be identified
Facility details	• Facility identity • Facility location • Facility capacity • Commencement of facility operation
Production	• Production pathway
Product specification	• Hydrogen produced (kg) • Hydrogen pressure level at gate • Hydrogen purity level at gate • Specification of contaminants
GHG emissions overview	• Emissions intensity of hydrogen batch
Batch/sub-batch details	• Beginning and end of batch/sub-batch dates • Batch quantity
Electricity	Location based emissions accounting: • Quantity of purchased grid electricity [kWh] • Location based emission factor used [gCO_2e/kWh] Market based emissions accounting • Quantity of purchased grid electricity [kWh] • Quantity of contracted electricity [kWh] and/or quantity of associated GOs or RECs • Type of GOs or RECs • Residual electricity • Residual mix emission factor [gCO_2e/kWh] On-site electricity generation • Quantity of on-site generation [kWh] • Emission factor for on-site generation (as applicable) [gCO_2e/kWh]
Other utilities	• Source(s) of water • Source(s) of steam • Quantity of purchased water [kg] • Quantity of purchased steam [kg] • Quantity of steam exported [kg]
Fuel feedstock	• Types of fuels combusted • Quantities of fuel combusted [L, kg] • Relevant emissions calculations and factors used

Process	• Water treatment technology • Electrolyser technology • Hydrogen purification technology
Water feedstock	• Water source(s) • Quantity of water used [kg]
Waste and/or co-products	• Quantity of oxygen produced [kg] • Quantity of oxygen sold [kg] • Emissions allocated to oxygen