TUV RHEINLAND Standard H2.21 Carbon-Neutral Hydrogen [Version 1.0 / July 2021]

1.1 Terms and definitions

Carbon-neutral

The status if the identified CCF or PCF is fully offset by appropriate mitigation or CCS measures.

CCF

Corporate Carbon Footprint - Amount of greenhouse gases emitted (represented as the mass of CO_2 equivalents) resulting from the operation of a company per time period (e.g. 1 year).

CCS

Carbon Capture and Storage - Method for the permanent capture and storage of CO_2 emissions in underground reservoirs.

Certificate

A one-page certificate from TÜV Rheinland with time-limited validity confirming that the test criteria for carbon-neutral hydrogen, and optionally for the additional criteria mentioned, have been checked and complied with.

Cradle

The starting point in the life cycle of a product, usually the extraction of raw materials.

Downstream

Life cycle section, subsequent to a reference point under consideration; here referring to subsections after X.

Gate

Usually the handover point at a manufacturer's plant exit in the life cycle or supply chain.

GHG Protocol

Greenhouse Gas Protocol - “A private transnational set of standards for greenhouse gas emissions accounting (carbon accounting) and related reporting for businesses and, increasingly, the public sector. The development of the GHG Protocol is coordinated by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD)" [Wikipedia].

Grave

The end point in the life cycle of a product, usually the final disposal or destruction or recycling with a transition to a new life cycle.

GWP

Global Warming Potential - mass-based factor as the CO_2 equivalent of a specific greenhouse gas to describe the climate effect in direct comparison to the gas CO_2.

Hydrogen, Blue

Carbon-neutral hydrogen whose CO_2 emissions from the manufacturing process are captured by CCS and permanently stored underground; optional additional criterion.

Hydrogen, Carbon-Neutral

Hydrogen whose PCF is zero or negative within the specified cradle to X life cycle stage; minimum requirement under this standard.

Hydrogen, Green

Carbon-neutral hydrogen produced with electrolysers fed with electricity from renewable sources; optional additional criterion (for specification of electricity from renewable sources, see section 1.4.1).

Hydrogen, Grey

Hydrogen produced with the aid of fossil raw materials or fuels. The resulting systemic CO_2 is released into the atmosphere as a greenhouse gas.

Hydrogen, RED II - Conformal

Carbon-neutral hydrogen that additionally fulfils relevant criteria of RED II; optional additional criterion (see section 1.4.4).

Hydrogen, Turquoise

Carbon-neutral hydrogen produced with the aid of thermal cracking of methane (pyrolysis); the resulting solid carbon is not released into the atmosphere as a greenhouse gas; optional additional criterion.

Life cycle

Refers to products (here: hydrogen) and their entire life cycle from raw material extraction (cradle) to final disposal (grave). According to the certification objective, intermediate stages can be defined, such as cradle to gate.

PCF

Product Carbon Footprint - Amount of greenhouse gases emitted (represented as a mass of CO_2 equivalents) associated with the life cycle or life cycle stage of a product.

RED II

Renewable Energy Directive (Version II), Standard (EU) 2018/2001 on the promotion of the use of energy from renewable sources, revised version of December 11, 2018.

Supply chain

Consideration of the life cycle of a product from the commercial perspective of value creation.

Scope 1 Emissions

According to GHG Protocol - directly caused greenhouse gas emissions (e.g. from incineration plants, vehicle fleet operation, heating systems, etc.) generated at defined locations.

Scope 2 Emissions

According to GHG Protocol - indirectly caused greenhouse gas emissions (e.g. through purchase and use of electricity, district heating/cooling or steam) produced outside the defined locations.

Scope 3 Emissions

According to GHG Protocol - indirect greenhouse gas emissions generated upstream or downstream of a defined site; contains 15 different categories.

Test mark

A TÜV Rheinland label in digital graphic format, which is part of the certificate and is used to authenticate the certificate and to publicly highlight the properties, features or characteristics of the individually tested hydrogen product.

Upstream

Life cycle section preceding a particular reference point under consideration; here referring to subsections before X.

X

Variable point in the life cycle chain of hydrogen between cradle and grave, to be defined by the customer, at which the hydrogen is to be certified carbon-neutral.

1.2 Background

Hydrogen is a high-energy gas that emits no CO_2 during combustion and material use. It is thus fundamentally suited to be used as a climate-protecting alternative to fossil fuels. The European Green Deal and Germany's National Hydrogen Strategy, for example, take this into account and promote hydrogen as a future energy carrier in the context of broader climate policy.

However, the sustainable use of hydrogen to displace fossil-based greenhouse gases only makes sense if the hydrogen itself does not accumulate greenhouse gas loads (PCF less than or equal to zero) during its life cycle. This aspect is extremely relevant, since the very energy-intensive conventional production of hydrogen has, to date, generally been based on fossil resources.

This TÜV Rheinland Standard H2.21 (Carbon-Neutral Hydrogen) aims to certify PCF as less than or equal to zero at variable points within the supply chains to be determined by customers. This includes compensation measures or CO_2 storage on a systemic basis. Holders of carbon-neutral-certified hydrogen can demonstrate complete carbon neutrality of hydrogen at their freely chosen point X within the supply chain in the cradle to X life cycle section.

This standard is deliberately designed to be open to all technologies and allows the certification of all manufacturing processes (e.g. steam reforming, electrolysis, pyrolysis, etc.), regardless of the energy source used (e.g. natural gas/petroleum, electricity, biomass/biogas, etc.). By fulfilling further specific criteria, the following optional additional criteria can also be certified, building on the “Carbon-Neutral Hydrogen" certification:

- Green hydrogen
- Blue hydrogen
- Turquoise hydrogen
- RED II - conformal hydrogen

1.3 Scope of application, system limits, remit

This standard defines requirements (criteria) for carbon-neutral hydrogen in the variable point X, to be defined by the customer, within the life cycle section cradle to X. The application of the standard is ideally suited to those parties involved in the hydrogen supply chain, e.g. manufacturers, suppliers and logisticians, users, see Fig.1.

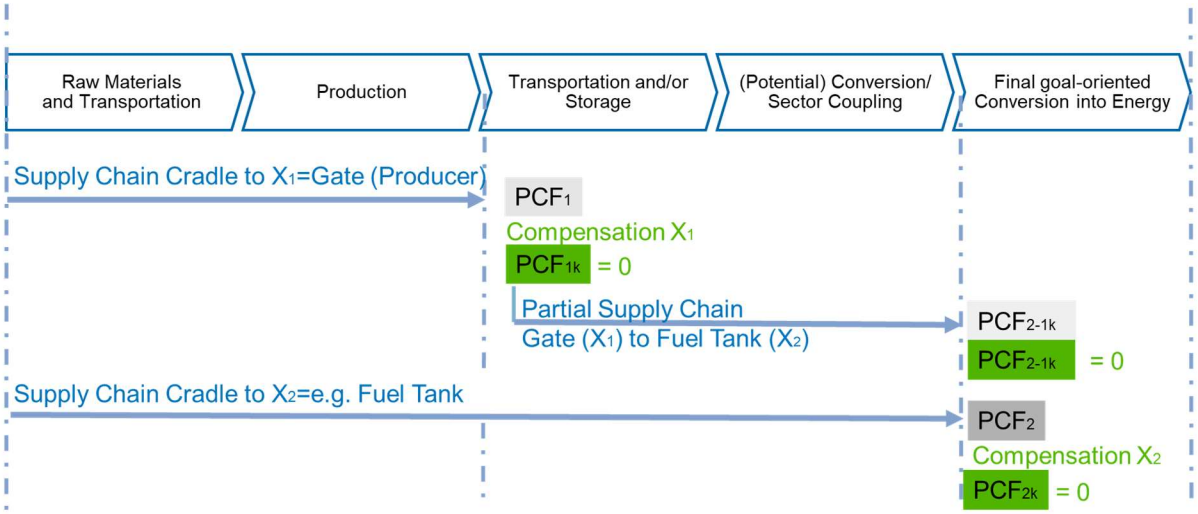

Figure 1: Typical supply chain for hydrogen with variable exemplary life cycle points X1 (exit gate manufacturer) and X2 (user) for certification of carbon neutrality

At point X, the PCF including all upstream chain emissions (cradle to X) must be calculated and verified, taking into account all upstream chain emissions of raw, input and auxiliary materials (direct and indirect upstream chain emissions). Emissions for the provision of process-specific plants and components (e.g. production plants, machines, vehicles, etc.) are not to be taken into account here. If no primary data on the upstream chain are available, generic data shall be applied with a sufficiently conservative level of certainty. Data sources should be used that are highly trusted (e.g., publications from government environmental agencies or from scientific databases with good reputations).

In principle, X in the supply chain can also be chosen outside the customer's sphere of influence (e.g. in the case of transport of the hydrogen after production by external logistics providers). If primary data cannot be obtained for the calculation, generic data shall be applied with a sufficiently conservative level of certainty.

If upstream chain emissions have already been calculated and verified by an independent institution (e.g. PCF1 at point X1), it is sufficient to consider the CO_2 loads of the further partial supply chain (e.g. between X1 and X2), and then to determine PCF2 mathematically by summation.

In most applications, CO_2 is the only greenhouse gas relevant in PCF calculations. In addition, the following greenhouse gases shall be included in the calculation if they occur and are emitted within the system limits:

- Methane (CH_4)
- Nitrous oxide (N_2O)
- Hydrofluorocarbons (HFCs)
- Perfluorinated hydrocarbons (PFCs)
- Sulphur hexafluoride (SF6).

As a reference measure, all calculated greenhouse gases must be converted into mass-based CO_2 equivalents (CO_2e) with their currently valid GWP.

If the PCF of the hydrogen at point X has a positive value, the PCF must be offset by at least the same amount (see section 1.4).

Identified errors, omissions or discrepancies in the calculation of the PCF must not exceed, in the aggregate of their effects on the overall result, the materiality threshold of 5% of the calculated PCF.

The Carbon-Neutral Hydrogen Standard allows:

- all types of manufacturing
- all distribution methods
- all applications
- substance balance separations, as well as
- certificate exchange
  (physical and certified hydrogen properties can be accounted for separately).

When an updated version of this standard is published, the new requirements for existing customers will be included in the next re-certification. The re-certification must take place at least 6 months after the publication of the updated version.

1.4 Requirements for carbon-neutral hydrogen

The criteria listed below must be met for certification as carbon-neutral hydrogen:

1. The PCF of hydrogen at point X is calculated according to ISO 14067, alternatively as part of a life cycle analysis according to ISO 14040/44.

2. In the case of production facilities, all direct and indirect emissions associated with these production processes must be taken into account. This includes the location of Scope 1 and Scope 2 emissions. Emissions for the provision of process-specific equipment and components (e.g. production facilities, machinery, vehicles, etc.) are not to be taken into account.

3. The PCF of the hydrogen at point X is zero or negative. Offsetting mechanisms to reduce PCF are allowed via 3 ways.
   - Implement direct offsetting measures by investing in climate protection projects. The climate protection projects must be free of double counting effects in balance sheet terms and must be quantitatively calculated and monitored for their greenhouse gas reductions in accordance with EN ISO 14064-2;
   - Implementation of indirect offsetting measures through purchasing and retiring registered CO_2 reduction certificates (carbon credits) from internationally recognised climate protection programmes (e.g. GoldStandard, CDM or Verra/VCS), and/or emission rights from established trading systems (e.g. EU ETS);
   - Implementation of CCS measures; permanently stored CO_2 is fully mitigated in the PCF offset calculation (see also section 1.4.2).

Based on the valid certification of carbon-neutral hydrogen, more specific certifications can be achieved by meeting other optional and additional criteria.

1.4.1 Additional requirements for green hydrogen

For the additional certification for green hydrogen, the criteria listed below must be met during production **in Germany**:

Carbon-neutral hydrogen produced by the electrolysis of water or aqueous solutions (e.g. chlor-alkali electrolysis) with the use of electricity from renewable sources. In order to ensure the purchase of electricity from renewable sources, the following criteria must be met for the purchase of electricity - based on §12i of the Regulation on the Implementation of the Renewable Energy Sources Act 2021 (EEG)[1]:

[1] The regulation is subject to approval by the European Commission under state aid law. The criteria of this standard are based on the requirements laid down in the regulation. Meeting the criteria does not result in an entitlement to exemption from the EEG levy.

- Demonstrably originating from plants for the generation of electricity from renewable energies according to §3 number 21 EEG, which do not receive public support through the EEG or through the Combined Heat and Power Act KWKG 2020.
- At least 80% from plants located in the German pricing zone. Installations located outside the German pricing zone must be electrically connected to it.
- The electrolysis plant has a maximum number of full utilization hours of 5,000 hours within one calendar year.

In addition, one of the following two criteria must be met:

Option 1: Electricity supplied to the electrolysis plant via a public grid must meet the following criterion:

- Certification and cancellation of Guarantees of Origin (according to §30 of the Regulation on the Implementation of Guarantees of Origin and Regional Guarantees of Origin) with indication of optional coupling (according to §16 (3) of the Regulation on the Implementation of Guarantees of Origin and Regional Guarantees of Origin) for installations in the German territory.

Option 2: Electricity delivered to the electrolysis facility via a direct line from a renewable generation facility, and thus not via a public grid, must meet the following criterion:

- The electricity consumption of the electrolysis plant must be completely covered, in relation to an interval of 15 minutes, by a renewable electricity generation plant connected to a direct line.

In the production of green hydrogen in a country **outside of Germany**, comparable legal criteria for electricity from renewable sources must be met for Option 1 (public grid). If these comparable legal criteria do not exist or cannot be identified, only electricity through a direct line from a renewable generation facility is allowed (Option 2).

The words "green hydrogen" confirm that the hydrogen meets the criteria set by TÜV Rheinland.

1.4.2 Additional requirements for blue hydrogen

For the additional certification as blue hydrogen, the criterion mentioned below must be fulfilled:

CO_2 gas produced during the manufacture of hydrogen is permanently stored via CCS measures and can thus no longer be emitted into the atmosphere. At least 50% [mass] of the CO_2 gas produced must be stored. Any residual emissions resulting from the capture of CO_2 must be covered by suitable offsets. The compressed CO_2 must be geologically monitored to detect possible leaks.

The words “blue hydrogen" confirm that the hydrogen meets the criteria set by TÜV Rheinland.

1.4.3 Additional requirements for turquoise hydrogen

For the additional certification as turquoise hydrogen, the criterion mentioned below must be fulfilled:

Turquoise hydrogen is produced via the thermal cracking of methane (methane pyrolysis). The elemental carbon formed in parallel with the hydrogen must be permanently secured. It must be ensured that the carbon is not converted into CO_2. According to the life cycle analysis, all emissions from the manufacturing process must be taken into account, including those from the heat source. Both fossil (e.g., natural gas) and renewable (e.g., bio-methane) sources are permitted for the origin of the methane.

The words "turquoise hydrogen" confirm that the hydrogen meets the criteria set by TÜV Rheinland.

1.4.4 Additional requirements for RED II conformity

With Standard (EU) 2018/2001 on the promotion of the use of energy from renewable sources ("RED II"), the European Union has committed itself to steadily increasing the share of renewable energies in final energy consumption. For example, according to Art. 25, para. 1, the share of renewable energies in the final energy consumption in the transport sector in the year 2030 in the member states shall be at least 14 %.

Terms frequently referenced in RED II for deployable renewable energy sources include biofuels, bio-methane, biomass fuels, and liquid or renewable fuels.

For the evaluation of the requirement "RED-II conformity", this TÜV Rheinland standard equates carbon-neutral hydrogen to a renewable energy carrier in terms of climate impact.

RED II results in the targets for greenhouse gas savings for the use of renewable energy sources shown in Table 1, measured by the so-called comparator (emission factor) for fossil fuels. These values are adopted for the use of carbon-neutral hydrogen.

Table 1: RED-II based minimum greenhouse gas reductions with use of carbon-neutral hydrogen, compared with use of fossil fuels.

Sector	**Greenhouse gas reduction with the use of carbon-neutral hydrogen compared to fossil fuels**	**Comparator value Fossil fuel/fuel (Emission factor)**
Transport	min. 70%, as of 01.01.2021	94 g CO2e / MJ
Electricity / Heating / Cooling	min. 70% for installations commissioned between 01.01.2021 - 31.12.2025. min. 80% for installations commissioned as of 01.01.2026.	Electricity production: 183 g CO_2e / MJ_{el} Useful heat, heating, cooling: 80 g CO_2e / MJ_{th} Useful heat with coal substitution: 124 g CO_2e / MJ_{th}

The energy content for hydrogen is to be set at 120 MJ/kg.

For the additional certification of RED II conformity, the criterion mentioned below must be met:

Carbon-neutral hydrogen with the sectors and associated greenhouse gas reductions listed in Table 1, compared to fossil fuels.

In addition, RED II has a delegated act pending that is to define the criteria for counting renewable fuels of non-biogenic origin (e.g., hydrogen from electrolysis plants) toward the stated reduction targets by the end of 2021. Based on the previously known formulation of the delegated act, the following additional criteria are set for the certification of electricity-based hydrogen according to "RED II conformity"[2]:

- The electricity used to produce hydrogen must demonstrably come from renewable energy plants that do not receive public subsidies.
- An electricity supply contract must be in place between the hydrogen producer and the RES-E producer.
- The dates of commissioning of the electrolysis plant and the power generation plant must not be more than 12 months apart.

For electrolysis plants that draw their electricity from a public grid, the following also applies:

- The electricity production related to each 15-minute time interval must be at least equal to the electricity consumption of the electrolysis plant.

[2] The final adoption of the delegated act is planned for the end of 2021. The criteria mentioned in this standard are based on the previously known drafts for the design of the delegated act and will be adapted as necessary in a subsequent version of the standard. A certification according to "RED II conformity" does not result in a claim for creditability as renewable fuels in the sense of RED II.

- Electricity and electrolysis facilities must be located in the same electricity price zone with the exception that electricity grid congestion between the facilities is excluded. In this case, the installations may also be located in neighbouring electricity price zones.

The words "RED-II conformity" confirm that the hydrogen meets the criteria set by TÜV Rheinland.

1.5 Calculation methods and standards

The following calculation methods and standards in their currently valid versions are approved:

- EN ISO 14064-1
- EN ISO 14064-2
- EN ISO 14064-3
- EN ISO 14067
- EN ISO 14040
- EN ISO 14044
- GHG Protocol, A Corporate Accounting and Reporting Standard
- GHG Protocol, Corporate Value Chain (Scope 3) Accounting and Reporting Standard
- RED II, Standard (EU) 2018/2001 on the promotion of the use of energy from renewable sources, revised version of December 11, 2018.
- 2009/28/EG
- Act for the Expansion of Renewable Energies (Renewable Energies Act - EEG 2021)
- TÜV RHEINLAND QMA H2.21 v1.0.

1.6 Verification and certification

Before issuing the certificate and the test mark, TÜV Rheinland verifies compliance with the requirement criteria specified in section 1.4, in particular ensuring that:

a. The PCF calculation submitted has been carried out correctly according to the rules of ISO 14067 or ISO 140440/44 and that all direct and indirect greenhouse gas emissions occurring in the life cycle have been taken into account within the cradle to X life cycle boundaries;
b. Direct offsetting measures are quantified in accordance with applicable common standards and methodologies, without any double counting;
c. Indirect offsetting measures are consistent with existing accounting and retirement rules;
d. The quantified total amount of all offsetting measures is equal to or higher than the calculated and verified PCF;
e. Additionally, in the case of green hydrogen, that the electrolysis is powered by electricity from renewable sources;
f. Additionally, in the case of blue hydrogen, that carbon capture and storage (CCS) is > 50% [mass] of the offsetting measures implemented and that the amount of carbon dioxide captured and stored can be quantified;

g. Additionally, in the case of turquoise hydrogen, that the hydrogen is produced by methane pyrolysis and the resulting elemental carbon is permanently secured;
h. Additionally, in the case of RED II-conformal hydrogen, that the greenhouse gas reductions listed in Tab. 1 are complied with and that the above criteria are met in the electrolysis-based production of hydrogen.

If the criteria listed under conditions a-d are met in full, the certificate and an associated test mark with the words **carbon-neutral hydrogen** will be issued.

If the criteria listed under conditions a-d and e are met in full, the certificate and an associated test mark with the words **carbon-neutral hydrogen** and **green hydrogen** will be issued.

If the criteria listed under conditions a-d and f are met in full, the certificate and an associated test mark with the words **carbon-neutral hydrogen** and **blue hydrogen** will be issued.

If the criteria listed under conditions a-d and g are met in full, the certificate and an associated test mark with the words **carbon-neutral hydrogen** and **turquoise hydrogen** will be issued.

If the criteria listed under conditions a-d and h are met in full, the certificate and an associated test mark with the words **carbon-neutral hydrogen** and **RED II-conformal hydrogen** will be issued.

The process of verification and certification is carried out according to TÜV Rheinland QMA H2.21 v1.0 and is monitored accordingly by our inspection body.

1.7 Certification body

TÜV Rheinland makes the testing of the criteria listed in this standard H2.21 available to other certification bodies, provided that they can present a valid accreditation according to EN ISO 14065:2013 or successor version, which includes at least the following scopes in their respective valid version:
EN ISO 14064-1
EN ISO 14064-2
EN ISO 14064-3

TÜV Rheinland accepts no liability for tests, assessments, certifications and statements of any kind by third parties that refer to this standard H2.21.