Hydrogen Production Criteria

The Hydrogen Production Eligibility Criteria of the Climate Bonds Standard & Certification Scheme

Draft Criteria

Version history	Date
First draft	August 2022

Definitions

Climate Bonds Initiative (Climate Bonds): An investor focused not-for-profit organisation, promoting large-scale investments that will deliver a global low carbon and climate resilient economy. Climate Bonds seeks to develop mechanisms to better align the interests of investors, industry, and government to catalyse investments at a speed and scale sufficient to avoid adverse effects of climate change.

Climate Bond: A climate bond is a bond used to finance – or refinance - projects or expenditures which address climate change. They range from wind farms, solar, and hydropower plants, to rail transport and building sea walls in cities threatened by rising sea levels. Only a small portion of these bonds have been labelled as green or Climate Bonds by issuers.

Certified Climate Bond: A climate bond that is certified by the Climate Bonds Standard Board as meeting the requirements of the Climate Bonds Standard (see below) as attested through independent verification.

Climate Bonds Standard (CBS): A screening tool for investors and governments that allows them to identify green bonds the proceeds of which are being used to deliver climate change solutions. This may be through climate mitigation impact and/or climate adaptation or resilience. The CBS is made up of two parts: the parent standard (CBS v3) and a suite of sector specific eligibility Criteria. The parent standard covers the certification process and pre- and post-issuance requirements for all certified bonds, regardless of the nature of the capital projects. The Sector Criteria detail specific requirements for assets identified as falling under that specific sector. The latest version of the CBS is published on the Climate Bonds website

Climate Bonds Standard Board (CBSB): A board of independent members that collectively represents $34 trillion of assets under management. The CBSB is responsible for approving i) Revisions to the CBS, including the adoption of additional sector Criteria, ii) Approved verifiers, and iii) Applications for Certification of a bond under the CBS. The CBSB is constituted, appointed, and supported in line with the governance arrangements and processes as published on the Climate Bonds website.

Climate Bond Certification: allows the issuer to use the Climate Bond Certification Mark in relation to that bond. Climate Bond Certification is provided once the independent CBSB is satisfied the bond conforms to the CBS

Green Bond: A green bond is a bond of which the proceeds are allocated to environmental projects or expenditures. The term generally refers to bonds that have been marketed as green. In theory, green bonds proceeds could be used for a wide variety of environmental projects or expenditures, but in practice they have mostly been earmarked for climate change projects.

Hydrogen production assets and projects: Assets and projects relating to the acquisition, installation, management and/or operation of infrastructure for hydrogen production

Technical Working Group (TWG): A group of key experts from academia, international agencies, industry, and NGOs convened by Climate Bonds. The TWG develops the Sector Criteria - detailed technical criteria for the eligibility of projects and assets as well as guidance on the tracking of eligibility status during the term of the bond. Their draft recommendations are refined through engagement with finance industry experts in convened Industry Working Groups (see below) and through public consultation. Final approval of Sector Criteria is given by the CBSB.

Industry Working Group (IWG): A group of key organisations that are potential issuers, verifiers and investors convened by Climate Bonds. The IWG provides feedback on the draft sector Criteria developed by the TWG before they are released for public consultation.

Climate Bonds gratefully acknowledges the TWG Group and IWG members who supported the development of these Criteria. Members are listed in Appendix 1. Special thanks are given to Emre Gencer, the lead specialist, and Marian Rodriguez from Climate Bonds, in charge of developing the Criteria through the Technical Working Group.

Table of Contents

1.Introduction

The Climate Bonds Standard

The Climate Bonds Standard and Certification Scheme is an easy-to-use screening tool that provides a clear signal to investors and intermediaries on the climate integrity of Certified Climate Bonds.

A key part of the Standard is a suite of sector-specific eligibility Criteria. Each sector-specific Criteria sets climate change benchmarks for that sector that are used to screen assets and capital projects so that only those that have climate integrity, either through their contribution to climate mitigation, and/or to adaptation and resilience to climate change, will be certified. These sector-specific Criteria are determined through a multi-stakeholder engagement process, including TWG and IWG, convened and managed by Climate Bonds, and are subject to public consultation. Finally, they are reviewed and approved by the CBSB.

The second key part of the Standard is the overarching Climate Bonds Standard. This documents the common management of proceeds and reporting requirements that all Certified Climate Bonds must meet, in addition to meeting the sector specific Criteria.

Sector-specific eligibility criteria for the hydrogen sector

This document details the technical screening criteria for the following within the hydrogen sector:

- Decarbonisation measures and retrofitting activities within facilities producing hydrogen – see Section 3
- Hydrogen production facilities – see Section 4
- Hydrogen production companies – see Section 5

Other supporting documents

Further information to support issuers and verifiers using these Criteria is available at (https://www.climatebonds.net/standard/hydrogen)as follows:

- Hydrogen Background Paper: detailing the rationale underpinning the selected criteria;
- Hydrogen Brochure: providing a high-level overview of the criteria[1];
- Hydrogen Frequently Asked Questions (FAQs).[2]

More broadly:

- The Climate Bonds Standard: contains the requirements of the overarching CBS
- The Climate Bonds Standard & Certification Scheme Brochure: provides an overview of the Climate Bonds Standard & Certification Scheme, of which these Criteria are a part

For more information on Climate Bonds and the Climate Bonds Standard and Certification Scheme, see www.climatebonds.net.

Revisions to these Criteria

These Criteria will be reviewed on a regular basis – at least every three years or earlier if needed – in order to take stock of the latest climate science, updated transition pathways for the sector and developments in improved methodologies and data availability. As a result, the Criteria will be refined and may be tightened over time to maintain decarbonisation pathways aligned with the 1.5°C warming limit. Certification will not be withdrawn retroactively from bonds certified under earlier versions of the Criteria.

[1] Published post-public consultation
[2] Published post-public consultation

2. Scope of these criteria

2.1 Hydrogen supply chain in scope

The Hydrogen Criteria apply to eligible assets, projects and entities relating to the production of hydrogen.

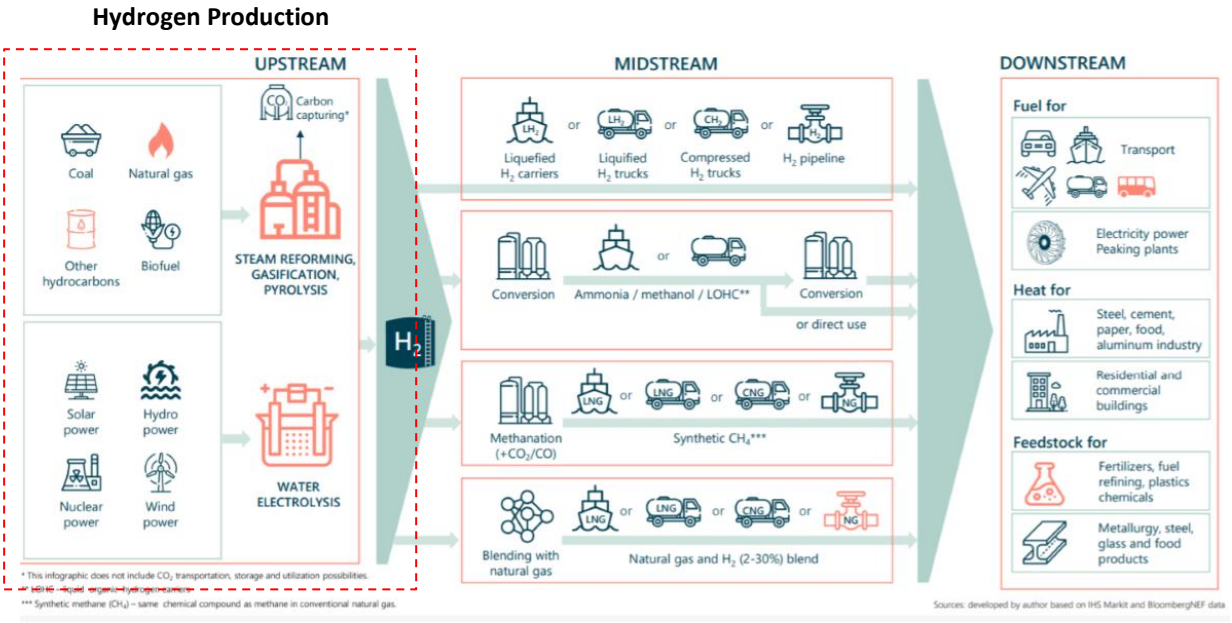

Figure N 1. Simplified Representation of Hydrogen Value Chain [3]

2.2 What can be certified

Subject to meeting the eligibility criteria in the following sectors, finance relating to the following can be certified under these criteria:

- Decarbonisation measures, retrofitting activities in existing production facilities or activities that alllow the production of low-carbon hydrogen - see Section 3
- Entire production facilities – see Section 4
- Companies operating hydrogen production facilities – see Section 5.

In the criteria, new facilities are those that become operational in 2023 or later. They can be standalone and outside battery limits of existing facilities or integrated into existing facilities. Existing facilities are those operational prior to 2023.

[3] Developed by Šilinskaitė-Venslovienė based on IHS Markit and Bloomberg NEF data. https://enmin.lrv.lt/uploads/enmin/documents/files/2021-06-30_KN_Development%20of%20Hydrogen%20Value%20Chain_JSV_send.pdf

Where the bond portfolio includes several separately identifiable projects, expenditures, or groups of assets, these criteria must be met for each separately identified project or asset grouping. Bond issuers should determine these project boundaries, which may be based on geographical and/or supply chain linkages.

2.3 Alignment with other Sector Criteria

In some cases, it may not immediately be clear whether activities, facilities or projects might fall under these criteria or other sector criteria. The possible overlaps, and appropriate sector criteria to be used, are clarified in Table 1.

Table 1: Assets or projects partially or wholly covered by other sector criteria

Potential use-of-proceeds	Sector Criteria
Use of hydrogen for steel production	Steel
Use of hydrogen for cement production	Cement
Use of hydrogen for ammonia production	Basic chemicals
Renewable energy generation including Solar, Wind, Marine Renewable, Hydropower and Geothermal energy	Relevant corresponding energy sector criteria
Use of biomass for hydrogen production	Bioenergy criteria

3. Criteria for Decarbonisation Measures in Facilities Producing Hydrogen

Table 2 lists decarbonisation measures, retrofitting activities, and capital investments eligible for certification due to their climate mitigation potential, and any associated eligibility criteria specific to those investments.

In addition to the specific criteria in table 2, the capital investment must relate to a production facility where:

- The energy source is not coal or coal derivatives
- The feedstock is not coal or coal derivatives
- The energy source is not biomass from primary sources. Only secondary organic streams are eligible. Wood and other dedicated crops are not eligible.
- Grid electricity is used for electrolysis-based production if it has at least 90% of renewable energy share.
- Adaptation and resilience criteria are met (see Section 4.3).

Where the bond portfolio includes several separately identifiable projects, expenditures, or groups of assets, these criteria must be met for each separately identified project or asset grouping. Bond issuers should determine these project boundaries, which may be based on geographical and/or supply chain linkages.

Table 2: Mitigation criteria for eligible capital investments

Area	Eligible Capital Investment	Mitigation criteria
Various		
Manufacture of equipment and components to produce low-carbon hydrogen	Electrolysers, hydrogen generators, compressors, etc.	Equipment and components must be utilised only for the production of low-carbon hydrogen that meets the carbon intensity benchmark in table 2.
Carbon Capture and Storage	Infrastructure related to CO_2 capture of emissions from the hydrogen production, transportation, and storage	• The minimum capture rate from the entire facility should be 90%. • Issuers must demonstrate MRV (monitoring, reporting and verification), and mitigation measures for methane leaks on site and upstream.[4]

[4] Monitoring alternatives include satellite-based or drone-based measurement

		• Upstream methane emissions must be below 0.2%. • There is evidence[5] that demonstrates the CO_2 will be suitably transported and stored in line with the criteria below: **Transport** 1. The CO_2 transported from the installation where it is captured to the injection point does not lead to CO_2 leakages above 0.5 % of the mass of CO_2 transported. 2. Appropriate leakage detection systems are installed and a monitoring plan is in place, with the report verified by an independent third party. **Storage** 1. Characterisation and assessment of the potential storage complex and surrounding area, or exploration[6] is carried out to establish whether the geological formation is suitable for use as a CO_2 storage site. 2. For operation of underground geological CO_2 storage sites, including closure and post-closure obligations: a. appropriate leakage detection systems are implemented to prevent release during operation; b. a monitoring plan of the injection facilities, the storage complex, and, where appropriate, the surrounding environment is in place, with the regular reports checked by the competent national authority. 3. For the exploration and operation of storage sites, the activity complies with ISO 27914:2017225[7] for geological storage of CO_2. Furthermore, the use of any certification scheme is encouraged. Examples of certification schemes include the U.S. EPA Class VI well certification, which includes reservoir characterization[8]. Another example includes the DNV GL certification framework to verify compliance with the ISO 27914:2017 Carbon dioxide capture, transportation, and geological storage – Geological storage[9].

[5] Either directly from the issuer or through contracts or agreements with a third party

Carbon Capture and Utilisation	Infrastructure related to CO_2 capture of emissions from the hydrogen production, transportation and utilisation	• The minimum capture rate from the entire facility should be 90%. • Issuers must demonstrate MRV (monitoring, reporting and verification), and mitigation measures for methane leaks on site and upstream.[10] • Upstream methane emissions must be below 0.2%. • There is evidence[11] that demonstrates the CO_2 will be suitably transported in line with the criteria below: **Transport** 1. The CO_2 transported from the installation where it is captured to the injection point does not lead to CO_2 leakages above 0.5 % of the mass of CO_2 transported. 2. Appropriate leak detection systems are applied and a monitoring plan is in place, with the report verified by an independent third party. **Utilisation** 1. CO_2 must be used for the manufacture of durable products (e.g. construction materials stored in buildings, or recyclable products that will not be incinerated as a final disposal alternative). 2. CO_2 should not be used for products that release the CO_2 immediately when the products are used (such as in urea, carbonated beverages, or fuels)

[6] 'exploration' means the assessment of potential storage complexes for the purposes of geologically storing CO2 by means of activities intruding into the subsurface such as drilling to obtain geological information about strata in the potential storage complex and, as appropriate, carrying out injection tests in order to characterise the storage site

[7] ISO Standard 27914:2017, Carbon dioxide capture, transportation and geological storage — Geological storage (version of [adoption date]: https://www.iso.org/standard/64148.html).

[8] https://www.epa.gov/uic/class-vi-wells-used-geologic-sequestration-co2

[9] https://www.dnv.com/news/dnv-gl-launches-certification-framework-and-recommended-practice-for-carbon-capture-and-storage-ccs--108096

[10] Monitoring alternatives include satellite-based or drone-based measurement. Additional guidance can be found in the report Best Practice Guidance for Effective Methane Management in the Oil and Gas Sector. Monitoring, Reporting and Verification (MRV) and Mitigation. United Nations Economic Commission for Europe. 2019 https://unece.org/fileadmin/DAM/energy/images/CMM/CMM_CE/Best_Practice_Guidance_for_Effective_Methane_Management_in_the_Oil_and_Gas_Sector__Monitoring__Reporting_and_Verification__MRV__and_Mitigation-_FINAL__with_covers_.pdf

[11] Either directly from the issuer or through contracts or agreements with a third party

		3. CO_2 is not used for enhanced oil recovery, and the production of other forms of fossil energy sources.
Electrification of processes	Electric SMR infrastructure Acquisition of equipment to produce low-carbon hydrogen using electricity. It includes boilers, reactors, etc.	Electricity used must be from renewable sources and should be demonstrated using any of the following alternatives: a. Renewable-based[12] captive power generation, OR b. A power purchase agreement demonstrating a commercial link of the electrolyser with the new renewable power capacity; OR • Issuers must demonstrate MRV (monitoring, reporting and verification), and mitigation measures for methane leaks on site and upstream.[13] • Upstream methane emissions must be below 0.2%.
Hydrogen as a by product from chlor-alkali production	Infrastructure for production of hydrogen from chlor-alkali processes Refurbishment and retrofitting of facilities producing hydrogen from chlor-alkali processes Acquisition of equipment to produce hydrogen from chlor-alkali processes	The facility must meet the criteria for chlor-alkali production in CLIMATE BONDS basic chemicals criteria.
Relating to feedstock used		
Using biomass as a feedstock	Infrastructure for production of hydrogen using biomass Refurbishment and retrofitting of facilities to use biomass	The biomass used complies with the criteria applicable for biomass sourcing set out in the CLIMATE BONDS Bioenergy criteria.[14] Only secondary organic streams are eligible. Wood and other dedicated crops are not eligible.

[12] Energy produced from renewable sources such as wind, solar, and small hydropower generation

[13] Monitoring alternatives include satellite-based or drone-based measurement

[14] https://www.climatebonds.net/files/files/standards/Bioenergy/Bioenergy%20Criteria%20Document%20Mar%202021.pdf

	Acquisition of equipment to produce hydrogen using biomass	
Using landfill gas as a feedstock	Infrastructure for the production of hydrogen using landfill gas Refurbishment and retrofitting of facilities using landfill gas as a feedstock Acquisition of equipment to produce hydrogen using landfill as a feedstock	1. Issuers must demonstrate MRV (monitoring, reporting and verification), and mitigation measures for methane leakages on site and upstream.[15] Upstream methane emissions must be below 0.2%. 2. Landfill gas complies with the CLIMATE BONDS waste management criteria for landfill gas recovery.[16]
Using manure-biomethane	Infrastructure for the production of hydrogen using manure biomethane Refurbishment and retrofitting of facilities using manure biomethane Acquisition of equipment to produce hydrogen using manure biomethane	Issuers must demonstrate MRV (monitoring, reporting and verification), and mitigation measures for methane leaks. Upstream methane emissions must be below 0.2%. Manure biomethane complies with the CLIMATE BONDS waste management criteria for composting.[17]
Relating to electricity source[18]		
Using Wind, solar, hydro, geothermal energy-based electricity	Infrastructure for the production of hydrogen using renewable energy sources Refurbishment and retrofitting of facilities using renewable energy sources	Renewable energy produced on site must comply with the most up to date CLIMATE BONDS criteria for the relevant source of energy. Issuers must demonstrate the use of only additional renewable electricity. To do that, issuers can implement the following options:

[15] Monitoring alternatives include satellite-based or drone-based measurement. Additional guidance can be found in the report Best Practice Guidance for Effective Methane Management in the Oil and Gas Sector. Monitoring, Reporting and Verification (MRV) and Mitigation. United Nations Economic Commission for Europe. 2019 https://unece.org/fileadmin/DAM/energy/images/CMM/CMM_CE/Best_Practice_Guidance_for_Effective_Methane_Management_in_the_Oil_and_Gas_Sector__Monitoring__Reporting_and_Verification__MRV__and_Mitigation-_FINAL__with_covers_.pdf

[16] https://www.climatebonds.net/files/files/standards/Waste%20Management/Crit%20Waste%20Management%20Criteria.pdf

[17] https://www.climatebonds.net/files/files/standards/Waste%20Management/Crit%20Waste%20Management%20Criteria.pdf

[18] Although nuclear energy is another electricity source alternative, CLIMATE BONDS cannot certify nuclear-based production until criteria are available for nuclear energy generation.

	Acquisition of equipment to produce electrolytic hydrogen using renewable energy sources	c. Renewable-based[19] captive power generation, OR d. A power purchase agreement demonstrating a commercial link of the electrolyser with new renewable power capacity:; OR e. Excess of renewable-based electricity that would have been otherwise curtailed; Further, for options a) and b), temporal and geographical correlation between the additional renewable electricity generation and the electrolyser electricity consumption must be demonstrated. See Box 1 for more details.

Box 1. Notes for demonstrating additionality

a. Renewable-based captive power generation: On-site production of renewable power supplies the electricity requirements of an electrolyser.
b. A power purchase agreement demonstrating a commercial link of the electrolyser with new renewable power capacity: Issuers must show that the renewable power plant started operation simultaneously or after the electroyser installation. The total electricity consumption cannot be higher than the electricity supplied by the new renewable power plants. A producer can use more than one PPA to cover the entire electricity requirements of its electrolysers.
c. Excess of renewable-based electricity that would have been otherwise curtailed: Flexible hydrogen production projects focusing on times of high renewable generation and low emission factor. Issuers must demonstrate that the electrolyser uses renewable energy from an existing renewable plant only during those hours of the year when surpluses occur.
d. Temporal correlation: Issuers must demonstrate that the electricity is produced and used simultaneously, on a monthly basis, using telemetry measurement techniques. Renewable electricity that has been locally stored can be used as well.
e. Geographic correlation: Issuers must demonstrate physical capacity to transport the electricity from the renewable generation plant to the electricity consumption site. The electricity must not pass a zone of grid congestion.[20]

[19] Energy produced from renewable sources such as wind, solar, and small hydropower generation

[20] Grid congestion occurs due to a lack of transmission line capacity to deliver electricity without exceeding thermal, voltage and stability limits designed to ensure reliability. Retrieved from https://www.nrg.com/insights/energy-education/transmission-congestion---constraints.html

4. Criteria for Facilities Producing Hydrogen

For certification, the facility must meet:

Hydrogen production mitigation criteria (see Section 4.1); AND
Cross-cutting mitigation criteria (see Section 4.2); AND
Adaptation and resilience criteria (see Section 4.3) *Pending to include*

In addition to these criteria, the production facility must comply with the following headline requirements:

- The energy source is not oil, coal or coal derivatives
- The feedstock is not coal or coal derivatives
- The energy source is not biomass from primary sources. Only secondary organic streams are eligible. Wood and other dedicated crops are not eligible.
- Grid electricity is used for electrolysis-based production if it has at least 90% of renewable energy.

Where the bond portfolio includes several separately identifiable projects, expenditures, or groups of assets, these criteria must be met for each separately identified project or asset grouping. Bond issuers should determine these project boundaries, which may be based on geographical and/or supply chain linkages.

4.1 Hydrogen mitigation criteria: carbon intensity thresholds

- Hydrogen production must meet specific carbon intensity thresholds over the term of the bond. These thresholds are listed in Table 3.
- To demonstrate compliance with any of the emissions intensity thresholds set in Table 3, issuers are required to carry out a life cycle assessment as described in Box 2.

Table 3: Hydrogen carbon intensity thresholds

Asset type	Criteria				Remarks
	2022	**2030**	**2040**	**2050**	
Production of hydrogen	3 $kgCO_2e/kgH_2$	1.5 $kgCO_2e/kgH_2$	0.6 $kgCO_2e/kgH_2$	0 $kgCO_2e/kgH_2$	for the life cycle emissions of hydrogen

Box 2. Methodological notes for Life Cycle Assessment (LCA)

- Life Cycle GHG Assessment for hydrogen: A cradle-to-site system boundary, which includes cradle-to-gate emissions plus any transportation emissions to the site where a product is used. In this case, the life cycle assessment should follow the latest releases of ISO st[21] (ISO 14040, ISO 14044 for life-cycle assessment, and ISO 14067 for product carbon foot print). The Recommendation 2013/179/EU will be acceptable for assets located in the EU. Results should be verified by an independent third party.
- GHG emissions must be estimated for a purity of 99.9% vol, and a gauge pressure of at least 3 MPa using correction factors.
- Carbon emissions include all GHGs based on the latest 6th IPCC Assessment Report (AR6) and energy values use the lower heating value (LHV).
- The methodology factor in a Global Warming Potential for a period of 100 years (GWP100) for methane should be 30.[22]

Box 3. Meeting the emissions intenisty thresholds

In terms of meeting the emissions intensity thresholds going forward, issuers may either:

a. Calculate the average emissions intensity threshold over the term of the issuance, and meet that threshold at the time of issuance; or

b. Meet the threshold at the time of issuance and commit to 3 yearly assessments by an approved verifier. During each assesment, the asset should meet the lower emissions intensity threshhold in place at the time. If during any of the assessments the asset does not meet the emissions intensity threshhold, certification will be removed

[21] ISO standards available at: https://www.iso.org/standard/38498.html; https://www.iso.org/standard/37456.html

[22] Sixth IPCC Assessment report

4.2 Cross-cutting mitigation criteria for facilities producing hydrogen

4.2.1 Additional criteria depending on the age of the facility

New facilities commencing operation in 2023 or after are eligible only if they:

- Implement technologies that avoid or reduce direct process emissions in order to prevent carbon lock-in. (e.g. renewable-based production; methane pyrolysis with MRV (monitoring, reporting and verification), and mitigation measures for methane leakages).
- Implement CCS or CCU when using fossil gas, which is eligible up to 2035. CCS or CCU must comply with the criteria in table 2 for decarbonisation measures.

4.2.2 Additional criteria depending on the feedstock used

Facilities using the following feedstock are eligible only if they meet the nex criteria:

- **Fossil gas**: Only eligible for existing facilities when combined with CCS or CCU measures. CCS or CCU must meet the criteria in Table 2. Any venting or burning to be reported and accounted in the LCA. Projects using fossil gas combined with CCS should demonstrate MRV (monitoring, reporting and verification), and mitigation measures for methane leakages.[23] Upstream methane emissions must be below 0.2%.
- **Biomass**: The biomass used complies with the criteria applicable for biomass sourcing set out in the CLIMATE BONDS Bioenergy criteria. Only secondary organic streams are eligible. Wood and other dedicated crops[24] are not eligible.
- **Landfill gas**: Issuers must demonstrate MRV (monitoring, reporting and verification), and mitigation measures for methane leakages. Landfill gas complies with the CLIMATE BONDS waste management criteria for landfill gas recovery. Methane emissions must be below 0.2%.
- **Manure biomethane:** Issuers must demonstrate MRV (monitoring, reporting and verification), and mitigation measures for methane leakages. Manure biomethane complies with the CLIMATE BONDS waste management criteria for composting. Upstream methane emissions must be below 0.2%.

4.2.3 Additional criteria depending on the electricity source

Facilities using the following electricity sources are eligible only if they meet the next criteria:

- **Facilities using electricity from renewable sources**, such as geothermal, solar thermal, and wind. The energy source must comply with the CLIMATE BONDS most up to date criteria for each source of energy. Issuers must demonstrate the use of only additional renewable electricity. To do that, issuers can implement one of the following options for renewable energy production:

a. Renewable-based[25] captive power generation; OR
b. A power purchase agreement demonstrating a commercial link of the electrolyser with new renewable power capacity; OR
c. Excess of renewable-based electricity that would have been otherwise curtailed;

[23] Additional guidance can be found in the report Best Practice Guidance for Effective Methane Management in the Oil and Gas Sector. Monitoring, Reporting and Verification (MRV) and Mitigation. United Nations Economic Commission for Europe. 2019 https://unece.org/fileadmin/DAM/energy/images/CMM/CMM_CE/Best_Practice_Guidance_for_Effective_Methane_Management_in_the_Oil_and_Gas_Sector__Monitoring__Reporting_and_Verification__MRV__and_Mitigation-_FINAL__with_covers_.pdf

[24] Dedicated energy crops are non-food crops that can be grown particularly to provide biomass.

[25] Energy produced from renewable sources such as wind, solar, and small hydropower generation

Further, for ítems a) and b), temporal and geographical correlation between the additional renewable electricity generation and the electrolyser electricity consumption must be demonstrated. For ítem c) only temporal correlation must be demonstrated. Additional details in Box 1.

4.3 Climate adaptation and resilience criteria

To meet the requirements for Climate Bonds Certification, physical climate risks associated with the facility over its operational lifetime must be addressed. This includes both a) any impacts that climate change may have on the facility, and b) any impacts that the facility may have on the wider climate resilience of the system it operates within.

This includes taking appropriate measures to identify and mitigate those risks in the face of the uncertain impact of climate change. In general, issuers must demonstrate that they:

- Understand the acute and chronic climate risks faced by the asset, activity or system in question, including capital assets, operations, logistics and supply, and labour;
- Have addressed those risks by undertaking risk-reduction measures and adopting flexible management plans that take account of inherent uncertainties around climate change, ensuring that the asset, activity or system is robust, flexible and fit-for-purpose in the face of that uncertainty;
- Can deliver resilience benefits over and above addressing identified risks (for system-focused investments[26]);
- Are undertaking regular (re)evaluation of the asset and/or system's climate resilience performance, adjusting to risk reduction measures over time as needed.

To demonstrate compliance, all assets and projects must satisfy the requirements of the checklist detailed in Appendix 2.[27] This checklist is the tool to verify that the issuer has implemented sufficient processes and plans in the design, planning and decommissioning phases of a project to ensure that the operation and construction of the asset minimises environmental harm and the asset is appropriately adaptive and resilient to climate change and supports the adaptation and resilience of other stakeholders.

All elements of this checklist must be addressed, and appropriate evidence provided that these requirements are being met or are not applicable in respect of the specific assets and projects. It is expected that their evidence will encompass a range of assessment and impact reports and associated data, including but not limited to those reports required to meet national and local licensing and approval processes. This might include Development Consent Orders, planning regulations adhered to, Environmental Impact Assessments, Vulnerability Assessments and associated Adaptation Plans.

4.3.1 Other environmental impacts

- Issuers must present a thorough Environmental Impact Assessment for the facility and its site consistent with local regulations and conducted by an independent third-party expert.
- Hydrogen production using desalination water plants must present a brine management plan, developed and approved as within the EIA process, addressing all potential environmental risks and mitigation measures associated with brine disposal and meet the Climate Bonds criteria for desalination plants in the Climate Bonds water sector criteria.

[26] See CLIMATE BONDS's climate resilience principles document. https://www.climatebonds.net/climate-resilience-principles

[27] The adaptation and resilience check list developed for basic chemicals production was adopted for hydrogen production projects.

In addition, the following specific requirements apply:

a. Pollution prevention

- For hydrogen produced as a by-product from chlor-alkali production, emissions must be lower than Best Available Techniques emissions levels for the production of chlor-alkali[28] and the Best Available Techniques emissions levels for the wastewater and waste gas treatment/management systems in the chemical sector[29]
- For hydrogen produced from fossil resources, emissions must be lower than Best Available Techniques for refining of oil and gas.[30]

b. Land use

- Potential land-use change risks must be identified and a mitigation plan to address them must be demonstrated
- Emissions from ILUC must be included in the LCA
- Facilities must meet the requirement 2: Reducing the risk of indirect land use impact in the CLIMATE BONDS bioenergy criteria[31]

c. Water Consumption

- Issuers must present a robust water resource management plan. If freshwater is used issuers should present a water use licence issued by the regional environmental regulator as part of the environmental authorisation process.
- Issuers must conduct a local water availability assessment and demonstrate that water use for hydrogen production is not impacting water availability for human consumption and agriculture. Hydrogen production assets should not be located in regions with high water stress that do not have seawater desalination as an alternative.[32]
- Wastewater treatment facilities are available.[33]

4.3.2 Disclosure component

In the interests of transparency and disclosure, issuers of Certified Climate Bonds are required to publicly disclose the following in respect of the assets and use-of-proceeds incorporated in that deal:

- The planning standards, environmental regulations and other regulations that the facility has been required to comply with.
- The environmental impacts assessment and the measures to address potential risks

[28] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013D0732&from=EN

[29] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016D0902&from=EN

[30] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014D0738&from=EN

[31] https://www.climatebonds.net/files/files/standards/Bioenergy/Bioenergy%20Criteria%20Document%20Mar%202021.pdf

[32] When the demand for water exceeds the supply or when poor quality limits its use

[33] Renewable Fuels of Non-Biological Origin under RED II

5. Criteria for companies

- - - These criteria are currently still under discussion. However, feedback is sought on the working proposal outlined below - - -

WORKING PROPOSAL

For investments aimed at financing the transition of an entire company producing hydrogen or the segment of a company dedicated to hydrogen production, they can be certified if they meet the following requirements:

a. Emissions intensity performance:

- The weighted average emissions intensity across all of the company's production facilities dedicated to hydrogen production meet the threshold values as per table 3 **at the time of certification**
- Transition plans detail what further action will be taken to ensure the weighted average emissions intensity across all of the company's production facilities will continue to meet the threshold values per table 3 over the full timeframe from certification to 2050
- The enabling environment (governance etc) that will enable those plans to be carried out is in place

a) Adaptation and Resilience

At the time of certification, all of the company's facilities meet the adaptation and resilience criteria described in the criteria document.

b) Cross-cutting criteria:

The company's facilities:

- Using alternative feedstock meet the cross-cutting criteria in the criteria document
- Using alternative electricity sources meet the cross-cutting criteria in the criteria document
- Using CCS or CCU meet the criteria in the criteria document

c) Additional considerations for plants becoming operational in 2023 or thereafter:

- The company commits that any future plant will meet the criteria described in the criteria document for new assets. Details of this to be provided in the company's transition plan.

d) Safeguards on non-assessed parts of the entities will be included in alignment with the Climate Bonds standards framework

The specific requirements for transition plans and supporting governance will be detailed separately and consulted on separately - as these requirements will be generic across all sectors open to certification, but they will be consistent with the framework of the '5 Hallmarks for a Credible Transition' described in the paper "Transition Finance for Transforming Companies".

Appendix 1: TWG and IWG members

Technical Working Group (TWG) Members

Clarissa Bergman Fonte. Researcher in Energy planning. Federal University of Rio de Janeiro, Brazil
Cédric Philibert. Independent Senior Energy Consultant.
Gabriela Nascimento da Silva. Hydrogen consultant. KfW (the development bank of Germany)
Giuseppe Bianchi. Senior Professional in Innovation and Decarbonisation. Independent consultant.
Gniewomir Flis. Associate. Energy Revolution Ventures. Senior Advisor Hydrogen
Graeme Sweeney. Chair of the Advisory Council, European Technology Platform of Zero Emission.
Joe Powell. Independent senior consultant.
Maria de los Angeles Valenzuela. Manager Consultant Chile. HINICIO
Marta Lovisolo. Advisor on Renewable Energy Systems at Bellona Europa
Narayan Kumar. Associate Director Electricity and Fuels. TERI (The Energy and Resources Institute)
Patrick Molloy. Manager Breakthrough Technologie. Rocky Mountain Institute (RMI)
Rachel Fakhry. Green Hydrogen Sector Lead, Climate Champions.Race to zero UNFCCC
Zainab Datti. Technical Advisor Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
Zaffar Hussain Team Hydrogen. Power-to-X Lead Africa. Agora Energiewende.

Additional experts consulted

Herib Blanco. Analyst - Hydrogen Energy (Power to X) · International Renewable Energy Agency (IRENA)

Technical Lead Advisor

Emre Gencer - Technical Lead Hydrogen Criteria. Principal Research Scientist. MIT Energy Initiative.

Industry Working Group (IWG) Members

CWP Global

Hydrogen Europe

Hydrogen Brazil

Green Hydrogen Coalition

IFA (International Fertilisers Association)

Institutional Investors Group on Climate Change (IIGCC)

Sustainalytics

NSW | Point Advisory an ERM Group Company

Bureau Veritas

Rubicola Consulting

Carbon Trust

Apendix 2: A&R requirement checklist

Table 3 Checklist for evaluating the issuer's Adaptation & Resilience performance in respect of a hydrogen production facility

	Item	Proof given	Overall assessment
		For verifier to complete	
1. Clear boundaries and critical interdependencies between the infrastructure and the system it operates within are identified.			
1.1	Boundaries of the infrastructure are defined using 1. a listing of all infrastructure and assets and activities associated with the use of the bond proceeds 2. a map of their location, and 3. identification of the expected operational life of the activity, asset or project.		
1.2	Critical interdependencies between the infrastructure and the system within which it operates are identified. Identification of these interdependencies should consider the potential for adverse impacts arising from, but not limited to: 1. the effects of supply disruption or interruption on dependent electricity users or populations; 2. exacerbation of wildfires; 3. relationships of the asset/activity to surrounding water bodies and water courses; 4. relationships of the asset/project to residential neighbourhoods surrounding the plant; 5. damage or reduction in value of neighbouring property due to boundary structures at risk of falling during storm events; 6. reduction in value of neighbourhood property due to pollution caused by the chemical facilities, due to extreme weather events (e.g., release of toxic chemicals due to failure in safety systems in case of extreme weather events); 7. reduction in biodiversity or High Conservation Value habitat[34]; 8. relationships of the asset/project to nearby flood zones; 9. fire and other practices that affect air quality;		
1.3	•Have cascading impacts across infrastructure been considered? •Any ways in which production facilities might affect the climate resilience of other users/stakeholders?		
1.4	Potential co-occurrence of risks is identified		
1.5	Force measures implemented locally to mitigate some potential risks are identified		

[34] High Conservation Value (HCV) habitat criteria in accordance with https://www.hcvnetwork.org.

2. An assessment has been undertaken to identify the key physical climate hazards to which the infrastructure will be exposed and vulnerable to over its operating life.			

2.1	• Is there a good understanding of the risks facing the facility today? In five years? In ten years?
	• Are risks defined and detailed?
	• Are locally implemented measures to mitigate potential risks identified?
	• Are risk areas for hazardous materials identified?
	• Was a hazard assessment conducted to identify toxic, flammable, volatile and reactive chemicals?[35]
	• Was a Risk management plan (RMP) conducted for the chemicals in the list of regulated substances? [36]
	• Key physical climate risks and indicators of these risks are identified based on:
	  ○ a range of climate hazards, and
	  ○ information about risks in the current local context, including reference to any previously identified relevant hazard zones, e.g., flood zones. In order to be confident that assets and activities are robust and flexible in the face of climate change uncertainties, it is essential that the climate risks being assessed and addressed cover those that are of greatest relevance to the production of basic chemicals.
	• Is there an accident management plan in place?
	• Risk should be identified for each of the following categories[37]:
	  ○ Capital Assets
	  ○ Operations
	  ○ Logistics and Supply
	  ○ Labour
	
	• Time horizon is set according to the severity of the risks. Higher risk locations: shorter time (every 5 years). Lower risk locations: Longer time (every 10 years)[38]. See section 5.4 of the Background Paper for tools and reference guidelines to assess degree of risks.
	
	• Where accurate assessments of climate variability for specific locations are not possible, use worst-case scenarios.
	
	The potential impacts that must be considered in the risk assessment include[39]:
	Temperature rise and heat waves
	• Potential increase in temperature may result in expansion and stress of plant, pipework and fittings.
	• There could be an increase in dust emissions from the site.
	• There could be an increase in odour from the site.
	• Increase in fugitive or diffuse emissions from the site.
	• Increase in pollution
	• Increase in water consumed for cooling purposes.
	• Increase in energy consumption due to added pumping of cooling water around site.
	• Limited cooling, which implies that throughputs could need to be reduced or processes shut down
	• Volatile chemicals can exceed their temperature range during transportation
	Extreme cold weather
	• Failure of trace heating systems
	• Freezing of cooling water, resulting in blockages – particularly on long pipelines and storage in exposed areas
	• Process failures
	• Pipework ruptures, affecting:
	• Boiler condensate, process water, cooling water, effluent systems, this in turn may lead to process interruption.
	• Failure of pH control due to caustic systems solidifying (such as effluent treatment)
	• Catalytic processes can be affected, reducing performance		

- Freezing of coolant lines, equipment, and chemical reaction vessel resulting in rising reaction temperature and pressure
- Frozen onsite roadways may restrict access for staff and emergency vehicles.
- Lack of water for fire suppression
- Damage to site infrastructure from snow-loading over extended periods.

Daily extreme rainfall

- Flooding could lead to increased site surface water and flash flooding
- The site may experience reduced access or egress due to site flooding.
- Stored substances can react with water or be contaminated
- Uncontrolled chemical reactions, for example due to shut down of refrigeration systems as a consequence of power outages and lack of backup facilities
- Emergency relief systems, which work at atmospheric discharge pressure can be affected due to the static head of water.
- Process equipment running hot materials can be affected by thermal stress

Season rainfall increase

- Overland flow or groundwater flooding.
- Flooding and associated impacts, as previously identified.
- Sea level rise
- If located near the coast a site could experience increased:
- Risk of flooding and associated impacts, as previously identified
- Corrosion due to increase in saltwater spray
- Reduction of useful life of assets due to frequent exposure to salty water

Drier seasons

- Potential increased use or reliance on mains water for dust suppression and cleaning.
- Potential for increase in dust emissions from the site.
- Decreased river flow
- Reduced dilution available in receiving watercourse for discharge of effluent, resulting in increased pollution

Wildfires

- Severe damage on buildings, process equipment and industrial infrastructure
- Release of toxic pollutants
- Volatile organic solvents with low flash points can exacerbate the fire risk
- Explosions
- Pipelines for transporting oil and gas, fuel storage facilities, external floating roof tanks for combustible liquids can spread the fire
- Supply chain disruption
- Optional guidance for carrying out risk assessments is offered in section 5.4 of the Background Document.

The above potential risks could derive in some impacts to labor and logistics. Adress the following questions:[40]

a. Threats to labor safety and the potential migration of the workforce

- Could severe weather or climate change impact staff comfort?
- Could severe weather or climate change impact health and safety of workers?
- Could severe weather or climate change impact employees' families, homes or communities?

b. Disruption to transport or availability of feedstock supplies

- Would you be affected if weather disrupted or damaged transport infrastructure or services?
- Could there be any issues arising from impacts on key suppliers?
- Would you be affected if weather disrupted or damaged utilities or communications infrastructure and services?
- Are any of the materials you transport temperature or weather sensitive?

3. The measures that have or will be taken to address those risks, mitigate them to a level such that the infrastructure is suitable to climate change conditions over its operational life.			
3.1	Address the following questions[41]: ● What information, awareness or skills would improve your resilience to your priority risks? ● What operational changes could you make to manage your priority risks? ● What physical changes or technology could you invest in to manage your priority risks? ● Due to the nature or size of the risk or opportunity are there any strategic responses that should be considered, such as by relocating, developing a new product, exploiting a new market or creating a strategic partnership to manage shared risks? ● The issuer must annually verify this ongoing monitoring and evaluation of climate resilience performance. This reporting will only be required for the lifespan of the Certified Climate Bond. ● The following are examples of risk management activities that bond issuers might consider, or that might be adopted as part of regulations (e.g. codes and standards). This list is not exhaustive and bond issuers should fully assess the mitigation measures that are relevant to the climate risks and impacts identified in the risk assessment. Measures depend on the specific and local conditions of an asset. Additional technologies and innovation for adaptation and resilience, such as digitalisation of the supply chain (The use of sensors, tracking devices, IoT, analytics, and AI to optimise supply chains) are eligible **Temperature rise and heat waves** ○ Identify temperature limits that could impact your processes and workers ○ Regular inspection and preventative maintenance of plant and equipment. ○ Regular site cleaning and use of dust suppression systems ○ Appropriate odour abatement is in place and maintained effectively ○ Appropriate odour management plan is in place ○ Make sure an appropriate fugitive or diffuse emissions plan is in place. ○ Water can be cleaned and recirculated for reuse on site ○ Alternative cooling systems. ○ Assess how efficient the current cooling system is, and to propose upgrades or modifications where necessary. **Extreme cold weather** ○ Identify temperature limits that could impact your processes and workers ○ Regularly inspect and maintain insulation, particularly on pipework and equipment in exposed areas of the site. ○ Consider added insulation on pipework containing water review operating procedures to make sure pipework is not left full of static water when not in use identify any potential dead legs where static		
4. The infrastructure enhances the climate resilience of the defined system it operates within, as indicated by the boundaries of and critical interdependencies with that system as identified in item 1 in this checklist.			

[41] Chemical Industries Association, 2021. Safeguarding chemical businesses in a changing climate. How to prepare a Climate Change Adaptation Plan

4.1	• Issuers are to assess the climate resilience benefits of system focused assets and activities and demonstrate they are 'fit for purpose', in the sense that they enhance climate resilience at a systemic level, with the flexibility to take into account the uncertainty around future climate change impacts. The assessment is conducted according to the principle of best available evidence during the investment period taking into account the infrastructure's boundaries and critical interdependencies as defined in Criteria 1. • Any ways in which hydrogen facilities improve the adaptation capacity of other users/stakeholders? 'Fit for purpose' is defined as measures that mitigate the effects. Some of them are listed in section 1.2 of this checklist as a reference. • The plant should be connected with the community to work together to improve resilience. [42]		
5. The issuance is required to demonstrate that there will be ongoing monitoring and evaluation of the relevance of the risks and resilience measures and related adjustments to those measures will be taken as needed.			
5.1	• Indicators for risks identified under item 2 in this checklist are provided. • Risk thresholds/trigger levels, for which new adaptation actions are set, are monitored		
5.2	• Indicators for risk mitigation measures identified under item 3 in this checklist are provided. • Determine whether planned outputs and outcomes from adaptation actions have been achieved.		
5.3	• Indicators for "fit for purpose" resilience benefit measures identified under item 4 in this checklist are provided.		
5.4	• Issuers have a viable plan to annually monitor and evaluate (a) climate risks thresholds/triggers, (b) climate resilience performance, (c) appropriateness of climate resilience measure(s) and to adjust as necessary to address evolving climate risks.		

[42] Dale, 2021. Improve Your Plant's Resilience. https://www.chemicalprocessing.com/articles/2021/disaster-planning-improve-your-plants-resilience/