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Requirements for the production and export of green-sustainable hydrogen

International Certification Framework & German Off-Taker Survey

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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Content

Acronyms and Glosary

2BSvs	Biomass Biofuels Sustainability Voluntary Scheme
AIB	Association of Issuing Bodies
CEN	European Committee for Standardization
CERA4in1	Standard for the Certification of Mineral Resources
DAC	Direct Air Capture
EEA	European Environmental Agency
EECS	European Energy Certificate System
EIA	Environmental Impact Assessment
ESIA	Environmental and Social Impact Assessment
EU	European Union
FLO	Fairtrade Labelling Organizations International
FSC	Forest Stewardship Council
GBEP	The Global Bioenergy Partnership
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GO	Guarantee of Origin
H_2	Hydrogen
H2PA TF	Hydrogen Production Analysis Task Force
HFE	Hero Future Energies
ILF	ILF Ingeniería Chile Limitada
ILO	International Labour Organization
IPHE	International Partnership for Hydrogen and Fuel Cells in the Economy
IRENA	International Renewable Energy Agency
ISCC	International Sustainability and Carbon Certification System
ISO	International Organization for Standardization
JRC	Joint Research Center
KZR	KZR INIG System
LBST	Ludwig-Bölkow-Systemtechnik
MS	Member State of the European Union
O&M	Operation and Maintenance
RED II	Renewable Energy Directive recast
RED	Renewable Energy Directive
RES	Renewable Energy Sources

RFNBO	Renewable Fuels of Non-Biological Origin
RSB	Roundtable on Sustainable Biomaterials
RTRS	Round Table on Responsible Soy
SDG	Sustainable Development Goals
SIA	Social Impact Assessment
SQC	Scottish Quality Farm Assured Combinable Crops
TASCC	Trade Assurance Scheme for Combinable Crops
TC	Technical Committee
UFAS	Universal Feed Assurance Scheme

Executive Summary: International Certification Framework

This study identifies certification schemes applied in Europe for the production and import of green hydrogen and its derivatives (synfuels, methanol, ammonia, etc.) from green hydrogen exporting countries, such as Chile. Furthermore, the study identifies other certification schemes not specifically dedicated to hydrogen that could help to define sustainability criteria that should be considered in the processes of the value chain for the production and export of green hydrogen, such as social, economic, and environmental aspects. Sustainability certification of hydrogen and derivatives is relevant to several of the United Nations sustainable development goals (SDG), notably affordable clean energy (7) and climate action (13), but also SDGs 8, 9, 10, 12 and 14.

The identified certification schemes were analyzed, and a matrix was prepared displaying the sustainability criteria coverage of the different schemes. Seven main criteria were identified, with several sub-criteria related to each of them: biodiversity conservation, soil conservation, air quality, sustainable water, community development, social impact, and safety & labor. Furthermore, greenhouse gas balance, requirements to renewable electricity input to hydrogen production and sources of CO_2 are relevant categories of criteria covered here.

The Renewable Energy Directive recast (RED II) is the central regulatory basis in Europe for the certification of hydrogen and its derivatives. The Amendment to the Renewable Energy Directive recently proposed by the European Commission is of relevance, too, but is subject to change during the legislative process.

The hydrogen production and supply value chain consist of a number of individual elements from renewable electricity production to hydrogen consumption. Certification criteria and the certification schemes covering them are relevant to certain elements of the hydrogen production value chain, but not necessarily to all. An overview matrix of the relevance of each criterion for each element of the value chain developed for this study provides guidance to project developers for preparing for future hydrogen certification. Further guidance also useful for public entities and certification scheme holders is provided by overviews of the coverage of relevant criteria by a number of selected certification schemes. **It should be noted, however, that dedicated hydrogen certification schemes so far only cover a very limited set of criteria, while other certification schemes cover wider sets of criteria, but are not related to hydrogen, at least for the time being.**

RED II, which had to be transposed into national law in the 27 European Union Member States by 30 June 2021, lays the foundation for both Guarantees of Origin (GO) and certification for legal target compliance. Based on the increased climate ambition of the EU in the framework of the “Green Deal”, the European Commission has proposed an Amendment to the Renewable Energy Directive on 14 July 2021, which is now in the legislative process in the European Parliament and in the Council with the objective of a joint adoption. As such, it is still subject to changes over the coming one to two years. While in general RED II provisions related to certification of green hydrogen remain unchanged, the use of hydrogen and derivatives, which are called “renewable fuels of non-biological origin” (RFNBO) where they are produced from renewable electricity, have been extended from covering consumption in the transport sector only to also include industry, both as a feedstock or as fuel. Also, a dedicated quantitative sub-target for RFNBOs has been introduced. And overall, the targets for 2030 have been increased in order to achieve the increased climate ambition of the European Union.

Guarantees of Origin from renewable energy designed for consumer disclosure of reliable information are geographically limited to Europe, plus eventually third countries once the European Union will have concluded an agreement with on mutual recognition. The potential relevance for Chile and Latin America in general is subject to further developments in the future.

Through RED II, suppliers of transport fuels have the obligation to increase the share of renewable energy in transport fuels over time. This can be accomplished by biofuels or hydrogen and its derivatives. Fuel suppliers use certification by so-called “voluntary schemes” for demonstrating compliance with the obligation. These voluntary schemes still need to be recognized by the European Commission.

Voluntary schemes cover the full chain of custody of transporting the renewable fuels from production to consumption, certifying compliance with the criteria defined in RED II. Recently, the process of voluntary schemes applying for recognition under RED II has started. Until now, voluntary schemes only certify biofuels, but do not certify hydrogen and its derivatives yet.

CertifHy and CMS70 are two existing certification schemes in Europe for green hydrogen, focusing on energy and climate-related sustainability criteria for the time being. Others are restricted to specific jurisdictions such as California, USA (Low Carbon Fuel Standard) or China (Hydrogen Standard). Furthermore, a number of standards and certification schemes are under development such as in Australia or the United Kingdom. A number of certification schemes exist, which are not specifically targeting hydrogen but could help to define sustainability criteria not included in legal requirements. Among these are voluntary schemes under RED II focusing on biofuels, and other relevant schemes such as the Forest Stewardship Council and Fairtrade. Voluntary schemes cover the legal requirements defined in RED II, notably on greenhouse gas emissions, biodiversity aspects and further sustainability requirements. Furthermore, the schemes assessed here cover environmental aspects, notably soil, water and air protection, which represent indirect requirements of RED II, as well as socio-economic aspects such as benefits to local communities, land rights, labor conditions, etc.

The hydrogen production and supply value chain consist of a number of individual elements from renewable electricity production over hydrogen production, conditioning or transformation into derivatives and national as well as international transport to reconversion of derivatives into hydrogen in the target country. Water supply to electrolysis as well as energy supply to conditioning or transformation of hydrogen into derivatives as well as to reconversion into hydrogen are further important value chain elements. Also, feedstock supply, notably nitrogen supply from air separation units to ammonia synthesis or carbon dioxide supply to methanol or synfuel synthesis, are relevant value chain elements. **For certification, it is relevant to subdivide all steps of the value chain into installation and assembly on the one hand, and operation and maintenance on the other hand**. An analysis was made of all elements of the hydrogen value chain in order to identify which of the sustainability criteria are relevant to the different elements of the value chain, and which of them are covered by which certification scheme.

Certain certification criteria are relevant to many elements of the supply chain. A prominent example is the greenhouse gas balance, which covers the entire value chain in terms of operation and maintenance and is key to ensure a positive climate impact. Other criteria are only relevant to individual value chain elements. Requirements for CO_2 supply are an obvious example of a criterion specific to a single element of the value chain. For many elements of the value chain, relevance may depend on the specific circumstances of individual projects and their characteristics. Soil protection may, as an example, only be relevant to solar PV plants or wind farms in specific situations. On the other hand, the relevance of some criteria defined in RED II to certain elements of the value chain requires further regulatory definition in the delegated act to be adopted by the European Commission in the near future.

Many of the relevant sustainability criteria are not currently covered by hydrogen certification schemes such as water supply, social impact, community development, etc. This could imply a negative impact in the implementation and/or operation of green hydrogen projects. While the requirements of RED II include certain of these criteria, other criteria may only be covered by certification schemes on a voluntary basis. Where important criteria are not included in certification schemes, a necessity for developing a definition of “green sustainable hydrogen” may arise. As an alternative, governments in the exporting countries may consider defining regulatory requirements in view of such further criteria.

Both, the overview of the relevance of criteria to the various elements of the value chain and the overview of the coverage of these relevant criteria by the certification schemes analyzed here are intended to provide detailed and step-by-step guidance to developers of hydrogen and hydrogen derivatives production projects for the successful design, installation and operation of such projects. Furthermore, the study provides insights relevant to government institutions and certification schemes, and possibly to further stakeholders.

Executive Summary: Survey German Off-Takers

Based on the analysis of the sustainability criteria and certification levels identified for hydrogen and its derivatives, a survey was conducted in order to create knowledge about concrete requirements and demands of potential and future off-takers of green hydrogen and derivatives with regards to sustainability, especially in Germany.

To this end, an online survey has been conducted with off-takers in Germany in December 2021.

83 companies from 19 sectors and sub-sectors, of which 12 energy intensive sectors, were taken into account for identifying potential survey participants; of these, 47 companies were actually identified and invited to respond. 18 full responses have been received out of 47 invitees, representing a response rate of 38%. **The survey covers a broad range of sectors**, most notably many energy intensive sectors (steel making, cement, glass, refineries and the chemical industry including, among others, methanol and ammonia production), which are a primary target for green hydrogen consumption according to the German national hydrogen strategy. It must be emphasized that the limited number of responses, which is due to the fact that off-takers for hydrogen or derivatives are small in number (although large in terms of hydrogen and/ or derivatives consumption), does not allow for a statistical analysis. The results presented here should be understood as (qualitative) tendencies rather than as representative results based on statistical evidence.

Of the 18 respondents, seven do not yet use hydrogen or derivatives, but plan to start doing so in the coming one to five years, while the remaining 11 already do today. Of these eleven, 10 use hydrogen, 4 ammonia and 2 methanol in different combinations. Accordingly, most are in the feasibility study, pre-FEED (front-end-engineering design) or FEED stage with only one investment decision already taken.

Most respondents consider both own production of hydrogen (14 respondents) and purchase from third parties in the future (17 respondents). Preferences for the geographic origin of future hydrogen or derivative consumption are rather limited. Some focus on Europe, while most do not exclude any geographical origins (12 respondents). Five respondents specifically mention Latin America, and three Chile, as potential geographic origin of future hydrogen or derivative consumption, among other potential origins.

The development of sustainability criteria, and more importantly the development of related legal requirements, is very dynamic. It is all the more important to understand the sustainability requirements (covered in this study), the off-taker preferences (as analyzed by this study), and the producer realities and challenges (as compiled by the recent H2Global-related market consultation by the German Federal Ministry of Economic Affairs and Climate Action).

With the interest in green hydrogen and derivatives having increased considerably over the recent past, this is a relatively new topic for off-takers, and even more so are green hydrogen sustainability aspects. While most respondents have already advanced towards concrete considerations related to sustainability criteria or have even taken internal decisions or developed internal definitions, some are rather at an early stage of considerations. Energy intensive sectors are considerably more advanced in their considerations on average than other sectors in this survey.

Respondents were asked to rank 24 sustainability criteria individually on a scale from 1 to 4: 1 “unimportant”, 2 “rather unimportant”, 3 “rather important”, 4 “very important”. Looking at individual responses across all sustainability criteria, the average ranking of individual responses spans a rather large range from 2.25 (close to 2 “rather unimportant”) to 3.83 (close to 4 “very important”). Respondents thus seem to have overall appreciations of sustainability criteria that differ considerably. Furthermore, responses also differ in their variability between individual sustainability criteria; some display rather limited variability between criteria, while others show higher levels of differentiation between criteria.

As a general result, all 24 sustainability criteria covered here are ranked “very important” or “rather important” by many respondents. This demonstrates a high level of acceptance among off-takers for broad sets of sustainability requirements. Nonetheless, there are some differences: Most notably, the RED II requirements of additionality/ new installations, and temporal and geographic correlation, are controversial – off-takers appear to see some risk that the detailed definition of these requirements, through the delegated act according to RED II Art. 27(3), may hamper the dynamic development of the hydrogen sectors that politics and society aspire to become a key enabler towards climate neutrality.

The major groups of sustainability criteria received rankings as "rather important" or "very important" by at least 75% of all respondents: legally binding criteria; renewable primary energy (wind, solar, ocean energy, hydropower, etc.); low greenhouse gas balance; other environmental aspects (biodiversity, soil, water, air); socio-economic aspects; labor and safety.

Social criteria covering both local development issues (local infrastructure and development of services, improving the access to energy, local economic development and employment, local education and training) and social impacts criteria (Social Impact Assessment, indigenous peoples' rights, land rights) were ranked rather high by the respondents. The local development criteria were ranked somewhat lower than the social impact criteria.

Labor and safety criteria (working conditions, work contracts, health, and safety) were ranked high. It may be speculated that such criteria may be understood as being well-established in large groups of companies with international operations, which represent the vast majority of respondents.

Environmental criteria (protection and conservation of biodiversity and habitats, protection of soils, water quality, efficient use of water, air quality) are ranked highly in the detailed ranking. Although the small differences between the five criteria should not be understood as statistically significant, one may nonetheless note that the ranking of efficient water use is the lowest of these five.

RED II criteria relate to requirements of additionality as well as temporal and geographic correlation of renewable electricity consumption and hydrogen production. The debate at European level about these criteria is rather controversial, which seems to have led to a delay in the adoption of the above-mentioned delegated act by the European Commission, which was due by the end of 2021. This debate seems to be reflected in the ranking of these criteria by the respondents to this survey: one quarter rank additionality as unimportant, while almost half of the respondents rank temporal and geographic correlation as unimportant. Several comments by the respondents indicate that these criteria may hamper or slow down the ramp-up of hydrogen technologies. Most respondents rank these criteria substantially lower in importance than they individually rank the other sustainability criteria on average.

On the question "From which sources should CO_2 for the synthesis of hydrogen derivatives originate?", 13 out of the 17 respondents who answered, selected direct air capture and unavoidable process emissions (in the short-term). Fossil fuel sources and geothermal sources are supported by 30%; biogenic sources and sources that have already declared their CO_2 emissions under emissions trading schemes or others by more than 40%.

Asked for the level at which sustainability criteria should be standardized, respondents show a clear preference for a harmonization of sustainability criteria at international level, most notably for a consistent calculation methodology for greenhouse gas balances. Nonetheless, harmonization at European Union level is also desirable for a number of respondents.

The willingness to pay a premium for sustainability criteria that go beyond "greenness" of hydrogen and derivatives cannot be estimated; not even qualitatively; from this survey, as most respondents made no statement on this issue. Possibly, the topic is still too new for companies to have a robust basis for such assessments. Nonetheless, more targeted research into this topic would be beneficial to all stakeholders.

Comparing average rankings between the energy intensive sector respondents and the other sector respondents shows rather little differences between the two groups. Slight differences can be noted in renewable primary energy, which is ranked somewhat lower by energy intensive sectors, and in additionality, which is ranked higher compared to other sector respondents in this survey.

In contrast, respondents representing today's consumers of hydrogen and/ or derivatives rank a number of sustainability criteria differently than respondents representing future consumers. While today's consumers rank renewable energies lower than future consumers, they rank legally binding criteria and other environmental criteria higher. For the other sustainability areas, rankings are comparable for both groups.

In general, today's consumers rank social criteria substantially higher than those representing future consumers. Only indigenous peoples' rights are ranked high by both groups. The most pronounced difference is related to local education and training to which today's consumers assign much higher importance than future consumers.

Differences related to environmental criteria between todays and future consumers are small in general; the most notable difference is in efficient use of water, which is ranked more important by today's consumers than by future consumers.

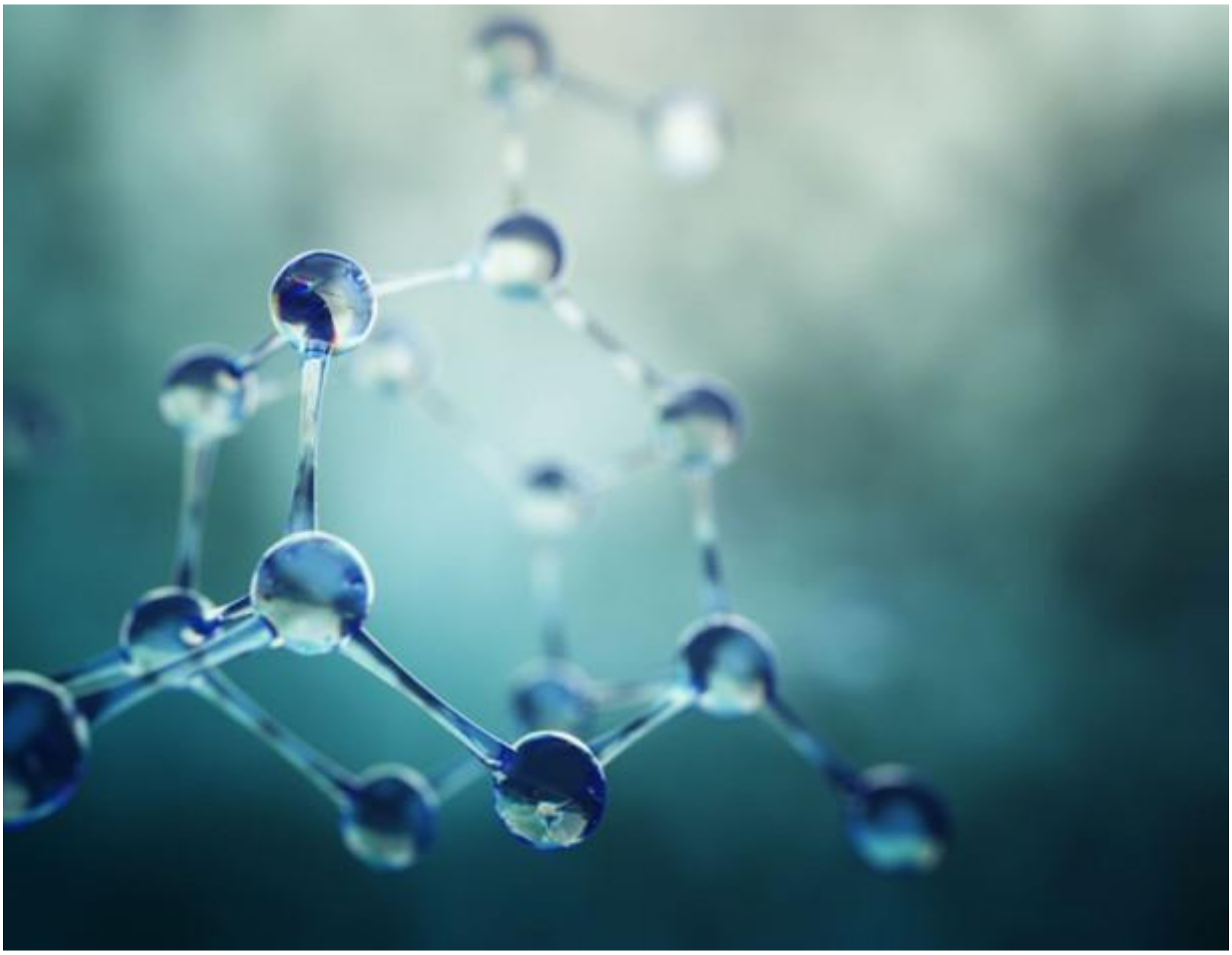
While in general the ranking of RED II criteria is low as described above, the differences between the two groups are large. Today's consumers rank additionality much higher than future consumers, and also temporal and geographic correlation, although somewhat less strongly.

With respect to sources of CO_2, future consumers mention biogenic and geothermal CO_2 sources more often than current consumers, while they mention fossil sources and sources that have already declared their CO_2 emissions under emissions trading or other less often than current consumers.

One possible explanation for these differences is that today's consumers are in general more advanced in their considerations of sustainability criteria than future consumers as shown by the responses. Also, today's consumers have commercial insights into the hydrogen and derivatives value chains.

More research to confirm the trends and tendencies identified in this study, to better explain differences between stakeholder groups, to provide more transparency to the future market of green hydrogen and derivatives, and to reduce risks of investment decisions would be beneficial to all stakeholders.

Hydrogen Certification Schemes and Standards



World-wide, a limited number of hydrogen certification schemes and standards are available or in an advanced status of development. Efforts are made internationally to harmonize requirements for renewable and low-carbon hydrogen, and to harmonize methodologies for the calculation of the greenhouse gas balance.

Certification schemes are systems for the verification of defined standards related to a certain product or service. These standards set criteria that the product or service has to comply with, which may be based on regulatory requirements or contractual agreements.

Certification schemes consist of two primary elements:

1) The **criteria** outlining the specific certification requirements (the standard) and

2) The **framework** for carrying out the certification of conformity with the criteria; this includes the procedures to be followed for all necessary processes, the audit methodology applied by certification bodies to certify the given product or service, the governance of the system, etc.

As countries continually push for cleaner, renewable based energy systems in view of climate protection on the basis of the Paris Agreement, certification schemes assuring consumed energy is indeed derived from renewable sources are becoming ever more important. Certification of energy produced in an environmentally and socially sustainable way supports the growth of renewable energy businesses becoming ubiquitous elements of the future economy. Hydrogen and its derivatives may play a crucial role in the energy transition and hence the certification of its clean and sustainable production and supply are the focus of this report.

In a recent study commissioned by the World Bank and carried out in close cooperation with the Ministry of Energy of Chile, hydrogen certification schemes have been analyzed in detail [1]. In another recent study commissioned by the UK Department for Business, Energy & Industrial Strategy, a comparison of hydrogen certification schemes has been made, and options for a UK low carbon hydrogen standard have been developed and assessed [2]. We refer the reader to these studies for finding details related to the different certification schemes and standards.

It has to be emphasized here that none of the existing certification schemes at present allows complying with the criteria required by European regulations. This is essentially because the requirements have been introduced in late 2018 and will be defined for the first time in detail in a delegated act by the European Commission, which was due by the end of 2021. Certification schemes and standards will then have to be adjusted and developed further to comply with these requirements. The hydrogen regulations will be described in the next chapter.

Types of certifications

In general, certification schemes are either based on legal requirements, or not. In the European Union, the Renewable Energy Directive (RED; see section RED II below) is the legal basis for both Guarantees of Origin (see section Guarantees of Origin and EN 16325 below), and for sustainability certifications for legal target compliance (see section Sustainability certification for legal target compliance below). TÜV SÜD CMS70 is an example of a private industry standard that is not based on legal requirements (see section TÜV SÜD CMS70 below).

Guarantees of Origin and EN 16325

Article 19 of the Renewable Energy Directive (recast – RED II; see section RED II below) constitutes the legal basis for Guarantees of Origin (GO) from renewable energy "for the purposes of demonstrating to final customers the share or quantity of energy from renewable sources in an energy supplier's energy mix" [3]. As such, GOs are designed for consumer disclosure of reliable information.

GOs guarantee the origin of the energy, but do not include the supply of such energy to the consumer. In other words, GOs claim that a certain amount of energy has been produced from specific sources of renewable energy; however, they do not claim that this amount of energy has been transported to the consumer to which this claim is addressed. GOs systems are thus based on a "book & claim" system where the renewable quality and the physical energy supply are separated. The consumer thus contributes to renewable production but does not physically consume the renewable energy.

"Member States shall ensure that a guarantee of origin is issued in response to a request from a producer of energy from renewable sources" [4] and that the same unit of energy from renewable sources is taken into account only once. To do so, "appropriate mechanisms to ensure that guarantees of origin are issued, transferred and cancelled electronically and are accurate, reliable and fraud-resistant" [5] in compliance with CEN - EN 16325 shall be put in place. This explicit reference to the European standard CEN – EN 16325 in RED II makes it legally binding for GO systems to comply with this standard. The current standard EN 16325-2013 + A1-2015 is limited to electricity and does not yet cover gaseous hydrocarbons, hydrogen as well as heating and cooling as required by RED II. It establishes the relevant terminology and definitions, requirements for registration, issuing, transferring and cancellation, while covering measuring methods and auditing procedures. Also, it will specify the requirements on the issuing bodies and on the auditing bodies. This standard will be suitable for certification purposes.

INFOBOX: Guarantees of Origin

Guarantees of Origin (GO) are a tracking system for energy. GOs are standardized in the European standard EN 16325 in line with European legislation with the "aim to create a standardized transferable GO that can be used for mainly disclosure and also supporting labelling. A GO is an instrument for proving production of energy in a specific source of production." [EN 16325:2013+A1:2015] GOs are electronic documents which identify the source and method of production of a unit of energy (1 MWh). GOs can be used for all uses of the energy – e.g. renewable electricity GOs can be used for demonstrating the renewable nature of electricity used for producing hydrogen.

In Europe, GOs are well-established for renewable electricity based on the Renewable Energy Directive (RED/ RED II) in the European Union Member States at national level. The national GO schemes coordinate their activities through the Association of Issuing Bodies (AIB). The purpose of the AIB is to develop, use and promote a standardized system of energy certification for all energy carriers: the European Energy Certificate System (EECS). EECS is based on structures and procedures which ensure the reliable operation of energy certificate schemes in Europe satisfying the criteria of objectivity, non discrimination, transparency and costs effectiveness. GOs are created, change owners and are eventually cancelled (or expire after a certain period) and thus made untransferable under EECS.

Internationally, electricity GOs are established in many countries on a voluntary basis.

Registration: For generating GOs, electricity producers must register with the national (or regional where countries are subdivided regionally) GO scheme based on the national (regional) requirements providing information about their production assets.

Issuing: Electricity producers can receive GOs from their registered production assets from the nationally (regionally) appointed Issuing Body. Measurements of the electricity produced and of energy/ fuels used may only be taken by the body approved for that purpose nationally (regionally).

Auditing: Information provided by electricity producers for the purpose of generating GOs, both related to the production assets and the production and potentially consumption of energy/ fuel, need to be audited by production auditors approved nationally (regionally).

The new standard EN 16325 is being developed by CEN/CLC/JTC 14 Working Group 5 "Guarantees of Origin related to energy" [6]. The timeline for this development work is not publicly available; it is thus unclear when this standard would be finalized and published. In the meantime, the European Energy Certification System (EECS) rules of the Association of Issuing Bodies (AIB) [7] should be used as a guideline. Once the new standard EN 16325 is approved, GO schemes in Europe and EECS need to be adjusted accordingly. The European standard may also be applied internationally on a voluntary basis, where deemed appropriate.

The recognition of GOs is limited to the European Union plus additional European countries. The recognition of GOs from third countries is possible based on strict requirements: “Member States (MS) shall not recognize guarantees of origins issued by a third country except where the Union has concluded an agreement with that third country on mutual recognition of guarantees of origin issued in the Union and compatible guarantees of origin systems established in that third country, and only where there is direct import or export of energy.” [8] No such agreement

between the EU and a third country has been concluded since RED II, where this requirement is defined, has been adopted in late 2018 [9].

In the Energy Community Contracting Parties, RED I is currently applicable [9]. On this basis, all Contracting Parties have the legal basis in place for governing renewable electricity GOs, and have designated the competent bodies to manage the schemes. Full implementation of the system has already taken place in Serbia with the Serbian GO registry having been connected to the AIB hub in November 2020:

“Serbia is the first Contracting Party to implement a functional GO system and become a full member of the AIB. EMS AD Belgrade was assigned the role of the Issuing Body and Registry Operator for GOs. In order to comply with Article 15 of RES Directive 2009/28/EC, EMS cooperated with Grexel, a registry provider. Grexel designed the registry of GOs for Serbia compatible with EECS and the RES Directive. […] Currently, Serbia is able to trade with the AIB members. An agreement between the EU and Serbia might be needed after the RED II is transposed and implemented in all EU countries from July 2021 on in order to continue cross-border trade with the EU AIB members.” [9] Such agreement relates to the requirement of RED II Article 19(11) mentioned above.

In the area of hydrogen GOs, CertifHy has announced on 16 December 2020 to be working with Morocco on hydrogen GOs harmonized with Europe: “Outside of EU boundaries, a collaboration is being set up with the Moroccan Ministry of Energy, Mines and Environment with the intent to experiment a pilot cross border GO transaction with the European Union. The pilot with Morocco will be one of the learnings CertifHy will use in a working group on H_2 GOs which CertifHy will lead within the (Middle Eastern – Northern African) MENA Hydrogen Alliance to work towards the region creating an H_2 GO scheme harmonized with Europe.”

Sustainability certification for legal target compliance

Where specific obligations are legally defined for specific parties, certification is a typical instrument for ensuring target compliance. In the European Union, such an obligation is put on fuel suppliers providing fuels to the transport sector. RED II requires the EU MSs to oblige fuel suppliers to increase the renewable share in transport fuels to reach a target of 14% in the European Union in 2030 [10]. Fuel suppliers use certification by so-called “voluntary schemes”, such as e.g. REDcert, RSB, ISCC, or others (see section

Other sustainability certification schemes and international recommendations below), for demonstrating compliance with the obligation (see section RED II below for more details). These voluntary schemes need to submit applications for being recognized by the European Commission.

In contrast to GOs, voluntary schemes apply a mass balance approach to the chain of custody of transporting the fuel to the consumer. In other words, voluntary schemes certify the production and supply to the consumers according to specific criteria. More information on these two concepts of GOs versus supply certificates is provided in section RED II below.

ISO standards

International standards by the International Organization for Standardization (ISO) cover a wide range of topics.

ISO Technical Committee (TC) 197 is specifically relevant for hydrogen, with the following standards currently in place:

- Standards directly related to hydrogen production:
    - ISO/AWI TR 15916 Basic considerations for the safety of hydrogen systems

- ISO/AWI 22734-1 Hydrogen generators using water electrolysis — Industrial, commercial, and residential applications — Part 1: General requirements, test protocols and safety requirements
- ISO/AWI TR 22734-2 Hydrogen generators using water electrolysis — Part 2: Testing guidance for performing electricity grid service

- Standards relevant to hydrogen production:
  - ISO/AWI 14687 Hydrogen fuel quality — Product specification
  - ISO/AWI 19884 Gaseous hydrogen — Cylinders and tubes for stationary storage
- Standards not directly relevant for hydrogen production:
  - ISO/AWI 17268 Gaseous hydrogen land vehicle refueling connection devices
  - ISO/AWI 19880-5 Gaseous hydrogen — Fueling stations — Part 5: Dispenser hoses and hose assemblies
  - ISO/CD 19880-6 Gaseous hydrogen — Fueling stations — Part 6: Fittings
  - ISO/AWI 19880-9 Gaseous hydrogen — Fueling stations — Part 9: Sampling for fuel quality analysis
  - ISO/AWI 19881 Gaseous hydrogen — Land vehicle fuel containers
  - ISO/AWI 19882 Gaseous hydrogen — Thermally activated pressure relief devices for compressed hydrogen vehicle fuel containers
  - ISO/AWI 19885-1 Gaseous hydrogen — Fueling protocols for hydrogen-fueled vehicles — Part 1: Design and development process for fueling protocols
  - ISO/AWI 19885-2 Gaseous hydrogen — Fueling protocols for hydrogen-fueled vehicles — Part 2: Definition of communications between the vehicle and dispenser control systems
  - ISO/AWI 19885-3 Gaseous hydrogen — Fueling protocols for hydrogen-fueled vehicles — Part 3: High flow hydrogen fueling protocols for heavy duty road vehicles
  - ISO/AWI 19887 Gaseous Hydrogen — Fuel system components for hydrogen fueled vehicles

Further TCs relevant to hydrogen include ISO/TC 22 Road vehicles, ISO/TC 58 Gas cylinders, and ISO/TC 158 Analysis of Gases.

The ISO standards listed above define technical and safety aspects, but are not directly related to sustainability aspects, which is the focus of this study. However, the following ISO standards, among others, are of relevance in this regard:

- ISO 14040:2006 Environmental management — Life cycle assessment — Principles and framework; Amendment: AMD 1:2020
- ISO 14044:2006/Amd 2:2020 Environmental management — Life cycle assessment — Requirements and guidelines — Amendment 2
- ISO 14067:2018 Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification
- ISO/IEC 17065:2012 Conformity assessment — Requirements for bodies certifying products, processes and services
- ISO 19011:2018 Guidelines for auditing management systems

ISO 14044 and ISO 14067 are to be applied for calculating of the greenhouse gas footprint of hydrogen according to CertifHy. CMS70 lists ISO 14040 and ISO 14044 under sources and legal basis, and fulfills the requirements of ISO 17065 and ISO 19011. These two examples highlight that these ISO standards are an important basis for certification schemes, which use these principles and requirements as a framework, and specify requirements and criteria in more detail.

CertifHy

CertifHy is a European certification scheme specifically dedicated to hydrogen (www.CertifHy.eu). CertifHy has been developed with a wide-ranging number of stakeholders through a consensus-based approach and implemented over the past 6 years. Its development continues, with phase 3 having started recently. CertifHy serves as a catalyst for establishing and implementing an EU-wide certificate scheme for Green & Low Carbon Hydrogen. The CertifHy Issuing Body has started operation in 2019 on a non-governmental basis, with a commercial roll-out having started recently, and as such the number of certifications is still limited. A CertifHy certificate discloses information on the hydrogen production plant (location, start date of operation, operator, subsidies received, etc.), the energy source of the hydrogen, its time of production, greenhouse gas intensity (amount of CO_2 equivalent per unit of energy) and date of certificate issuing. For the time being, CertifHy is restricted geographically to Europe, both for GO issuing and GO cancellation. However, a geographical extension in line with the geographical scope of GOs according to RED II (see section Guarantees of Origin and EN 16325 above) is foreseen to be established. Auditing and certification is carried out by entities accepted by CertifHy on the basis of relevant expertise; so far, TÜV SÜD has been accepted by CertifHy.

So far, CertifHy has been issuing GO-type certificates only; however, in its current phase 3, CertifHy is extending its scope to create an EU-wide Certification Scheme that covers both GO-type certificates and sustainability certificates for legal target compliance as defined in RED II articles 25-30. This includes extending CertifHy to include both hydrogen and hydrogen derivatives such as ammonia, methanol, synfuels, etc. Renewable hydrogen and derivatives are defined as “renewable liquid and gaseous transport fuels of non-biological origin” (RFNBOs) in RED II. For certification, no differentiation is made between different types of RFNBOs, i.e. criteria and certification processes are the same for hydrogen and for derivatives. The criteria to be covered are those defined in RED II (see section RED II below). Additional voluntary criteria may be considered to be included in the future based on decisions of the CertifHy stakeholder platform.

On the one hand, CertifHy certifies factual information about hydrogen production as listed above (including the GHG balance of hydrogen production), and on the other hand defines two labels, “Green Hydrogen” based on renewable energy and “Low-carbon Hydrogen” based on fossil or nuclear energy.

The criteria currently required by CertifHy for a GO-type certification and labelling as Green Hydrogen are:

- The greenhouse gas balance of the production plant since registration with CertifHy or during the latest period of 12 months where data is available must not be higher than the benchmark defined as state-of-the art steam reforming of natural gas in large installations with a greenhouse gas footprint of 91 gCO2eq/MJ (based on the lower calorific value);
- The input energy for hydrogen production must be renewable as defined by RED/ RED II;
- The greenhouse gas footprint of the hydrogen production batch of maximum 12 months is equal to or lower than a specified limit. This limit will be defined based on requirements defined in RED II. Until the time that these requirements have been clearly established, the specified limit is 36.4 gCO_{2eq}/MJ (based on the lower calorific value) which represents a reduction of 60% compared to the benchmark process.[1]

For CertifHy Low-carbon Hydrogen the same requirements are valid with the exception that non-renewable energy input is accepted.

[1] The detailed requirements according to RED II will be defined in a delegated act by the European Commission, which was due by the end of 2021 (see section RED II below).

For future CertifHy sustainability certificates for legal target compliance as defined in RED II articles 25-30, the detailed criteria of RED II to be defined in delegated acts (which were due by the end of 2021) will be adopted by CertifHy (see section RED II below for more details).

TÜV SÜD CMS70

TÜV SÜD of Germany established the private Green Hydrogen standard and certification system CMS70 in 2011, which is currently under revision. It refers to German and European legislation (RED II) as well as to international standards and can be applied worldwide. However, it does not allow demonstrating compliance with legal requirements. Auditing and certification are carried out by TÜV SÜD but can in principle also be carried out by other entities.

The standard offers two alternative scope options:

1) Point of production certification
2) Point of use certification with a mass balancing approach (following RED II)

The following hydrogen production pathways are covered by the standard:

1. Electrolysis of water using electricity from renewable sources of energy
2. Biomethane steam reforming
3. Pyro-reforming of glycerin, where the glycerin is a by-product of a biodiesel production plant/installation certified according to a voluntary scheme approved by the EU.
4. Electrolysis of aqueous hydrogen chloride solutions (hydrochloric acid) and aqueous sodium chloride solutions using electricity from renewable energy sources (chlor-alkali electrolysis; by-product hydrogen)

The standard covers mobile and stationary applications of hydrogen including storage ("Power-to-Gas"), injection into the gas grid, use as feedstock and/or for chemical purposes.

The criteria for compliance with CMS70 depend on a number of factors, and are as follows:

- Green hydrogen used in the transport sector and not generated by electrolysis must have a greenhouse-gas reduction potential of at least 60 per cent compared to the currently valid reference value of fossil fuels defined in RED II. If the plant/installation for hydrogen production was placed into service before 31 December 2016, the reduction potential is reduced to at least 50 per cent. According to RED II, the reference value for fossil fuels is 94 g CO_{2eq}/MJ at present.
- Green hydrogen not used as a fuel in the transport sector and not generated by electrolysis must have a greenhouse-gas reduction potential of at least 60 per cent compared to conventional hydrogen. If the plant/installation for hydrogen production was placed into service before 31 December 2016, the reduction potential is reduced to at least 50 per cent. The reference value for conventional hydrogen is currently 89.7 g CO_{2eq}/MJ.
- Depending on its later use (transport or other applications), green hydrogen generated by electrolysis of water or aqueous hydrogen chloride solutions (hydrochloric acid) and aqueous sodium chloride solutions shall have a GHG reduction potential of at least 75 per cent compared to the currently valid reference value of fossil fuels or compared to conventional hydrogen.
- In case of purely book & claim certification without the "Mass-balanced Delivery" module (Certificate Model), transport emissions need not to be considered in GHG accounting. However, the minimum values of GHG reduction potential are increased (see standard for details).
- The energy input for hydrogen production must be 100% renewable. Evidence of the use of electricity from renewable energy sources must be provided through the cancellation of GOs, unless evidence can be furnished that electricity is generated and consumed on site without the use of the public grid.
- The standard provides three options for providing proof of additionality of the electricity input:

- Option 1: New renewables requirement: At least 30 per cent of the renewable energy must come from new plants/installations which, at the time of initial certification, had not been placed into service more than 36 months previously.
- Option 2: Development funds / fund model: at least 0.2 eurocent per kWh used in the generation of green electricity must be paid into a development fund used to support projects that are aimed at the expansion and/or integration of energy from renewable sources into the energy market.
- Option 3: Technology mix: the following minimum shares apply for the first year of accounting:
  - Hydropower under 2 MW: 15%, or
  - Wind power: 30%, or
  - Solar energy, geothermal energy, biomass, biogas / biomethane from plants/installations each under 2 MWel: 5%.

TÜV Rheinland

Furthermore, TÜV Rheinland of Germany has announced on 13 July 2021 that it offers certification services related to hydrogen based on proprietary labels on the one hand, and also covering a check of compliance with RED II requirements on the other hand [11]. For the time being, no further information is publicly available.

Other hydrogen certification schemes and developments

In two recent studies, hydrogen certification schemes have been analyzed and compared in detail [1] [2]. We refer the reader to these studies for finding details related to the different certification schemes and standards.

In addition to the two certification schemes described above, further schemes and standards exist and are under development, such as:

- Low Carbon Fuel Standard, California, USA (established 2011; hydrogen certified since 2015) [12]
- Hydrogen Standard, China (established 2020) [13]
- Hydrogen Guarantee of Origin certification scheme, Australia (discussion paper of 2021 by the Australian Government, Department of Industry, Science, Energy and Resources; public consultation carried out until 6 August 2021) [14]
- Low carbon hydrogen standard, United Kingdom (in public consultation) [15]

The International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE), established in 2003, has the mission to facilitate and accelerate the transition to clean and efficient energy and mobility systems using hydrogen and fuel cell technologies across applications and sectors. In October 2019, IPHE established a Hydrogen Production Analysis Task Force (H2PA TF) addressing the need for a consistent framework and methodology in assessing hydrogen production technologies from diverse sources. The Terms of Reference for this Task Force include developing a report describing the methodology to assess the emissions of hydrogen production, which should be finalized in 2021. The objective of the work is to come to a non-binding consensus on the methodology among the participating countries[2].

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[2] These include Australia, Canada, Costa Rica, European Commission, France, Germany, Japan, Korea, Netherlands, Norway, South Africa, United Kingdom, United States.

Other Pertinent Certification Schemes

Other pertinent certification schemes

Other certification schemes that are not specifically related to hydrogen may nonetheless be applied in certain processes in the value chain of production and export/import of green hydrogen and its derivatives to certify its sustainability, or they may include criteria that could be suitable for hydrogen sustainability certification.

In addition, a number of international standards refer to the securing of social acceptance for energy projects through measures of public participation and a Just Transition (Worldbank, UN, OECD, IFC, GRI, among others). These standards formulate an established minimum requirement for large-scale projects, as is the case with hydrogen projects, but cannot be analyzed in detail here.[3]

In this section, selected certification schemes are assessed in view of criteria suitable for hydrogen sustainability certification. It is not the intention here to provide a comprehensive overview, but to assess selected schemes for potentially suitable criteria and approaches in view of hydrogen and derivatives offtake in Europe.

For the analysis of the study, those certifications schemes that could include Green Hydrogen or its derivates in the future or those that currently include it in a limited way (RFNBOs) were selected. In this sense, the CERA4in1 that could consider H2 as a raw material, the voluntary schemes under RED II that focus on biofuels and those certifications that could be interesting for Chile because they are already applied to other industries are selected.

The reviewed schemes are summarized and compared at the end of this section to give clarity to the environmental and social/economic sustainability aspects that each scheme encompasses. The specific criteria that were addressed are displayed in Table 1.

Table 1 Environmental and Social/Economic criteria considered from other pertinent certifications

Criteria	Sub-Criteria
Biodiversity conservation	Biodiversity Natural habitats, ecosystems High conservation value areas
Soil conservation	Soil protection Residues, wastes Waste management
Sustainable water	Water rights Water quality Water management, conservation Efficient use of water
Air quality	Air pollution
Community development	Local infrastructure and services development[4] Increase in energy access[5] Local economic development[6]/employment Local professional skills training[7] and Education

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[3] *An overview and description of these national and international standards is offered, for example, by GIZ Chile's study "Guía Cierre de centrales térmicas a carbón: recomendaciones y buenas prácticas para el involucramiento de actores", p. 13ff (https://4echile-datastore.s3.eu-central-1.amazonaws.com/wp-content/uploads/2021/03/07144135/Cierre-de-centrales-termicas-a-carbon-recomendaciones-y-buenas-practicas.pdf).*

[4] *For instance, schools, health, water & sanitation, roads & transportation, among others.*

[5] *For instance, through electrification infrastructure/connections, energy services at household or community-level, among others.*

[6] *For instance, through shared ownership, preferential rates & discounts, recurring payments to local government & community, among others.*

[7] *For instance, through skills & training, programs, scholarships, among others.*

Social impact	Social impact assessment[8] Indigenous peoples' rights Land rights issues
Labor & safety	Working conditions Contracts Health and safety

CERA4in1

The standard CERA 4in1 has been developed since 2015 and represents a standardized certification scheme that targets environmental, social and economic sustainability. It was initially created within the DMT- GROUP of Germany, before a formal project consortium was formed together with TÜV NORD CERT of Germany in 2017. The DMT GROUP is a company for engineering and consulting services. Its main focus is on plant & process engineering, infrastructure & construction and raw materials. DMT is part of the TÜV NORD GROUP.

CERA4in1 covers the extraction, processing, trading and manufacture of raw materials, comprising minerals and chemical elements, and is applicable worldwide. The CERA 4in1 certification system was developed within an EIT RawMaterials-funded project [16] by a consortium of companies and universities, supported by an international advisory board drawn from European representatives and industry.

The sustainability topics with related subjects underlying the CERA 4in1 certification system are based on the Sustainable Development Goals (SDG) of UN Agenda 2030 and ISO 26000 "Guidance on social responsibility".

In order to cover the entire value chain, CERA 4in1 created four different standards that address different aspects:

The **CERA 4in1 Readiness Standard (CRS)** governs the objectives for evaluation of a deposit in terms of social and environmental subjects during the exploration process.

The **CERA 4in1 Performance Standard (CPS)** refers to a production facility or a group of production facilities and includes the mining, processing and refining operations.

The **CERA 4in1 Chain of Custody Standard (CCS)** refers to the product and lays down criteria for ensuring the complete traceability of responsibly extracted raw materials and traded commodities.

The **CERA 4in1 Final Product Standard (CFS)** certifies an end product that consists of raw materials that have been sourced and traded in accordance with sustainability considerations. The sustainability criteria used vary according to the respective product and its requirements.

Depending on the object of the certification and the individual conditions of the applying organization, a combination of the four standards and criteria mentioned are required for certification.

All Standards build on each other, whereas the Performance Standard represents the first published standard according to CERA 4in1.

The concrete scope of the Performance Standard covers three so-called "topics": 1. Corporate Governance; 2. Social Responsibility; 3. Environmental Responsibility. Each topic is then subdivided into so-called "themes", twelve in total, which define a task or organizational section within a particular topic with reference to responsible mining and sustainability.

[8] *Despite the fact that the criteria Indigenous people´s rights and Land rights issues are included in a social impact assessment, because of the relevance of these criteria for the country, they are presented separately in order to highlight them.*

Table 2 CERA 4in1 structure of certification topics and themes

Topic	Theme
1 Corporate Governance	1.1 Legal compliance
	1.2 Best available practice
	1.3 Business integrity
	1.4 Stakeholder involvement
	1.5 Supply chain due diligence
2 Social Responsibility	2.1 Human and community targets
	2.2 Labor conditions
	2.3 Occupational health and safety
	2.4 Safety and security
3. Environmental Responsibility	3.1 Emissions and waste
	3.2 Resources and efficiency
	3.3 Biodiversity and mine closure

The themes in turn cover 43 criteria, so-called "key aspects". Those key aspects define what organizations need to address or to cover in their process of certification.

Regarding the concrete implementation of a standard on site, the key aspects are translated into their respective "implementation details". An Implementation Details document is available for each of the four CERA 4in1 standards. The structure and systematics of these Implementation Details follow their respective standard. The Implementation Details contain further information, notes and explanatory texts to the rules and requirements included in the standards. These details lay out how an organization seeking to be certified needs to implement the standard criteria and are specific to a raw material and to the needs and scope of the particular value chain actor. The Implementation Details are managed within the CERA 4in1 database. The database software generates an individual document with the specific Implementation Details for each certification depending on the input information, for example raw material, country, extraction method and processing step(s). This internal database is, however, not publicly available. In order to define which implementation details an organization has to fulfil, an auditor examines and assesses the conditions and requirements on site resulting in an auditor checklist. This checklist is then reviewed by CERA 4in1, and needs to be approved by CERA 4in1.

The contracted auditors and certification bodies have to be recognized by CERA 4in1. For the time being, the list of recognized auditors and certification bodies is not publicly available, but this is to change once the first currently ongoing pilot certification projects are completed and the official CERA 4in1 entity is established.

Complementing the requirements described above, CERA 4in1 developed their so-called "CAMD-System": Commitment (C), Assessment (A), Monitoring (M) and Disclosure (D). The CAMD-System is based on the OECD's 5-Step Management Approach [17] and the "Plan-Do-Check-Act" (PDAC) approach of the ISO quality management standards. This CAMD system is built as a modular system, with the four different steps building on each other. It describes the procedure to be followed at all times during implementation of the Performance Standard.

For now, CERA 4in1 is not fully established or market ready, but is still in the pilot phase, running four different pilot projects in the Democratic Republic of the Congo, China, Portugal and Norway. The pilot project in Congo is the most advanced of the four pilot projects.

With regard to the target group of companies and organizations, the CERA 4in1 standard primarily targets four sectors: automotive, investment, insurance and mining. As an example, CERA 4in1 is implementing the pilot project in Congo together with Volkswagen, as the topic of mining resources related to the further development of battery-electric vehicles will play a major role for OEMs. Banks on the other hand may be interested in the aspect of evaluation before financing a project, as it covers the social, environmental but also economic responsibility of a project. This especially relates to the CERA 4in1 Readiness Standard.

When finally operational, the CERA 4in1 standards, currently led by the DMT GROUP, are planned to be held by an independent body (CERA 4in1 Entity), which will be the responsible actor for the standard and will be designed as a non-profit organization.

The DMT GROUP and TÜV NORD CERT are already considering including the production of hydrogen into CERA 4in1 in the future, once the system is fully established. Therefore, it may be important to consider the criteria of CERA 4in1 and their further development, as this might create a certification system for hydrogen that does not exclusively consider technical requirements, production method and the energy and climate impacts related to them, but also social sustainability, additional environmental aspects as well as corporate governance issues.

Voluntary schemes under RED II

There are several certifications that take into consideration additional sustainability aspects such as soil, water, air protection and social criteria. These certifications schemes are private; however, the European Commission may recognize them. The European Commission had recognized a number of voluntary schemes under RED, but has so far not recognized voluntary schemes under the Recast Renewable Energy Directive (EU) 2018/2001. The Commission has made a preliminary positive assessment of the following voluntary schemes:

2BSvs, Better Biomass, Bonsucro EU, ISCC EU, KZR INiG, REDcert, Red Tractor, RSB EU RED, RTRS EU RED, SQC, TASCC, UFAS and SURE.

The voluntary certification schemes preliminarily approved by the Commission that include the broadest scope of sustainability and social criteria relevant to the study are described below. The study focuses on these selected voluntary schemes in order to discuss potentially relevant aspects and criteria for hydrogen certification without having the ambition to assess all existing certification schemes in detail. According to the assessment, RSB covers the broadest scope of criteria, while REDcert covers the minimum requirements defined by RED (RED II in the future). Furthermore, the selected voluntary schemes cover different types of bioenergy, while other voluntary schemes focus on selected crops, e.g. Bonsucro (sugar cane) or RTRS (soy). Finally, the selected voluntary schemes operate internationally, while other voluntary schemes have geographical limitations, e.g. Red Tractor (UK).

These voluntary schemes are focusing on biofuels for the time being following the requirements of RED. However, some have already taken up hydrogen, or more generally RFNBOs, to a limited extent. The demanding requirements of RED II are not implemented, however.

One example is RSB, which includes RFNBOs based on their first introduction into RED I in 2015 without the demanding requirements of RED II. However, the RSB Standard for Advanced Fuels covering RFNBOs is not applicable for certifications under RED II. The RSB list of eligible renewable fuels of non-biological origin covers hydrogen, synthesis gas, and synthetic liquid fuels. The requirements are to “demonstrate that only renewable electricity is used for the production of renewable fuels”, to avoid double counting of input electricity by providing Guarantees of Origin in the European Union, or by other means in other geographies, and by considering all greenhouse gases over the full supply chain from production of renewable electricity up to hydrogen end use [18].

Another example is ISCC – the ISCC EU scheme under RED II does not include hydrogen/RFNBOs, but under the ISCC plus scheme not related to RED II, renewable feedstocks covering materials of non-biological origin (which includes hydrogen) can be certified. The requirements to be fulfilled are limited focusing on the renewable origin: “The renewability of electricity can be proven via renewable energy obligations, renewable power purchase agreements (PPAs) or via a direct connection/ link of the processing unit with the respective unit producing renewable electricity.” [19]

Also, REDcert mentions hydrogen. The REDcert EU and REDcert DE schemes under RED II do not include hydrogen/RFNBOs, but under the REDcert² scheme for biomass-balanced products in the chemical industry not related to RED II, hydrogen is included in "biomass", which "can also include hydrogen, for example, as long as it comes from electrolysis using electricity from renewable energy sources." [20]

Currently, the voluntary schemes under RED II are in the process of adapting to the new requirements of RED II related to biofuels. In the future, some of them may enlarge their scope to hydrogen, or more generally RFNBOs as defined in RED II. For that purpose, the delegated acts defining the detailed requirements for RFNBOs still need to be adopted (see section RED II below). In such a perspective, it is appropriate to analyze these voluntary schemes in this study, notably with respect to criteria not specifically targeting biofuels, but potentially applicable to hydrogen or RFNBOs as well.

RSB

The Roundtable on Sustainable Biomaterials (RSB) Principles & Criteria [21] describe how to produce biomass, biofuels and biomaterials in an environmentally, socially and economically responsible way.

The RSB Principles are general tenets of sustainable production and processing, while the RSB Criteria describe the conditions to be met to achieve these tenets, either immediately (minimum requirements) or over time (i.e. three years - progress requirements).

The RSB Principles & Criteria presented in the table below are complemented by a set of standards, procedures and guidance documents, which constitute the RSB Standard.

The RSB Standard for Advanced Fuels [18] describes the requirements for the production of advanced fuels, including Renewable liquid and gaseous fuels of non-biological origin[9] and apply to any operation and operator using renewable electricity for the purpose of producing advanced fuels. With the exception of Principle 6 and 8, the RSB Principles & Criteria [21] and related documents shall apply to any processing facility[10]. For renewable fuels of non-biological origin, RSB establish as a pathway-specific requirements:

1. The operator shall not use on-product claims that refer to biofuels or biomaterials.
2. Operators shall demonstrate that only renewable electricity is used for the production of renewable fuels.
3. Operators shall demonstrate that the risk of double booking of the renewable electricity is avoided. In the EU, GO shall be provided for the total electricity consumption of the fuel production.
4. The operator shall provide evidence that for compliance with Principle 3, the following the following greenhouse gas emissions are considered: emissions from the production of the electricity, emissions from the production of the fuel, compression of the gas, transport from the production of the fuel up to the fuel station/final distributor (including grid losses).

The Principles and criteria established by the RSB are as in the following table:

[9] Liquid or gaseous fuels other tan biofuels whose energy content comes from renewable energy sources other than biomass. Hydrogen, Synthetic gas and Synthetic liquid fuel are considered like eligible renewable fuel of non-biological origin.
[10] Operators only conducting mechanical processing are not considering a processing facility.

Table 3 RSB Principles and Criteria

Principle	Criteria
1. Legality	Operations shall comply with all applicable laws and regulations of the country in which the operation occurs and with relevant international laws and agreements
2. Planning, Monitoring & Continuous Improvement	Operations shall undertake an impact assessment process to assess impacts and risks and ensure sustainability through the development of effective and efficient implementation, mitigation, monitoring and evaluation plans.
	Free, Prior & Informed Consent (FPIC) shall form the basis for the process to be followed during all stakeholder consultation, which shall be gender sensitive and result in consensus-driven negotiated agreements. The impact assessment facilitator shall invite all locally affected stakeholders, local leaders, representatives of community and indigenous people's groups and all relevant stakeholders to participate in the consultative process.
	Operators shall implement and maintain a transparent and easily accessible grievance mechanism for directly affected local communities.
	Biofuel operators shall make adequate resources available to ensure compliance with the RSB Standard.
3. Greenhouse Gas Emissions	Biofuels shall meet all applicable GHG reduction requirements set by national and/or regional and/or local regulations.
	Lifecycle GHG emissions of biofuel shall be calculated by using system boundaries from Well to Wheel, including GHG emissions from land-use change, including, but not limited to above and below-ground carbon stock changes and incentivizing the use of co-products, residues and waste in such a way that the lifecycle GHG emissions of the biofuel are reduced.
	Biofuels shall have on average 50% lower lifecycle greenhouse gas emissions relative to the fossil-fuel baseline (60% for new installations).[11].
4. Human and Labor Rights	Workers shall enjoy freedom of association, the right to organize, and the right to bargain collectively.

[11] RSB does not establish a percentage for Hydrogen (or Renewable fuels of non-biological origin) but establish that operators shall provide evidence for compliance with Principle 3. RED II requires a 70% reduction for RFNBOs (which includes H_2); however, the benchmark is not defined yet, from which the 70% reduction are to be achieved (see section "RED II").

	No slave labor or forced labor shall occur. The participating operator shall not be engaged in or support the use of forced, compulsory, bonded, trafficked or otherwise in-voluntary labor as defined in ILO Convention 29.
	No child labor shall occur, except on family farms and then only when work does not interfere with the child's schooling and does not put his or her health at risk.
	Workers shall be free of discrimination of any kind, whether in employment or opportunity, with respect to gender, age, wages, working conditions, and social benefits.
	Workers' wages and working conditions shall respect all applicable laws and international conventions, as well as all relevant collective agreements. Where a government-regulated minimum wage is in place in a given country and applies to the specific industry sector, this shall be observed. Where a minimum wage is absent, the wage paid for a particular activity shall be negotiated and agreed on an annual basis with the worker. Men and women shall receive equal remuneration for work of equal value.
	Conditions of occupational safety and health for workers shall follow internationally recognized standards
	Operators shall implement a mechanism to ensure the human rights and labor rights outlined in this principle apply equally when labor is contracted through third parties.
	Operators shall implement and maintain a transparent and easily accessible grievance mechanism, open for all workers and contracted workers
5. Rural and Social Development[12]	In regions of poverty, the socio-economic status of local stakeholders impacted by the operations shall be improved.[13] The minimum requirements established RSB to measure the local benefits are presented in Table 4.
	In regions of poverty, special measures that benefit and encourage the participation of women, youth, indigenous communities and the vulnerable in the operations shall be designed and implemented.

[12] Examples of possible measures for social and rural development enhancement are provided in RSB Rural and Social Development Guidelines [22].

[13] The RSB has set national-level thresholds for Regions of Poverty based on the United Nations Human Development Indicators. If the country is listed at the inequality-adjusted human development index (IHDI), the threshold is 0.59. If no data is available, the Human Development Index (HDI) may be used with the threshold 0.74. Both indices can be accessed via the UNDP Human Development Indicators World Map. According to the 2019 Human Development Report, Chile´s IHDI corresponds to 0.709. http://hdr.undp.org/en/indicators/138806

6. Local Food Security	Operations shall assess risks to food security in the region and locality and shall mitigate any negative impacts that result from their operations.
	In food insecure regions, operations shall enhance the local food security of the directly affected stakeholders. The criteria only apply for crops as a feedstock, in case of land with no crop value, it does not apply as a threat to the food supply.
7. Conservation	Conservation values of local, regional or global importance within the potential or existing area of operation shall be maintained or enhanced
	Ecosystem functions and services that are directly affected by the operation shall be maintained or enhanced
	Operations shall protect, restore or create buffer zones[14].
	Ecological corridors shall be protected, restored or created to minimize fragmentation of habitats
	Operations shall prevent invasive species from invading areas outside the operation site
8. Soil	Operators shall implement practices to maintain or enhance soil's physical, chemical, and biological conditions.
9. Water	Operations shall respect the existing water rights of local and indigenous communities
	Operations shall include a water management plan which aims to use water efficiently and to maintain or enhance the quality of the water resources that are used for the operations
	Operations shall not contribute to the depletion of surface or groundwater resources beyond replenishment capacities
	Operations shall contribute to the enhancement or maintaining of the quality of the surface[15] and groundwater resources[16]

[14] RSB define Buffer zones as small areas or strips of land in permanent vegetation, designed to intercept pollutants and manage other environmental concerns. Buffer Zones include the regions near the border of an area which is protected or managed for conservation, transition zones between areas managed for different objectives (including e.g. riparian buffer zones between rivers and production areas), or areas on the edge of protected areas that have land use controls and allow only activities compatible with protection. of the core area, such as research, environmental education, recreation, and tourism. Buffers include: riparian buffers, filter strips, grassed waterways, shelterbelts, windbreaks, living snow fences, contour grass strips, crosswind trap strips, shallow water areas for wildlife, field borders, alley cropping, herbaceous wind barriers, and vegetative barriers [23].

[15] RSB defined Surface water as all waters on Surface of the Earth found in rivers, streams, ponds, lakes, marshes, wetlands, ice and snow, and transitional, coastal and marine waters.

[16] In Chile the quality of the brine discharged into the sea must comply with Table 5 of the DS 90. In addition, Directmar establishes criteria and secondary environmental quality standards for brine in view of the lack of criteria established by the Chilean law [24].

10. Air Quality	Air pollution emission sources from the operations shall be identified, and air pollutant emissions minimized through an air management plan
	Operations shall avoid and, where possible, eliminate open-air burning of residues, wastes or by-products, or open air burning to clear the land
11. Use of Technology, Inputs, and Management of waste	Information on the use of technologies in operations shall be fully available, unless limited by national law or international agreements on intellectual property
	The technologies used in operations including genetically modified plants, micro-organisms, and algae, shall minimize the risk of damages to environment and people, and improve environmental and/or social performance over the long term
	Micro-organisms used in operations which may represent a risk to the environment or people shall be adequately contained to prevent release into the environment
	Good practices shall be implemented for the storage, handling, use, and disposal of biofuels, fertilizers and chemicals
	Residues, wastes and byproducts from feed-stock processing and biofuel or biomaterial production units shall be managed such that soil, water and air's physical, chemical, and biological conditions are not damaged
12. Land Rights	Existing land rights and land-use rights, both formal and informal, shall be assessed, documented, and established. The right to use land for the operations shall be established only when these rights are determined
	Free, Prior, and Informed Consent shall form the basis for all negotiated agreements for any compensation, acquisition, or voluntary relinquishment of rights by land users or owners for operations

For RSB certification compliance is verified by RSB-accredited certification bodies at the level of criteria and minimum/progress requirements. There are several minimum requirements established by the RSB. The following requirements may be highlighted as they could be of specific relevance to hydrogen certification in Chile.

Table 4 Outstanding minimum requirements of RSB for operation in Chile

Principle	Minimum Requirements
Legality	The operator shall implement and maintain a system for ensuring that all relevant laws and regulations are complied with, which includes (among others) a system that ensure that all forms of bribery, conflicts of business interest and fraudulent practices are prohibited, including a written policy by the management and appropriate staff training.

Planning, Monitoring and Continuous Improvement	The impact assessment facilitator shall invite all locally affected stakeholders, local leaders, representatives of community and indigenous people groups and all relevant stakeholders to participate in the consultative process. The Dispute resolution mechanism shall be based on negotiation between affected parties and decision shall be made on consensus.
Rural and Social Development	Where the socioeconomic baseline survey undertaken during the social impact assessment process in accordance with the Social Impact Assessment Guidelines (RSB-GUI-01-005-01) identifies an excess of unemployed or underemployed labor in the locality of the operations, operations shall optimize the job-creation potential. Measured improvements in the social and economic indicators as set against the baseline survey carried out under the social impact assessment process shall be targeted for review every three years. At least one measure to significantly optimize the benefits to local stakeholders shall be implemented within a three-year period of the start of the operations, for instance: a) Creation of year-round and/or long-term jobs b) The establishment of governance structures that support empowerment of small-scale farmers and rural communities such as co-operatives and micro-credit schemes c) Use of the locally produced bioenergy to provide modern energy services to local poor communities d) Shareholding options, local ownership, joint ventures, and partnerships with the local communities. e) Social benefits for the local community such as the building or servicing of clinics, homes, hospitals and schools
Water	The use of water for the operation shall not be at the expense the same water source(s) for Subsistence. The operator shall assess the potential impacts of the operations on water availability within the local community and ecosystems during the screening exercise of the impact assessment process and mitigate any negative impacts.
Air Quality	The operator shall investigate and, whenever possible in the local context, implement Best Available Technology (BAT) to reduce air pollution, appropriate to the scale and intensity of operation.

ISCC

The objective of the International Sustainability and Carbon Certification System (ISCC) [25] is to contribute to the sustainable cultivation, processing, and use of different types of biomass and their products. The ISCC 202 document "sustainability requirements" comprises six sustainability principles, which are presented below:

Table 5 ISCC Principles and criteria

Principle	Description	Criteria
1. Protection of Land with High Biodiversity Value or High Carbon Stock	The objective of ISCC is to protect areas which are biodiverse or rich in carbon, which serve the protection of threatened or vulnerable species, or which have other ecological or cultural importance. Furthermore, high conservation value (HCV) areas shall be protected.	1.1 Biomass is not produced on land with high biodiversity value
		1.2 Biomass is not produced on land with high carbon stock
		1.3 Biomass is not produced on peatland
2. Environmentally Responsible Production to Protect Soil, Water and Air	Compliance with national and local laws and regulations relevant to soil degradation, soil preservation, soil management, contamination and depletion of water sources, water quality, air emissions and burning practices is required. Good Agricultural Practices shall be applied. Furthermore, compliance with the requirements listed below is necessary.	2.1 Conservation of natural resources and biodiversity
		2.2 Use of best practices to maintain and improve soil fertility
		2.3 Use of best practices in fertilizer application
		2.4 Restrictions on plant protection products and seeds
		2.5 Avoiding plant protection products by integrated pest management
		2.6 Use of best practices in plant protection product application
		2.7 Use of best practices in handling and disposing plant protection products
		2.8 Use of best practices storing operating resources
		2.9 Use of best practices to maintain and improve water quality and quantity
		2.10 Use of best practices in waste and energy management
3. Safe Working Conditions	Compliance with national and local laws on working conditions is required. The company should be familiar with the relevant legislation and should remain informed about changes in legislation.	3.1 Training and competence
		3.2 Prevention of and handling with accidents
	The criteria listed here are based on internationally recognized requirements concerning social	4.1 Rural and social development

4. Compliance with Human, Labor and Land Rights	aspects (International Labor Organization, core ILO standards: ILO 29, 105, 138, 182, 87, 98, 100, 111). In addition, compliance with relevant national and local laws is required. In addition, compliance with relevant national and local laws is required.	4.2 Employment conditions
5. Compliance with Laws and International Treaties	Responsible use of land	5.1 Legitimacy of land use
		5.2 Compliance with applicable laws and treaties
6. Good Management Practices and Continuous Improvement	Maintain a good document registration system and maintain good financial sustainability	6.1 Economic stability
		6.2 Management

Regarding social sustainability addressed in Principle 4, the ISCC states that "For countries that have ratified the ILO Standard Convention, it may be assumed that the social requirements (ISCC Principle 4) are fulfilled, unless the auditor arrives to a different result in the framework of the risk assessment and during the audit" [25]. Discussion of the ILO is covered in the next section below.

To further break down the specifications directly related to the "Rural and social development" criterion of Principle 4, the relevant criterion have been compiled in Table 6.

Table 6 Rural and social development criterion of ISCC

Criterion number	Criterion
4.1	**Rural and social development**
4.1.1	A self-declaration on good social practice regarding human rights is available
4.1.2	Negative environmental, social, economic, and cultural impacts are avoided
4.1.3	Biomass production does not impair food security
4.1.4	Fair and transparent contract farming arrangements are in place
4.1.5	Farm/plantation residents have access to basic services
4.1.6	All children living on the farm/plantation have access to quality primary school education
4.1.7	Other forms of social benefits are offered by the employer to workers and their families and/or community
4.1.8	Workers and affected communities must be able to make a complaint
4.1.9	Mediation is available in case of a social conflict

REDcert

REDcert offers certification schemes for sustainable biomass, biofuels and bioliquids, and agricultural raw materials for the food/feed and chemical industries. REDcert was founded in 2010 as a support mechanism for the practical implementation of the Sustainability Ordinances of the EU Directive on Renewable Energy.

REDcert requires that the minimum requirements of Directive (EU) 2018/2001 be met as well as amplifying to a slight degree the following sustainability criterion:

- Groundwater protection
- Fertilizer use
- Use of sludge
- Application and handling of plant protection products
- Integrated pest management
- Prevention of soil erosion
- Preservation of organic matter and structure of soils
- Water protection and management
- Social responsibility

Some examples of criteria from the list mentioned above that may be pertinent to hydrogen certification are presented in

Table 7.

Table 7 REDcert criteria that may be pertinent to hydrogen certification

Topic	Example Criteria
Groundwater protection	Producers may not release harmful substances[17] into groundwater as defined in Annex I of Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration and in Annex II Part B of Commission Directive 2014/80/EU of 20 June 2014 amending Annex II to Directive 2006/118/EC of the European Parliament and of the Council on the protection of groundwater against pollution and deterioration.
Water protection and management	When water is used for irrigation, a license from the national or local authorities is required. Farmers must prove that comply with irrigation regulations. Documentation showing the amount of water used and the time period of irrigation must be kept and be available at any time.

[17] Brine from desalination is not directly mentioned in the Directives considered by REDcert as a harmful substance, however parameters indicative of salinity must be monitored by means of conductivity.

Social responsibility	All countries from which biomass is sourced must adopt and meet the minimum requirements laid down and ratified by the International Labor Organization (ILO).

Other sustainability certification schemes and international recommendations

International Labor Organization (ILO)

The International Labor Organization (ILO) is a United Nations agency whose mandate is to advance social and economic justice through setting international labor standards. Certain certification schemes (such as REDcert) require country ratification of the ILO's Eight Fundamental Conventions [26], or consider the ratification of the ILO Standard Convention as sufficient for the approval of certain social and/or labor related principles (ISCC). In Chile, all eight of these standards have been ratified and consist of [27]:

1) Freedom of Association and Protection of the Right to Organize Convention, 1948 (No. 87)
2) Right to Organize and Collective Bargaining Convention, 1949 (No. 98)
3) Forced Labor Convention, 1930 (No. 29) (and its 2014 Protocol)
4) Abolition of Forced Labor Convention, 1957 (No. 105)
5) Minimum Age Convention, 1973 (No. 138)
6) Worst Forms of Child Labor Convention, 1999 (No. 182)
7) Equal Remuneration Convention, 1951 (No. 100)
8) Discrimination (Employment and Occupation) Convention, 1958 (No. 111)

Forest Stewardship Council (FSC)

The Forest Stewardship Council A.C. (FSC) was established in 1993 as a follow-up to the United Nations Conference on Environment and Development (the Earth Summit at Rio de Janeiro, 1992) with the mission to promote environmentally appropriate, socially beneficial, and economically viable management of the world's forests by awarding FSC Certifications to products derived from FSC Certified forests.

FSC is an international organization that provides a system for voluntary accreditation and independent third-party certification. This system allows certificate holders to market their products and services as the result of environmentally appropriate, socially beneficial and economically viable forest management. FSC also sets standards for the development and approval of FSC Stewardship Standards which are based on the FSC Principles and Criteria. In addition, FSC sets standards for the accreditation of conformity assessment bodies (also known as certification bodies) that certify compliance with FSC's standards. Based on these standards, FSC provides a system for certification for organizations seeking to market their products as FSC certified.

The FSC certification process is detailed on the FSC website with downloadable documents explaining the specific certification requirements needed by a forest management body. The principles and guidelines are developed to be applicable worldwide and relevant to all kinds of forest ecosystems, as well as a wide range of cultural, political and legal settings.

The principles, criteria and indicators of the certification process are detailed in the following documents:

- **FSC-STD-01-001 V5-2:** Principles and Criteria for Forest Stewardship are designed to serve as a common starting point for developing National Forest Stewardship Standards.
- **FSC-STD-60-004-20 V2-0:** International Generic Indicators.

FSC-STD-01-001 V5-2, most recently updated in 2015, defines the general principles and criteria, scope, responsibility of compliance, basis for certification, and questions regarding interpretations and disputes of the certification process. The ten (10) principles outlined in this document are:

Table 8 FSC Principles and Criteria

Principle 1: Compliance with Laws	The Organization shall comply with all applicable laws, regulations and nationally ratified international treaties, conventions and agreements.
Principle 2: Workers Rights and Employment Conditions	The Organization shall maintain or enhance the social and economic wellbeing of workers.
Principle 3: Indigenous People´s Rights	The Organization shall identify and uphold Indigenous Peoples' legal and customary rights of ownership, use and management of land, territories and resources affected by management activities.
Principle 4: Community Relations	The Organization shall contribute to maintaining or enhancing the social and economic wellbeing of local communities.
Principle 5: Benefits from the Forest	The Organization shall efficiently manage the range of multiple products and services of the Management Unit to maintain or enhance long term economic viability and the range of environmental and social benefits.
Principle 6: Environmental Values and Impacts	The Organization shall maintain, conserve and/or restore ecosystem services and environmental values of the Management Unit, and shall avoid, repair or mitigate negative environmental impacts.
Principle 7: Management Planning	The Organization shall have a management plan consistent with its policies and objectives and proportionate to scale, intensity and risks of its management activities. The management plan shall be implemented and kept up to date based on monitoring information in order to promote adaptive management. The associated planning and procedural documentation shall be sufficient to guide staff, inform affected stakeholders and interested stakeholders and to justify management decisions.
Principle 8: Monitoring and Assessment	The Organization shall demonstrate that, progress towards achieving the management objectives, the impacts of management activities and the condition of the Management Unit, are monitored and evaluated proportionate to the scale, intensity and risk of management activities, in order to implement adaptive management
Principle 9: High Conservation Values	The Organization shall maintain and/or enhance the High Conservation Values in the Management Unit through applying the precautionary approach.
Principle 10: Implementation of Management Activities	Management activities conducted by or for The Organization for the Management Unit shall be selected and implemented consistent with The

	Organization's economic, environmental and social policies and objectives and in compliance with the Principles and Criteria collectively.

The FSC Principles and Criteria expressed above have been implemented in a national FSC standard for Chile [28].

Table 9 presents some examples from the "FSC National Forest Stewardship Standard for Natural Forests – Operations at Large Scale" applied in Chile that may be used in hydrogen certification.

Table 9 Examples of FSC criteria applied in Chile

Principle	Criteria	Sub-Criteria	Verification
PRINCIPLE 2: Tenure and Use Rights and Responsibilities	2.3 Appropriate mechanisms should be employed to resolve disputes over tenure and use rights claims. The circumstances and status of any pending disputes shall be explicitly considered during certification evaluation. Disputes of substantial magnitude involving numerous and significant interests will normally disqualify certification of an operation. of an operation.	2.3.1 Relationships with the local community are based on understanding, and transparency based on the principles of participation[18] [29]	Interviews and testimonials from local community representatives
PRINCIPLE 4: Communal Relations and Workers' Rights	4.1 Communities within or adjacent to forest management areas should have opportunities for employment, training, and other services.	4.1.1 There is a commitment and documented efforts to favor the hiring of local labor and if necessary, training will be provided to the community to encourage their hiring.	Relevant documents, stakeholder testimonials, list of workers and employees.
PRINCIPLE 4: Communal Relations and Workers' Rights	4.4 Management planning and implementation should incorporate the results of social impact assessments. Populations and groups directly affected by	4.4 The Project of Forest Management (entity) has a systematic participatory social impact management procedure, which includes at least	Management Plan

[18] The principles of participation are a general code by which the FSC has developed its governance structure. This structure promotes consensus-based decision making allowing for a more transparent, democratic balance of interests.

	management operations should be consulted.	- Identification of operations causing social impacts - Identification of potentially affected groups - Consultation mechanisms with the local community - Incorporation of mitigation measures	
PRINCIPLE 6: ENVIRONMENTAL IMPACT	6.1 An environmental impact assessment should be completed according to the scale and intensity of forest management, as well as the peculiarity of the affected resources, which should be adequately incorporated into the management system. These assessments should consider the landscape and the impacts caused by the processes carried out at the site. An environmental impact assessment should also be carried out prior to initiating operations that may affect the site.	6.1.3 A summary of the results and recommendations of the Environmental Impact Assessment is available and known to the surrounding community and those who work in the respective management areas.	See sub criteria.

Fairtrade Labelling Organizations International (FLO)

Fairtrade Labelling Organizations International (FLO), or simply Fairtrade International, was established in 1997 with the goal of improving social sustainability in farming in developing countries by establishing better product prices and promoting decent working conditions and a fairer deal for farmers and workers. A product with the FAIRTRADE Mark means producers and businesses have met internationally agreed standards which have been independently certified.

Fairtrade International develops and reviews Fairtrade Standards and assists producers in gaining and maintaining certification and in capitalizing on market opportunities on the Fairtrade market. To ensure the transparency of the system, the standards are developed and reviewed by the FLO Standards and Policy Committee, in which FLO members, producer organizations, traders and external experts participate.

Founded in 2003, FLOCERT, the main independent certifier for Fairtrade, ensures that producers and traders comply with the FLO Fairtrade Standards and that producers invest the benefits received through Fairtrade in their development. Operating independently from any other interests, it follows the international ISO standards for certification bodies (ISO 17065).

The Fairtrade Standards include a range of economic, environmental and social criteria that must be met by producers and traders. If the criteria are not met, a producer organization can face suspension until remedial action can be undertaken and verified, or ultimately be decertified.

Within the Fairtrade certification scheme there exist specific standards for the following market sectors:

- Farmers, workers and other primary producers:
  - Small scale producers (with additional product-specific standards)
  - Hired labor organizations (with additional product-specific standards)
  - Contract production
  - Small-scale artisanal mining (AMSO)
- Companies, manufacturers, purchasers and others:
  - Trader standard (for companies trading Fairtrade goods)
  - Climate Standard (for Fairtrade cardon credits)
  - Textile standard for complete supply chain of textile manufacturers

For each bullet point listed above, there exists a specific standard with a unique structure depending on the nature of the entity pursuing certification.

A large portion of Fairtrade's certification requirements concern labor conditions (for instance anti-discrimination practices and no child labor restrictions) and health and safety requirements which may be considered for hydrogen certification.

Table 10 presents specific criteria from the various Fairtrade standards that could be used for hydrogen certification with regard to external environmental and social impacts.

Table 10 Potentially relevant socio-environmental criteria from Fairtrade [30] [31]

Sub Criteria ID	Sub Criteria
3.2.25	Availability of water
2.2.4	Minimizing environmental impact
2.2.5	Indigenous rights, human rights and sites of cultural importance
2.2.7	Local project endorsement
2.2.8	Project grievance mechanisms
1.3.5	Local sustainable development
1.4.1	Identification of local communities
1.4.2	Protection of land rights
1.4.3	Binding agreements with affected communities
3.2.20	Environmental licenses and permits
3.2.21	Protection area

Referring to Table 10 above, various criteria from Fairtrade's certification scheme may be referential for hydrogen certification. Fairtrade requires a Development Plan (Item 17 in Table 10) which is presented in the following Fairtrade Standard for Smallscale Producer Organizations:

You plan and document at least one activity with the intention to promote the progress of your business, organization, members, workers, community and/or environment. The plan is called the Fairtrade Development Plan. The plan includes:

- *the description of the activity (what you plan to do);*
- *the objective of the activity (why you plan to do it);*
- *the timeline of the activity (by when you plan to do it);*
- *the responsibilities (who will be in charge of doing it);*
- *and in case you need to spend funds (such as the Fairtrade Premium as described in requirement 4.1.3 or other sources of funds), the budget of the activity (how much you plan to spend).*

In the List of Ideas for the Fairtrade Development Plan for Small Producer Organizations [32], ideas are split into the following headings: Sustainable Livelihoods, Empowerment, and Making Trade Fair. Within each heading are presented various ideas of how an entity pursuing Fairtrade Certification can formulate their Development Plan, from internal worker trainings to local infrastructure investment.

GBEP

The Global Bioenergy Partnership (GBEP, www.globalbioenergy.org) brings together public and private actors, as well as actors from civil society with the purpose of providing a mechanism to organize, coordinate and implement targeted international research, development, demonstration, and commercial activities related to production, delivery, conversion and use of biomass for energy. Currently, the Association is made up of 23 countries and 14 international organizations and institutions. In addition, 28 countries and 12 international agencies participate as Observers, among which is Chile. The GBEP is not a certification scheme, however GBEP set up the Task Force on Sustainability (TFS) to develop a set of relevant, practical, voluntary, and science-based sustainability indicators and methodologies to assess the environmental, social, and economic impacts of bioenergy production and use.

The GBEP TFS published the first edition of "The Global Bioenergy Partnership Sustainability Indicators for Bioenergy" in 2011 addressing 24 indicators (see Table 11) and including a short description and a multi-page methodology sheet that outlines the approach for collecting and analyzing data highlights and data limitations. In 2020, the TFS published "The Implementation Guide for the Global Bioenergy Partnership Sustainability Indicators for Bioenergy" to complement and enhance the first edition of "The Global Bioenergy Partnership Sustainability Indicators for Bioenergy", including guidance based on the implementation of GBEP's indicators in 14 different countries.

Measured over time, the indicators will show the effectiveness of national bioenergy policies and programs taken to respond to environmental, social and economic impacts of their bioenergy production and use.

- Environmental: Greenhouse gas emissions, Productive capacity of the land and ecosystems, Air quality, Water availability, use efficiency and quality, biological diversity, land-use change, including indirect effects.
- Social: Price and supply of a national food basket, Access to land, water and other natural resources, Labor conditions, Rural and social development, Access to energy, Human health and safety.
- Economic: Resource availability and use efficiencies in bioenergy production, conversion, distribution and end-use, Economic development, Economic viability and competitiveness of bioenergy, Access to technology and technological capabilities, Energy security/Diversification of sources and supply, Energy security/Infrastructure and logistics for distribution and use.

Table 11 GBEP sustainability indicators

Environmental	Social	Economic
	Indicators	
1. Lifecycle GHG emissions	9. Allocation and tenure of land for new bioenergy production	17. Productivity
2. Soil quality	10. Price and supply of a national food basket	18. Net energy balance
3. Harvest levels of wood resources	11. Change in income	19. Gross value added
4. Emissions of non-GHG air pollutants, including air toxics	12. Jobs in the bioenergy sector	20. Change in consumption of fossil fuels and traditional use of biomass
5. Water use and efficiency	13. Change in unpaid time spent by women and children collecting biomass	21. Training and re-qualification of the workforce
6. Water quality	14. Bioenergy used to expand access to modern energy services	22. Energy diversity
7. Biological diversity in the landscape	15. Change in mortality and burden of disease attributable to indoor smoke	23. Infrastructure and logistics for distribution of bioenergy
8. Land use and land-use change related to bioenergy feedstock production	16. Incidence of occupational injury, illness and fatalities	24. Capacity and flexibility of use of bioenergy

Of the indicators presented in Table 11, Indicator 14, "Bioenergy used to expand access to modern energy services", may be of specific relevance to hydrogen certification. As defined in "The Global Bioenergy Partnership Sustainability Indicators for Bioenergy", modern bioenergy sources include electricity delivered to the final user through a grid from biomass power plants, district heating and cooling, and stand-alone or grid-connected generation systems among others. Increased access to modern energy services for the purposes of this indicator is not intended to include increased consumption of energy for additional leisure activities, therefore establishment of a clear definition what access to modern energy services means, and which households and businesses do not have it or did not have it prior to the start of the measurement period are crucial.

Explanation of how to calculate the quantitative value of this indicator are given in "Bioenergy used to expand access to modern energy services", however it is stated that a lack of existing baseline data and information at the local level could be a limitation.

Sources of CO_2 supply

So far, no certification scheme includes any criteria related to CO_2 sourcing. This is a new field as CO_2 as a feedstock is not relevant in any established certification area, but becomes relevant for certain hydrogen derivatives, notably synfuels.

On the one hand, this topic has been discussed in scientific studies such as the German "E-fuels"[19] study [33]:

"Carbon dioxide from concentrated sources is in principle an attractive feedstock for the synthesis of e-fuels, especially in the early phase of e-fuel deployment. This is because the energy needed for fuel production is lower and investments in CO_2 extraction from the air can be avoided. However, CO_2 from concentrated sources is limited if environmental/sustainability aspects for the various sources are taken into account:

- Fossil fuel phase-out because of the Paris Climate Agreement
- Renewable CO_2 from biomass because of limited biomass potential regarding energy consumption
- Industrial CO_2 phase-out, e.g. because of direct reduction with renewable PtH_2 in steel works

Not all CO_2 sources can be considered equally sustainable. Table 12 gives an overview of the sustainability of various concentrated sources. The different "shades of greenness" are depicted in traffic light colours."

Table 12: Sustainability, competing uses and long-term strategic aspects of different concentrated CO_2 sources (Source: LBST based on [33])

CO_2 sources	Environmental sustainability	Alternative CO_2 uses	Towards carbon-neutrality; Risks
Extraction from air	Subject to electricity source		
Biogas upgrading	Subject to feedstock & process	Power-to-methane	Other biomass uses
Solid biomass fired heat (& power) plants	Subject to feedstock & process	Bio-CCS	Other biomass uses
Fermentation to alcohols	Subject to feedstock & process	Beverage industry	Other biomass uses
Geothermal sources	Subject to geo-phys. CO_2 cycle	CO_2 re-injection (closed loop)	Hot dry rock a potential no-go
Cement production	Short-term exemptions?	Power-to-chemicals	Shift to alternative materials, recycling; Technology lock-in
Steel production	Short-term exemptions?	Top-gas for heating & reduction	Shift to direct reduction with H_2
Fossil fuel firing	Short-term exemptions?	CCS	Phase-out; Technology lock-in

The contents of Table 12 are based on an earlier LBST summary published in [33]. It has been updated for this report based on new results from on-going research in the field of concrete recycling. Until recently, the non-energetic share of CO_2 emissions resulting from chemical reactions for cement production was considered 'unavoidable'. However, new R&D[34] shows promising results as to using renewable energies and closing the CO_2 loop in cement production through the recycling of demolished concrete. Additional CO_2 emissions from the calcination of limestone could thus be avoided in the future.|

On the other hand, German regulation has a requirement on CO_2 for the synthesis of methane from hydrogen in its Energy Act (Energiewirtschaftsgesetz) where "biogas" is defined as:

[19] The term "e-fuels" includes both hydrogen and synthetic fuels.

"Biomethane, gas from biomass, landfill gas, sewage gas, and mine gas as well as hydrogen produced from water electrolysis, and synthetic methane where the electricity for electrolysis and the carbon dioxide or carbon monoxide for methane synthesis can be demonstrated to stem to the largest extent from renewable energy sources as defined in Directive 2009/28/EC (OJ L 140, 5.6.2009, p. 16)"[35], which is the Renewable Energy Directive (RED).

Further discussions will be needed for taking this topic up in certification schemes for hydrogen derivatives.

Certification scheme comparison of sustainability and social criteria

Certification scheme comparison of sustainability and social criteria

All schemes analyzed do incorporate environmental and social/economic sustainability criteria. However, each scheme incorporates these criteria to a varying extent. Overall, labor, health and safety criteria are universally covered due to the ratification of the ILO's Fundamental Conventions in Chile.

Environmental sustainability criteria are present in all schemes. These schemes also require that all local laws must be abided by, meaning any relevant environmental protection regulation is considered.

Economic and social sustainability criteria are included to varying degrees in the analyzed schemes. REDcert only indicates that ILO Fundamental Conventions must be followed. The FSC has the most prominent list of criteria for relations with indigenous peoples. Fairtrade requires a development plan that may take on the form of a community development project while GBEP, though not a certification, promotes as one of its indicators increase in energy access. RSB's Rural and Social Development principle requires that in regions of poverty, the socio-economic status of local stakeholders impacted by the operations shall be improved, also recommending as a implementation method of the criteria local access to energy produced from the biofuel.

Table 13 Scheme comparison of sustainability and social criteria

Scheme	GBEP*	RSB	ISCC	CERA4in1	FSC	Fair Trade	REDcert
Scope	Bioenergy & Biofuels	Biofuels	Bioenerg y	Sust. raw material	Fores t Mngt	Agri, textile, mining	Bioenerg y
ENVIRONMENTAL SUSTAINABILITY							
Biodiversity Conservation							
Biodiversity	x	x	x	x	x	x	x
Natural Habitats, ecosystems	x	x		x	x	x	
High conservation value areas		x	x	x	x	x	x
Soil conservation							
Soil protection	x	x	x		x	x	x
Residues, wastes		x		x			x
Waste Management		x	x	x	x	x	x
Sustainable Water							
Water rights		x	x			x	x
Water quality	x	x			x	x	x
Water management, conservation		x	x	x	x	x	x
Efficient use of water	x	x		x		x	
Air Quality							
Air pollution	x	x	x	x			x
SOCIAL/ ECONOMIC SUSTAINABILITY							
Community Development							
Local infrastructure and services development	x	x			x	x	
Increase in energy access	x	x					
Local economic development and employment	x	x	x	x	x		
Local professional skills training and education		x	x	x	x	x	
Social Impact							
Social Impact Assessment	x	x	x	x	x		

Scheme	GBEP*	RSB	ISCC	CERA4in1	FSC	Fair Trade	REDcert
Indigenous peoples' rights		x	x	x	x	x	
Lands right issues	x	x	x	x	x	x	x
Labor & Safety							
Working conditions	x	x	x	x	x	x	x
Contracts		x	x		x	x	x
Health and safety		x	x	x	x	x	x

**GBEP is not a certification scheme and is thus not included in the assessment of certifications schemes.*

Hydrogen Regulations

The Renewable Energy Directive (recast) of 2018 (RED II) requires the European Union Member States to oblige fuel suppliers to increase the renewable share in transport fuels to reach a target of 14% in the European Union in 2030.

Hydrogen and derivates have been included in this obligation but have not yet contributed to the renewables shares on the market.

RED II

RED II [36] was adopted in December 2018 and defined a deadline for transposition into national law of the European Union Member States of 30 June 2021. Based on the increased climate ambition of the EU in the framework of the "Green Deal", the European Commission officially introduced a legal proposal to amend RED II (see section RED II Amendment below for more details); this proposal is now in the legislative process in the European Parliament and in the Council, which typically takes one year or more.

RED II has two relevant sets of provisions related to the certification of hydrogen:

1. Guarantees of Origin for consumer disclosure (Art. 19); see section Guarantees of Origin and EN 16325 above for more details;

2. Certification for use in transport in view of the obligation on fuel suppliers to increase the share of renewable energies in transport (Art. 25-30).

Hydrogen based on renewable electricity and derivatives such as ammonia, methanol, synfuels, etc. are defined as "renewable liquid and gaseous transport fuels of non-biological origin" (RFNBOs) in RED II. RFNBOs and biofuels (including hydrogen produced from bioenergy) can contribute to fulfilling the obligation of fuel suppliers to increase the renewable share in transport fuels, while direct electricity use in transport additionally contributes to the overall EU target of 14% renewables in transport as defined in RED II.

Fuel suppliers use certification by so-called "voluntary schemes" for demonstrating compliance with the obligation. [20] These voluntary schemes need to submit applications for being recognized by the European Commission (Art. 30(4, 5)). For the time being, none of the voluntary schemes are recognized for the certification of hydrogen and other RFNBOs according to RED II (see section Voluntary schemes under RED II). Currently, the European Commission evaluates the applications of voluntary schemes under RED II and expects the recognition of the first voluntary schemes under the recast directive "to happen in the short term" [15]. Whether such recognitions include RFNBOs is open as the detailed requirements related to RFNBOs, which are important for certification, to be defined by the delegated acts described below have not yet been published and adopted.

While the certification of biofuels of world-wide origins by voluntary schemes for consumption in Europe is thus well-established, certification of RFNBOs has not yet been carried out. The sustainability criteria related to biofuels were defined in RED of 2009, have been revised over time, and have been adjusted and extended by RED II. For RFNBOs, sustainability criteria have been defined in general terms in RED II (Art. 25, 27). These general criteria will be detailed in delegated act by the European Commission, which was due by the end of 2021:

1. A delegated act specifying the methodology for assessing greenhouse gas emissions savings from renewable liquid and gaseous transport fuels of non-biological origin (Art. 28(5));

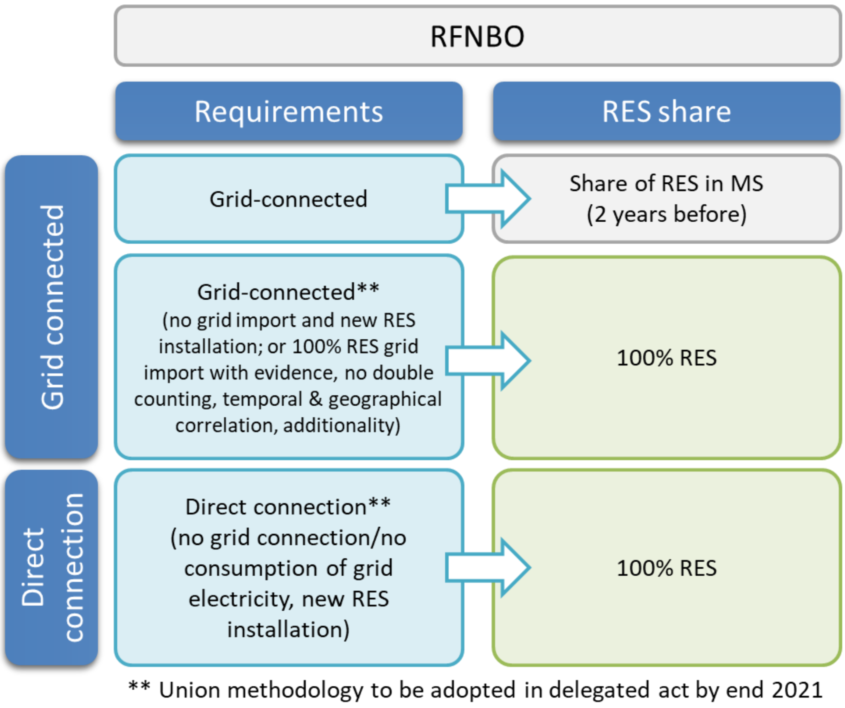
[20] RED II also provides for the option of national schemes to be implemented by EU MS. This option has been adopted by Austria where, as a consequence, voluntary schemes are not applicable.

2. A delegated act establishing a Union methodology setting out detailed rules by which economic operators are to comply with the requirements of additionality as well as of temporal and geographic correlation (Art. 27(3)). Recital 90 of RED II in this sense states: "The Commission should develop, by means of delegated acts, a reliable Union methodology to be applied where such [renewable] electricity is taken from the grid. That methodology should ensure that there is a temporal and geographical correlation between the electricity production unit with which the producer has a bilateral renewables power purchase agreement and the fuel production."

Once these delegated acts are adopted, they are immediately legally binding in all EU MSs. Voluntary schemes aiming at certifying RFNBOs thus need to incorporate the requirements and criteria defined in the delegated acts before being able to certify RFNBOs according to RED II. The European Commission has announced to be launching a public consultation of the draft delegated acts before they will be adopted, which were due by the end of 2021.

As an alternative to using 100% renewable electricity, RED II also allows using grid electricity. However, in such a case, only a certain share of the produced hydrogen (RFNBO) is counted as renewable. This share is defined as the "average share of electricity from renewable sources in the country of production, as measured two years before the year in question" (Art. 27(3)). It should be noted that this definition does not specify whether this is the production mix, the consumption mix or the residual mix. However, it is generally interpreted as designating the production mix.

Figure 1: Renewable energy share of produced RFNBOs according to RED II



The criteria for RFNBOs are as follows:

1. A GHG reduction of 70% (Art. 25(2)). Delegated acts will define the methodology for calculating the GHG balance, and will define the benchmark GHG balance compared to which the savings are to be calculated.

2. “Additionality”:

   a. Renewable electricity plants that are directly connected to the RFNBO production plant need to:

      i. “come into operation after, or at the same time as, the installation producing the renewable liquid and gaseous transport fuels of non-biological origin; and

      ii. is not connected to the grid or is connected to the grid but evidence can be provided that the electricity concerned has been supplied without taking electricity from the grid.” (Art. 27(3)).[21]

   b. Electricity for RFNBO production “that has been taken from the grid may be counted as fully renewable provided that it is produced exclusively from renewable sources and the renewable properties and other appropriate criteria have been demonstrated” (Art. 27(3)).

   c. Recital 90 explains: “there should be an element of additionality, meaning that the fuel producer is adding to the renewable deployment or to the financing of renewable energy.”

   d. In an unofficial draft of parts of the delegated acts “leaked” in spring 2021, further options for additionality requirements were included.

3. Temporal correlation: recital 90 explains: “For example, renewable fuels of non-biological origin cannot be counted as fully renewable if they are produced when the contracted renewable generation unit is not generating electricity.”

4. Geographic correlation: recital 90 explains: “Another example is the case of electricity grid congestion, where fuels can be counted as fully renewable only when both the electricity generation and the fuel production plants are located on the same side in respect of the congestion.”

The requirements for temporal and geographic correlation as listed above under points 3 and 4 are to be detailed in a delegated act as mentioned above. Temporal correlation in the strict sense requires ensuring that the electricity consumed for hydrogen production is produced in the same hour or quarter hour. To this end, hourly or quarter-hourly production profiles of the renewable power production need to be measured and recorded, and hourly or quarter-hourly consumption profiles of the electrolyser need to be measured and recorded. Both profiles need to match. Less demanding requirements have been suggested in the public debate; however, this remains speculation as long as the delegated acts is not adopted.

Geographic correlation requirements are less obvious to define and may be ensured by solutions with different levels of complexity. At the more ambitious end would be requirements to monitor actual grid congestions between the renewable power plant and the electrolyser. At less ambitious end, general requirements could be defined to ensure that both the renewable power plant and the electrolyser are within a certain electricity grid area, or that they are on the same side of typical grid congestions.

Furthermore, RED II Art. 30(4) defines: “The Commission may decide that those schemes contain accurate information on measures taken for soil, water and air protection, for the restoration of degraded land, for the avoidance of excessive water consumption in areas where water is scarce [...].” This provision is an indirect requirement for voluntary schemes including criteria on soil, water protection and consumption, air and degraded land (see section Voluntary schemes under RED II below for more details).

[21] No details are publicly available on how to provide such evidence, or which evidence to provide.

For biofuels, both RED and RED II have had a clear orientation towards imports into the European Union. However, for imports of RFNBOs, some provisions in RED II are ambiguous. As an example, Art. 7 defines how to calculate the "gross final consumption of energy from renewable sources in each Member State", which is to be calculated as the sum of consumption of electricity, of energy in heating and colling, and of energy in transport. For transport, "renewable liquid and gaseous transport fuels of non-biological origin that are produced from renewable electricity shall be considered to be part of the calculation of energy consumption in the transport sector] [...] only when calculating the quantity of electricity produced in a Member State from renewable sources. In other words, the renewable electricity input to hydrogen production is to be counted as renewable energy consumption, not the consumption of RFNBO in transport. When it comes to import, this means that the electricity for producing RFNBO is consumed in the country of production and does not count towards the energy consumption in the importing country, which is in clear contrast to the provisions for biofuels. As a consequence, the Netherlands have legally excluded imported RFNBOs (both from other EU MS and from third countries) to be counted as renewable energy in transport. The amendment to RED II recently proposed by the European Commission has adjusted this provision in view of counting RFNBO consumption in transport rather than the electricity for their production (see section RED II Amendment below).

For the chain of custody covering the full transport and supply chain from fuel production to consumption, RED II defines that MSs "shall require economic operators to use a mass balance system" (Art. 30(1)). A mass balance system

(a) "allows consignments of raw material or fuels with differing sustainability and greenhouse gas emissions saving characteristics to be mixed for instance in a container, processing or logistical facility, transmission and distribution infrastructure or site.

(b) allows consignments of raw material with differing energy content to be mixed for the purposes of further processing, provided that the size of consignments is adjusted according to their energy content.

(c) requires information about the sustainability and greenhouse gas emissions saving characteristics and sizes of the consignments referred to in point (a) to remain assigned to the mixture; and

(d) provides for the sum of all consignments withdrawn from the mixture to be described as having the same sustainability characteristics, in the same quantities, as the sum of all consignments added to the mixture and requires that this balance be achieved over an appropriate period of time." (Art. 30(1)).

Other Pertinent Regulations

Based on the increased climate ambition of the EU in the framework of the "Green Deal", the European Commission officially introduced a legal proposal to amend RED II on 14 July 2021. This proposal is now in the legislative process in the European Parliament and in the Council.

RED II Amendment

The RED II Amendment [37] is a proposal by the European Commission, and as such is subject to changes by the European Parliament and the Council with the objective of a joint adoption. As such, the changes proposed in this amendment are to be understood as preliminary and subject to change.

RED II defines an overall EU target for renewable energy in transport of 14% by 2030 and requires MSs to put an obligation on fuel suppliers in order to achieve this target. The RED II Amendment changes this towards expressing the transport target as a GHG intensity reduction target of 13% by 2030. As biofuels are required by RED II to reduce GHG emissions by 50% to 65% depending on the commissioning date of the biofuels production plant, and RFNBOs need to demonstrate a 70% reduction, a 13% GHG reduction requires a significantly higher renewable share in transport fuels. In this sense, the 13% GHG intensity reduction target in transport of the Amendment is much more ambitious than the 14% renewables in transport target of RED II. As a side-note, the German transposition of RED II has defined a GHG intensity reduction target for Germany of 22% by 2030, while the target for 2020 was 6% (compared to a 10% renewable energy in transport target of RED for 2020).[22]

Furthermore, a dedicated quantitative sub-target for RFNBOs of a 2.6% share of renewable energy in transport in 2030 has been introduced.

In RED II, so-called multipliers are defined multiplying the physically consumed renewable energies for the purpose of calculating renewable consumption based on the objective to incentivize certain fuels, and to adjust certain inequalities. For example: "the share of renewable electricity shall be considered to be four times its energy content when supplied to road vehicles" (RED II Art. 27(2)). Recital 32 to the Amendment explains: "Expressing the transport target as a greenhouse gas intensity reduction target makes it unnecessary to use multipliers to promote certain renewable energy sources."

The definition of RFNBO is adjusted in the Amendment to: "renewable fuels of non-biological origin", thus eliminating the former focus on transport use of RFNBOs. This is also reflected in a new Art. 22a "Mainstreaming renewable energy in industry", which includes a new target for RFNBOs in industry: "Member States shall ensure that the contribution of renewable fuels of non-biological origin used for final energy and non-energy purposes shall be 50% of the hydrogen used for final energy and non-energy purposes in industry by 2030". Thus, use of RFNBOs is extended by the Amendment from transport to additionally cover industry. However, RFNBOs used as an intermediate product in the production of conventional transport fuels continue to be counted in the transport sector as in RED II.

The criteria defined for RFNBOs (see section RED II above for more details) remain unchanged, and will be detailed in a delegated act by the European Commission, which was due by the end of 2021. These criteria apply both the RFNBO use in transport and in industry, according to the Amendment.

While RED II counted the energy consumed in RFNBO production towards the renewable energy consumption in each EU MS, which has been a barrier to RFNBO import (see section RED II above), the amendment adjusts this towards counting RFNBO consumption: "Energy produced from renewable fuels of non-biological origin shall be accounted in the sector - electricity, heating and cooling or transport - where it is consumed." (Art. 7(1)).

The Amendment continues to prescribe the use of a mass balance system for the chain of custody of fuel supply from production to consumption.

[22] Germany has switched from a renewable energy in transport obligation on fuel suppliers to a GHG intensity reduction obligation in 2015. RED II allows MSs to define the obligation "*inter alia*, by means of measures targeting volumes, energy content or greenhouse gas emissions" (Art. 25(1)).

Hydrogen value chain and certification criteria

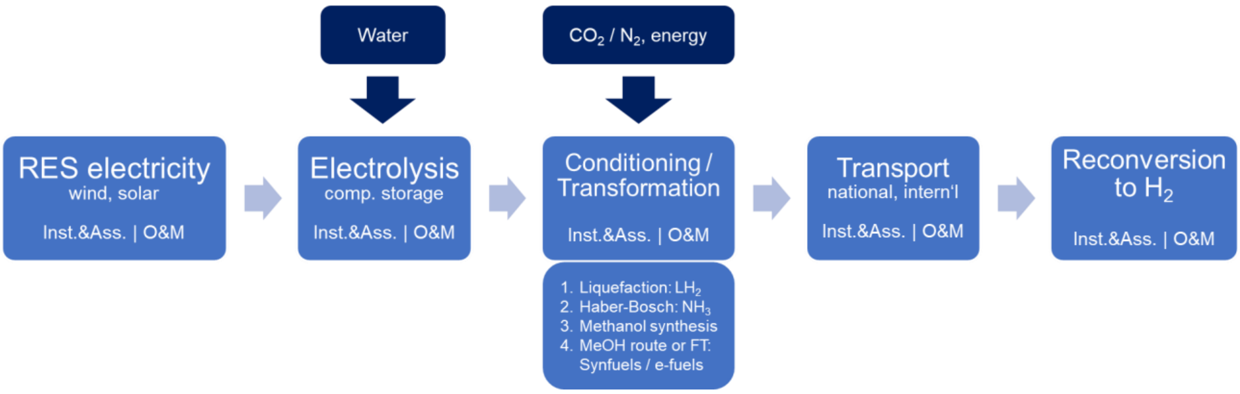
The hydrogen production and supply value chain consist of a number of individual elements from renewable electricity production towards hydrogen consumption. Hydrogen certification criteria and the certification schemes covering them are relevant to certain elements of the value chain, but may be less or not at all relevant to other value chain elements. An overview matrix of the relevance of each criterion for each element of the value chain gives guidance to project developers for preparing for future hydrogen certification.

In general terms, the value chain (see Figure 2Figure 1 below) includes renewable electricity production (notably wind or solar), hydrogen production (electrolysis) typically including compression and local storage, the conditioning (liquefaction of hydrogen) or transformation into hydrogen derivatives such as ammonia, methanol, synthetic fuels, etc., national and international transport, and possibly reconversion of derivatives to hydrogen in the target country. Auxiliary processes include water supply to electrolysis including potentially seawater desalination, the supply of energy to liquefaction, or nitrogen (N_2) production and supply to ammonia synthesis, or carbon dioxide (CO_2) supply (e.g. through direct air capture) to derivatives synthesis, etc. After transport to the target country, hydrogen derivatives may be used as fuels or as feedstocks, or they may be reconverted into gaseous hydrogen. This latter step is not a focus of this analysis as the focus is on the producing country, but it is covered here in more general terms for comprehensiveness. The end use of the product is not covered by certification in general. These value chains are described in detail in the GIZ-study "*Cuantificación del encadenamiento industrial y laboral para el desarrollo del hidrógeno en Chile"* [38].For this study, we explicitly cover water supply for hydrogen production as a separate element of the value chain as water supply may be relevant both in environmental and social terms in areas where water is scarce.

Each of the elements of the value chain can be subdivided for business purposes into several steps from planning to decommissioning of installations. For certification it is relevant to distinguish between the installation and assembly stage on the one hand, and the operation and maintenance stage of an installation on the other hand. Decommissioning will have similar impacts as installation and can thus be taken to be similar to installation and assembly, but in general is not covered by certification.

Other steps of a project lifecycle such as acquisition of installations, or manufacturing of installations are generally not covered by certification of hydrogen or other energy carriers. Nonetheless, it should be emphasized here that such elements of the value chain may have relevant impacts, see e.g. estimates of the GHG impact of electrolyzer manufacturing [39].

Figure 2: Hydrogen value chain



The following sections discuss the criteria presented in the chapters above which may or may not be relevant to the various stages of the hydrogen production value chain and are structured into four primary categories: Red II Criteria, CO_2 Sources, Environmental Sustainability Criteria, and Social/Economic Sustainability Criteria.

For each category, criteria are presented and analyzed with respect to the stages of the value chain shown in Figure 2 and are subsequently characterized as either "relevant", "potentially relevant", or "not relevant" to the respective value chain stage. If a criterion is not yet known to be relevant or not, it is considered "to be confirmed", or "tbc" (see below for further details). The results of this exercise are presented in a matrix at the end of the chapter (Table 16) where the relevance of the different categories and their criteria are summarized along the value chain.

Once a criterion is deemed relevant or possibly relevant, the certification schemes discussed in the chapters above can then be applied to the specific criterion depending on whether the schemes address the criterion.

This assignation of certification schemes is discussed further in the next chapter "Relevance of sustainability criteria by hydrogen value chain element".

Regarding the definition of "relevant", "potentially relevant", "not relevant", and "to be confirmed", the said parameters are evaluated upon the following definitions:

"Relevant" indicates that the criterion is relevant for this element of the value chain. This means for this study that the criterion is pertinent and that, in general, there will be related impacts that need to be assessed. As an example, water rights are in general of relevance for water supply to electrolysis.

"Potentially relevant" indicates that the criterion may be relevant depending on the specific circumstances of the project. In other words, there may or may not be impacts associated to this criterion; where impacts can be identified, these would then need to be assessed. As an example, soil protection may be relevant to water supply for electrolysis depending on the type of water supply, e.g. from ground water, from surface water or from seawater desalination.

"Not relevant" indicates that the criterion is not relevant in general; in exceptional circumstances there may nonetheless be impacts. As an example, water rights will in general not be a relevant issue for solar PV power plants.

"To be confirmed (tbc)" indicates that the relevance of this criterion is still to be confirmed. Here, this relates to criteria generally defined by RED II, where, however, more detailed provisions through delegated acts, which are still pending, will clarify the relevance to the respective value chain elements.

RED II Criteria

For RFNBO certification as 100% renewable, RED II defines four major criteria:

1. Additionality
2. Temporal correlation
3. Geographical correlation, and
4. GHG balance

These criteria have to be met and verified by certification.

Additionality

Additionality relates to the renewable power plants providing electricity to the hydrogen production unit. Certification thus has to cover both the power production installations and the hydrogen production installations. In case the delegated act defines additionality only in terms of the commissioning dates of renewable plant and hydrogen plant then the verification of this criterion should be simple. RED II defines that a renewable power plant must come "into operation after, or at the same time as, the installation producing the renewable liquid and gaseous transport fuels of non-biological origin" (Art. 27(3)). However, it should be noted that an exact definition of "coming into operation" is required in order to avoid ambiguities. The operation of both plant types is not subject to verification for this criterion.

Temporal correlation

Temporal correlation also relates to the renewable power plants providing electricity and to the hydrogen production unit. Here, installation and assembly are not subject to verification, but operation. It can be assumed based on general discussions and a draft excerpt of the delegated act leaked in March 2021 that temporal correlation needs to be demonstrated at a quarter-hourly temporal resolution, i.e. electricity must be produced and consumed in equal quantities for each quarter of an hour over the full year. However, the leaked draft also put forward an alternative option for fulfilling this criterion. This option would compare the share of renewable electricity production in each quarter of an hour to the annual average renewable electricity production share in this given electricity bidding zone two years before. Such a requirement would be easier to verify but would require official data for renewable electricity production from the transmission system operator. For both options, this criterion requires verification related to the operation of renewable power installations and hydrogen production installations. Installation and assembly are not subject to verification.

For the time being it is undefined whether electricity consumption of conditioning / transformation needs to fulfill this criterion of temporal correlation, or whether this only relates to hydrogen production. Conditioning / transformation may cover the production/synthesis of derivatives, the supply of nitrogen by an air separation unit (for ammonia synthesis), or the supply of carbon dioxide from direct air capture (for methane, methanol or liquid fuels synthesis) or the liquefaction of hydrogen. Installation and assembly of such systems are not subject to verification.

Geographic correlation

Geographical correlation is required in order to avoid the creation or aggravation of grid congestions in the electricity grid. The draft excerpt of the delegated act leaked in March 2021 suggests defining this in terms of bidding zones; electrolyser and renewables plant must be either in the same bidding zone, or in neighboring bidding zones in case there is official determination that there are no systematic grid congestions between the two bidding zones[23]. This criterion needs to be verified for the date of both installations coming into operation, but not for later dates of operation. For the time being it is undefined whether electricity consumption of conditioning / transformation needs to fulfill this criterion of geographic correlation, or whether this only relates to hydrogen production.

Greenhouse gas balance

The greenhouse gas balance criterion is at the core of certification according to RED II. It relates to the full supply chain from renewable electricity production to the point of consumption (generally defined as the excise duty point where transport fuels are put on the market). In this sense, all elements of the supply chain need to be audited for their GHG emissions related to hydrogen (RFNBO), and the contributions of all supply chain elements need to be combined to result in the total GHG balance. However, only the operation is covered, not installation and assembly of value chain elements.

CO_2 sources

In case criteria are defined for CO_2 sources for the synthesis of methane, methanol or liquid fuels, the verification of such criteria will be limited to the operation of CO_2 supply facilities. All other elements of the RFNBO value chain will not be affected.

Environmental Sustainability Criteria

It should be taken into account that Before the actual installation and assembly of the plant can begin, a planning phase must precede it with regard to all the criteria to be taken into account. In this planning phase, it is necessary to plan for and consider all criteria with regard to their requirements in terms of sustainability and certifiability, which are to be met at a later stage. An environmental impact assessment (EIA) is a good basis for ensuring during the project planning phase that relevant potential environmental impacts are identified[24]. Adjustments to the project can then be made to mitigate impacts in order to achieve a level that is acceptable. For additionally taking into account socio-economic impacts, an environmental and social impact assessment (ESIA) is appropriate (see chapter Social/Economic Sustainability Criteria below). In this regard, the International Union for Conservation of Nature (IUCN) has published a guidance note on ESIAs, describing the central elements to be considered within such a study, while pointing out that the basis of such an assessment "must be tailored to each project as the scope and depth of the assessment depend on the nature, complexity and importance of the issues emerging […]" [40].

Moreover, the planning phase requires the inclusion of all current and future relevant stakeholders in the form of discussions and consultations. It is essential to consider planning and environmental requirements under the

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[23] It should be noted that this criterion will be defined in view of the European situation. It is undefined for the time being how this could or should be applied to the electricity systems of countries outside Europe.

[24] Criteria and requirements of an Environmental Impact Assessment should be revised from their national specifications.

relevant jurisdiction. These requirements will vary depending on the type of project, site characteristics and constraints, and the relevant legislative framework. The local or federal agencies should therefore be contacted as early as possible in the project planning stage to understand what matters need to be addressed as well as whether any further approvals are needed beyond the planning and development assessment framework.

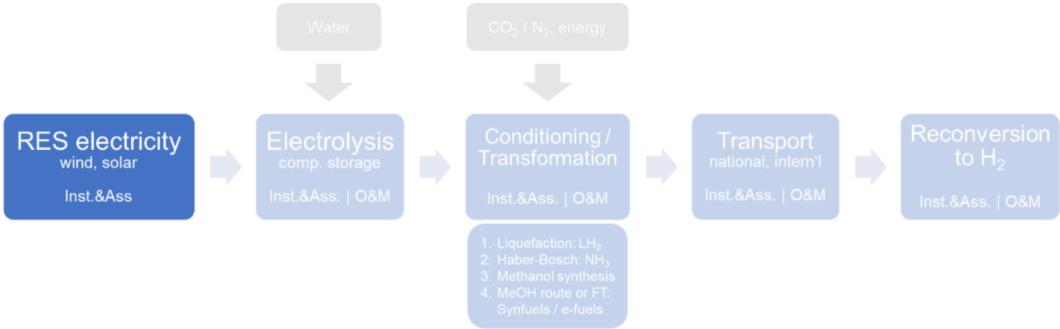
The following sections discuss the environmental sustainability criteria along the hydrogen production value chain. As discussed in Table 14 shows the specific environmental sustainability criteria analyzed in this study along with which considered certification schemes are possibly relevant to those criteria. This table can be used for reference as each criterion is discussed in detail below.

Table 14 Environmental Sustainability Criteria evaluated in study

Scheme	GBEP*	RSB	ISCC	CERA4in1	FSC	Fair Trade	REDcert
ENVIRONMENTAL SUSTAINABILITY							
Biodiversity Conservation							
Biodiversity	x	x	x	x	x	x	x
Natural Habitats, ecosystems	x	x		x	x	x	
High conservation value areas		x	x	x	x	x	x
Soil conservation							
Soil protection	x	x	x		x	x	x
Residues, wastes		x		x			x
Waste Management		x	x	x	x	x	x
Sustainable Water							
Water rights		x	x			x	x
Water quality	x	x			x	x	x
Water management, conservation		x	x	x	x	x	x
Efficient use of water	x	x		x		x	
Air Quality							
Air pollution	x	x	x	x			x

*GBEP is not a certification scheme, and it thus not included in the assessment of certifications schemes below.

RES and transmission – Installation and Assembly



Biodiversity Conservation

The 1992 Convention on Biological Diversity (Article 2) defines biodiversity as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems". [41]

Regarding the understanding of biodiversity, the installation and assembly of PV as well as wind parks represents a relevant factor for biodiversity, natural habitats and high conservation value areas. The construction may require removal of vegetation and surface grading across large areas of land. Furthermore, the construction of new wind or solar parks requires associated infrastructure and machinery such as access roads and heavy-duty vehicles, e.g. needed for the transportation of rotor blades for new wind turbines – modern onshore wind turbines have blade lengths of 60 to 80 meters. This can cause habitat loss, degradation and fragmentation, leading to a reduction in species richness and density. In addition, wind turbines are often installed in remote regions that have hardly been developed. Accordingly, this entails an additional effort with regard to the required infrastructure.

The significance of biodiversity impacts, however, varies depending on the level of degradation of the preexisting habitats, the geographic location of the project, and most notably on the local ecosystem with its species composition.

The effect of new transmission lines on the immediate environment depends on topography, land cover and existing land use. In forested areas, for example, the entire transmission line width is usually cleared and maintained free of tall-growing trees for the lifetime of the transmission line. The result is a permanent change of the transmission line land cover. For agricultural landowners, transmission line construction typically suspends the use of the land on a short temporary basis, as heavy vehicles move across the transmission line path.

Planners of a transmission line project may also be faced with a decision of whether to route construction through specially protected areas. In that case, the utility will need to allay concerns not only of private property owners, but local or federal government agencies as well.

In this context, sustainability schemes like RSB require an impact assessment and an adequate planned management process already during the planning phase.

Soil conservation

Soil conservation describes the protection of soil from erosion and other types of deterioration like reduced fertility caused by over usage, acidification, salinization or other chemical soil contamination [42]. The topic of soil conservation is also covered within the United Nations Sustainable Development Goals (SDGs). In particular, Goal 15 "Life on Land" promotes sustainable use of land and soils and the reversal of land degradation: "*Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss*".

The Joint Research Center (JRC) of the EU lists different types of threats to soil [43], namely soil compaction and soil sealing. Soil compaction describes a form of physical degradation resulting in the densification and distortion of the soil to an extent, that biological activity and permeability are reduced, and soil structure is partly destroyed. Soil compaction often is the result of the construction of larger facilities and can reduce water infiltration capacity and thereby increase the risk of erosion through accelerated run-off. Soil sealing on the other hand is described by the JRC as the loss of soil resources due to the covering of land for housing, roads or other construction work.

With regard to the installation and assembly of PV and wind parks, the aspect of soil protection is potentially relevant, with special regard to the aspect of heavy-duty vehicles required for the transport of the necessary components for the installation and the assembly of wind parks. As can be seen from the example of a standard *Vestas* wind turbine, such a turbine with a hub height of between 90 and 100 meters can weigh a total of over 300 tons. A single rotor blade makes up to 7 tons, whereas the nacelle alone comes to almost 70 tons [44]. This requires a corresponding infrastructure and machinery like heavy-duty trucks as well as special truck-mounted cranes with strengthened lattice booms capable of assembling the wind turbine. Furthermore, over the past 20 years, the average hub height of wind turbines has doubled [45], which means increased technical requirements together with larger and heavier machinery. This inevitably leads to higher strain on the soil.

In order to minimize negative impacts especially during construction phases, several measures can be taken into account in advance like limiting the number and speed of vehicle movements to, from and within the project area, especially during wet or winter periods, or prohibiting travel on unauthorized roads to protect existing vegetation and minimize soil inversion[25]. RSB for example defines the protection of soil structure as one of its minimum requirements criteria.

The treatment and management of residues or wastes can be considered as not specifically relevant for the installation and assembly phase for solar or wind parks. However, these aspects are covered in the EIAS.

Sustainable Water

The aspect of sustainable water can be considered as not relevant in this context. Although potential hazards to surrounding water resources may occur during construction and installation (fuel spills or other pollutants released into the environment during the construction process), no major risks are to be anticipated overall.

Air pollution

Among the impacts, a significant role is played by direct air emissions, particulate matter and trace gases, released by the machinery and equipment used during construction of the power plants, which temporarily affect the local air quality.

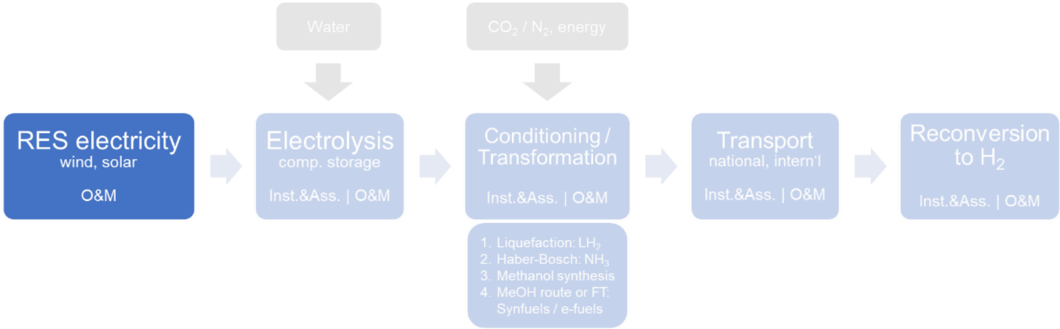
The relevance of air pollution differs between the installation of a PV park, where it is potentially relevant, and the construction of wind parks, where air pollution represents a relevant factor. This is related to the parks and their required components, their size, weight, and assembly. The components for a solar park, such as solar modules and their framework, can be transported on site by means of smaller transporters, which in turn have lower pollutant emissions. Wind farms, on the other hand, require much more powerful and therefor energy intensive vehicles and machinery for construction. The rates of exhaust emissions from construction equipment are notably determined by the type and size of the components to be installed, and, in connection with this, the engine size and power of the machines required for the construction, as well as their technological development. Engines of newer generations can have significant reductions in emission rates and fuel consumption. At the

[25] In the case of Chile, most of the impacts during construction and their respective mitigations are regulated in the environmental permits, "Resolución de calificación ambiental (RCA)". The administrative permit act of the Environmental Impact Assessment System

same time, the equipment replacement to newer generations is slow due to large initial investment and affordability for small to medium size contractors.

Air pollution criteria are defined in several voluntary schemes like, ISCC, RSB or CERA 4in1. These schemes mainly focus on the operation of installations, but the principles are also applicable to the phase of installation and assembly and the related air pollution through construction work.

RES and transmission – Operation and Maintenance



Biodiversity Conservation

Biodiversity conservation issues during operation and maintenance can be considered potentially relevant. Solar plants typically require some form of vegetation management under, and in the gaps between solar panel arrays, meaning during operation, vegetation may get lost or altered permanently. Unwanted vegetation is sometimes discouraged using herbicides, or by covering the ground with gravel to facilitate facility operations. In other cases, some form of vegetation cover is grown but mowed frequently to keep it short. Depending on the land use before the installation of the solar power plant, biodiversity impacts can both be negative or positive.

Wind turbines on the other hand may endanger birds and bats through collision with the turbines or with associated transmission lines, potentially leading to fatalities across a range of vulnerable species groups living in the nearby area. Also, transmission lines pose a potential danger of electrocution to birds and bats. It should be noted that wind turbines cover only a small portion of the land directly, while most of the land remains untouched.

A large concentration of wind or solar farms in combination with other developments can increase habitat fragmentation, create barriers for species movement and potentially cause cumulative impacts to species populations.

At the same time, however, the overall impact of solar or wind farms remains only potentially relevant, regarding the fact that those projects can also enhance biodiversity, as they are able to provide refuge for plants and animals, under the condition that they are properly taken into account already during the planning and construction phase.

This potential relevance also accounts with regard to transmission lines. As mentioned before, for agricultural landowners, transmission line construction typically suspends the use of the land on a temporary basis during installation, but once construction is completed, the fields are restored, and agricultural use can resume.

To ensure the sustainable deployment of a project, some certification schemes, such as ISCC, require that an environmental impact assessment report must be available, ensuring those environmental aspects have been considered and negative impacts have been kept as limited as possible.

Soil conservation

The topic of *soil protection* is potentially relevant for operation and maintenance. The required infrastructure for wind and solar parks as well as power lines can for example lead to land-cover change and soil disturbance which, in turn, can have an influence on natural habitats and ecosystems with particular concern in areas of high biodiversity value, meaning the soil may be temporarily or permanently altered, but in general without significant negative consequences for the ground.

Another aspect of potential relevance is *waste management*, like for PV parks. While renewable energy waste may be composed of less toxic substances than fossil fuel by-products, they still can be a hazard to the environment. According to the International Renewable Energy Agency (IRENA) [46], there is evidence that broken solar panels can release toxic pollutants, although their extent remains limited in general. In order to ensure renewable energy is utilized in a sustainable manner, this has to be taken into account as well as the fact that it is essential to find solutions to their disposal, which requires in the end a sound waste management. Ensuring good waste management practices and measures should be established in the planning and construction phase, and then carried through to the operational phase, like it is required by CERA 4in1 in its rules regarding Environmental responsibility.

Sustainable Water

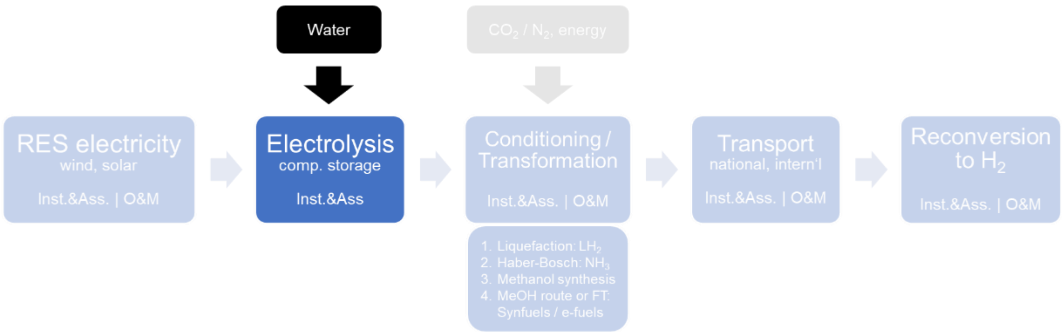
While the operation of wind farms is not relevant for aspect sustainable water, it may be of potentially relevant for PV farms with regard to *water rights*. This is related to the need for regular cleaning of PV modules. While installations in regions with enough annual rainfall mostly maintain their generation efficiency, installations in regions where rainfall alone does not remove contaminants, the panels must be cleaned additionally or more frequently. If these additional water resources are required, they have to be made accessible and available.

Water management or respectively the *efficient use of water* on the other hand are potentially relevant. The amount of water needed to remove contaminants should be used efficiently, especially given that solar modules are often located in very dry regions. The amount of water that is ultimately used can vary depending on how the panels are cleaned [46].

Air quality

The question of air pollution is not relevant for the operation and maintenance of PV and wind parks.

Production, Compression, local Storage – Installation and Assembly



The following part on production, compression and local storage discusses throughout the different sub-topics, and among other things, water supply as part of the production of hydrogen. This is why, the topic of water supply is separately highlighted besides the general aspect of electrolysis, compression and local storage.

Another aspect is that although water supply is necessarily related to the topic of water, a distinction is made between the effects of the construction and operation of the water supply (and its infrastructure) on biodiversity on the one hand, and the effects on aspects of sustainable water on the other. The decisive aspect for the allocation of each aspect is based on the respective sub-criteria.

Biodiversity conservation

Water supply represents a relevant factor for *biodiversity*, *natural habits* and *high conservation value areas*. The construction work for installing the necessary infrastructure for the extraction of local water resources can have effects on the respective habitats and the animals and plants living in them, including degradation and fragmentation of living spaces.

This also accounts for the construction works for desalination plants, where specific attention needs to be paid to potential impacts on marine biodiversity. The salt, minerals, and other compounds produced as a byproduct of desalination are generally discharged into the ocean as hypersaline brine. Brine is denser than the receiving ocean water and, depending on discharge methods, may settle on the seafloor and have adverse effect on marine organisms.

In both cases, the environmental impacts and the corresponding corrective measures must already be studied during the construction of these plants. This means also that starting from the study phase, the representatives of the communities that live near or within the catchment area of a possible plant location, should be included in the decision process that may affect these communities. The construction of such a plant also requires the consideration of the connections with the electricity grid and its possible environmental impact already during the planning phase.

The construction of hydrogen production installations represents a relevant factor for biodiversity, as it has the potential to damage natural habitats, threatening wildlife and plant species. During installation and assembly, habitat destruction may occur where a habitat is removed to make way for a new development. Plants and sessile animals in these areas are usually directly impacted generally resulting in alteration or reduction in biodiversity. As a result, animals retreat into remnant patches of habitat. Furthermore, there is the potential for noise from construction activities to disturb the surrounding environment, resulting in the relocation of animals and thus reducing the biodiversity of an area. However, it should also be noted that, an electrolyser installation can either be containerized for smaller capacities, or included in industrial buildings for larger capacities, meaning that the impact area is considerably smaller than the area needed for the RES.

RSB refers in the course of this to potentially preceding impact assessment studies and explicitly indicates potential negative impacts both inside and outside the operational site.

Soil conservation

The element of *soil protection* is potentially relevant. Its relevance depends for example on the size of the installation. New facilities for the production of hydrogen, meaning electrolysis, compression and storage, require adequate infrastructure and machines, which means associated implications are to be expected. This implies land consumption and soil sealing which in turn weaken plants, animals and microbes. However, this aspect also depends on the size of the facilities. Furthermore, these installations are more likely to be built near infrastructure that is already build and available, reducing the need of further soil sealing.

Waste and *waste management* are relevant criteria, as construction and demolition waste can contain a variety of substances such as concrete, bricks, wood, glass, metals and plastic. It includes all waste produced by the construction (or demolition) of buildings and infrastructure, as well as road planning and maintenance. This is why, a good waste management system has to be established so the waste can be separated properly, as it can contain small amounts of hazardous materials such as solvents and asbestos[26]. These in turn can pose particular risks to the environment and impede recycling. Therefore, ISCC for example demands a soil management plan aimed at sustainable soil management, erosion prevention and erosion control that must be documented.

Sustainable Water

Regarding sustainable water issues during the installation and assembly phase, questions concerning *water rights* are a relevant factor. If the water is gained from surrounding springs or groundwater, water rights must be settled before the construction of according to infrastructure. In general, each state and municipality will have regulations and limits to the extent of water diversion that may be permitted. Depending on local laws, the water resources might not be permitted for land irrigation or for commercial needs. These limits are intended to

[26] For more information, see demolition and hazardous materials (page 60-65) at https://4echile-datastore.s3.eu-central-1.amazonaws.com/wp-content/uploads/2020/11/07132233/The-Enviromental-best-Practice-Guido-to-Shutdown-Coal-Facilities-in-Chile.pdf

reduce the impacts that water removal could have on the surrounding environment. Some localities may allow for certain irrigation uses of the water and it may be possible to apply for water diversion rights that would allow for the transport of water away from its source. That would permit usage of the water for commercial purposes such as electrolysis.

In the case of desalination plants, local specifications must also be taken into account. These are generally not aimed at the extraction of local water sources, however desalination may require other types of rights, like it is the case in California, where an "ocean plan" is required, which includes requirements to ensure the construction and operation of seawater desalination facilities minimize negative impacts [47].

With regard to the impacts on the local population, higher standards as local or national environmental policies may be taken into account such as RSB, which requires that wherever a screening exercise has triggered the need for a Water Assessment, operators shall "define the use and share of water resources for operations in agreement with local experts and the community; any water-user committees shall be consulted." [48]

Besides water rights, *water quality* represents another relevant aspect, regarding water supply to electrolysis. This is primarily related to the interference in the water cycle resulting from the construction of the necessary infrastructure for water supply. This is particularly the case for the construction of desalination plants, which involves intervention both on land and in the coastal area, which can affect the surrounding water and its quality. The importance to avoid any potential contamination of the water resources is mentioned by several schemes. ISCC for example addresses the topic of water resources by stating that users have to assess and evaluate the use and recharge rates of the water source and set up water use plans to prevent water pollution, minimise and/or optimise the use of water and reduce wastewater.

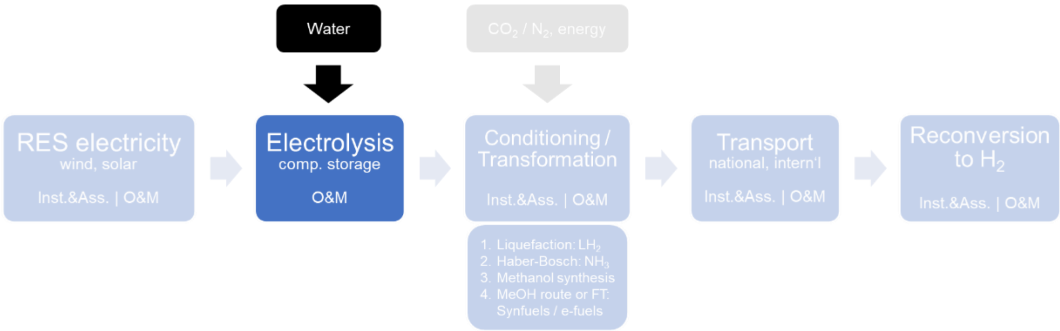
On the other hand, water quality regarding the installation and assembly of the electrolysis, compression and storage plant is of potentially relevant. The interference through the build-up of the required infrastructure can have an impact on the quality of the water, as potentially hazardous pollutants, in the form of fuel or construction substances, can leak into the surrounding water cycle during construction, but these are considered temporarily limited effects, not expected to cause any long-term damages [27].

Air quality

Air pollution issues are potentially relevant during the installation and assembly phase, due to reasons similar to the construction of new power parks, namely the direct air emissions in terms of particulate matter and trace gases, released by the machinery and equipment used during construction of the power plants, which temporarily affect the local air quality.

[27] Bodies of water are protected, there are standards to be met to assure no damages of water bodies. For more information see page 59 at https://4echile-datastore.s3.eu-central-1.amazonaws.com/wp-content/uploads/2020/11/07132233/The-Enviromental-best-Practice-Guido-to-Shutdown-Coal-Facilities-in-Chile.pdf

Production, Compression, local Storage – Operation and Maintenance



Biodiversity Conservation

Biodiversity conservation is a relevant factor for water supply during operation and maintenance, as it can affect *biodiversity*, *ecosystems* and *high conservation value areas* alike. Of particular concern are installations that are placed in or near areas recognized for their conservation significance, including sensitive breeding areas, important species migration routes, key biodiversity areas and protected areas. Where the production of hydrogen resorts to available natural freshwater resources, thus impacting aquatic or groundwater-dependent biodiversity and important ecosystem services. These impacts could include habitat loss, fragmentation and drying of water bodies or loss of groundwater-dependent habitats where large amounts of water are withdrawn for operations. Excessive groundwater withdrawal thus can reduce vegetation density and composition and contribute to the decline of endangered species.

The risk of contamination by brine disposal through desalination can also cause damage to the biodiversity of the marine ecosystem and land fauna, which might be either temporarily or permanently affected. This shows also the need to establish brine disposal management strategies as early as possible already during the planning phase, to limit negative environmental impacts and to reduce the economic cost of its disposal. Brine disposal includes discharging brine to sewers, surface water, injection wells, or sending it to environmental service providers.

The electrolysis, compression and storage of hydrogen is potentially relevant for the different aspects of biodiversity conservation. On the one hand, it must be considered that hydrogen is a flammable and explosive gas over wide ranges of concentrations. Storing pure hydrogen on site therefore requires engineering and safety protocols to ensure protection of the surrounding environment as well as workers and population, and the equipment. This is why in general a safety zone is created, which should be based on the results of a technical study conducted to assess risks of fire and explosion. At the same time, hydrogen is a volatile, non-toxic gas, which in turn poses a limited threat to the surrounding environment. In order to avoid unexpected problems, storage locations should be well protected, well ventilated, dry and separated from combustible materials. Ventilation for example becomes relevant in cases the oxygen generated during production is not used for other purposes. In such cases, ventilation systems are needed for air exhaust. The importance of a sufficient and constant ventilation is for example also mentioned by ISCC, to avoid the build-up of harmful vapours.

Moreover, they should not come in contact with sharp edges to avoid cracks and possible leaks. Overall, the conversion of variable renewable electricity into hydrogen incurs few environmental challenges. In general, hydrogen-storage solutions result in lower emissions than other energy-storage technologies, although their full lifecycle pollutants and GHG emissions depend on the primary energy source and power-production technology.

In order to address these issues, RSB for example requires an Environmental and Social Management Plan (ESMP) that helps to maintain ecosystem functions and services, such as biodiversity both inside and outside the operational site, on land which is directly affected by the operations.

Soil conservation

Soil conservation is potentially relevant. However, in case of desalination, wastewater and brine are produced, meaning an adequate waste management plan has to be established. The produced wastes by the desalination process have therefore to be discharged accordingly to existing national and local regulations opting in a preventive manner when there are options for the highest. In Chile, two foreign regulations are to be used instead of a Chilean regulation which is not existing yet regarding brine disposal.

Sustainable Water

According to the international water association, sustainable water systems should provide adequate water quantity and appropriate water quality for a given need, without compromising the future ability to provide this capacity and quality [49]. Otherwise said, this means an effective and holistic management of water resources. In addition to the management and efficient use of water, water rights must also be considered. This relates to the legal rights of property owners to access and use bodies of water adjacent to lands they hold.

The water supply for electrolysis is a relevant factor, as it can put strain on local water resources, which can create ecological change. In this context, it has to be noted that as far as hydrogen production is concerned water consumption results from the reaction equation for the production of hydrogen and is thus the same for all technologies. In general, water purification is necessary, which will lead to some rejected water of below 50% depending on the input water quality. This offers also the possibility to recirculate the wastewater into the purification system, or it may be used for other purposes. Nonetheless, the water requirement of electrolysis is a relevant factor to consider in an environmental impact assessment but is usually lower than for other low-carbon power generation technologies. Typically, around 8.3-18.7 liters of water are required per kg of hydrogen produced [50], where the lower value refers to deionized water while the upper value includes very high purification losses. Or put another way, NEL for example indicates for its high-pressure electrolyser P• 60 a rounded value of 10 l water per kg of hydrogen [51], which is confirmed by Cummins (former Hydrogenics). This information is also consistent with other studies such as the LCA study on Hydrogen Production from Non-Fossil Sources [52]. Per unit of energy produced this is a factor of 100 to 1,000 lower than typical water requirements for biofuel production [53]. As a sidenote in this context, sea water desalination requires an additional 0.13%-0.16% of electricity compared to the electrolysis process.

Besides the direct water consumption for hydrogen production, the water need for cooling also has to be taken into account. Cooling water consumption can, however, be largely avoided by using closed-loop cooling circuits. With a closed water circuit (similar to a car), there should be relatively little need for make-up cooling water. For a small electrolyser (like a container solution), Cummins indicates a flow rate of 15 m^3 of water per hour at full load. At a maximum hydrogen production of 60 Nm^3 per hour, this would be equivalent to 83 kg of water that have to be circulated in the cooling circuit [54].

Desalination on the other hand, bears the risk of contamination by brine disposal, affecting water quality and therefore damaging the surrounding marine ecosystem. An environmental impact assessment could try to identify and establish a minimum threshold below which alterations to the environment caused would not be acceptable, paying attention not only to the characteristics of the measures involved, but also to the environmental conditions [54].

In view of this, the question of *water rights* and therefore the amount of water granted for production also plays a relevant role. While the basic water rights have to be clarified already in the planning phase, during operation it must be ensured that water withdrawal does not exceed the prescribed quota, which would in turn violate the accorded rights. The importance for the respect of accorded water rights is underlined by several schemes like ISCC, RSB, REDcert or CERA 4in1.

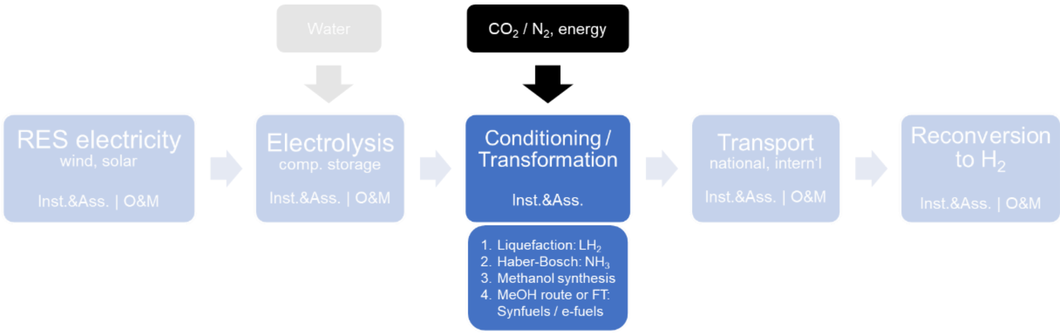
Once in operation, the production of hydrogen will be sustainable only if it promotes an efficient use of water on both the supply and the demand sides, which makes *water management* and an *efficient use of water* relevant as well. A sustainable approach in relation to water supply prioritizes measures promoting an efficient use of water and avoiding waste of water as far as possible. Effective water management will contribute to reducing water consumption and, consequently, reducing or avoiding the need for new water resources. Standards such as RSB therefore stipulate in their requirements that “operations shall not contribute to the depletion of surface or groundwater resources beyond replenishment capacities”.

Best practice mitigation measures, particularly efficient wastewater management and water conservation measures, should be applied at the facilities as they produce process effluents in the form of wastewater. For industrial utilities, this could include effective planning for water and wastewater systems to manage their operations and infrastructure and ensure the sustainability within the local communities.

Air quality

There are no relevant impacts on air quality in this phase.

Conditioning / Transformation – Installation and Assembly



Biodiversity

The process of conversion of hydrogen and the associated facilities typically requires removal of vegetation and surface grading across the required areas of land, comparable to the impacts mentioned for the installation of facilities for electrolysis, compression and storage. Therefore, the aspects of biodiversity can be potentially relevant for both the installation and assembly of the required infrastructure for the energy supply, as well as for the process of conditioning.

Nonetheless, attention has to be paid to the design and construction of the installations in order to reduce the likelihood and size of any leakages of hazardous substances. For example, it has to be ensured that the storage equipment, pipe work and connections conform to an approved technical and safety standard for the equipment.

Soil conservation

Soil protection is a relevant element in the conditioning and transformation phase. Similar to previous steps, this process requires larger facilities which goes along with greater soil sealing as well as soil compaction.

Residues and *waste management* are relevant too. Similar to the installation and assembly of the production facilities mentioned above, construction waste must be managed and disposed of properly. Therefore, an adequate waste management has to be organized beforehand, like it is required by all major sustainability schemes.

Sustainable Water

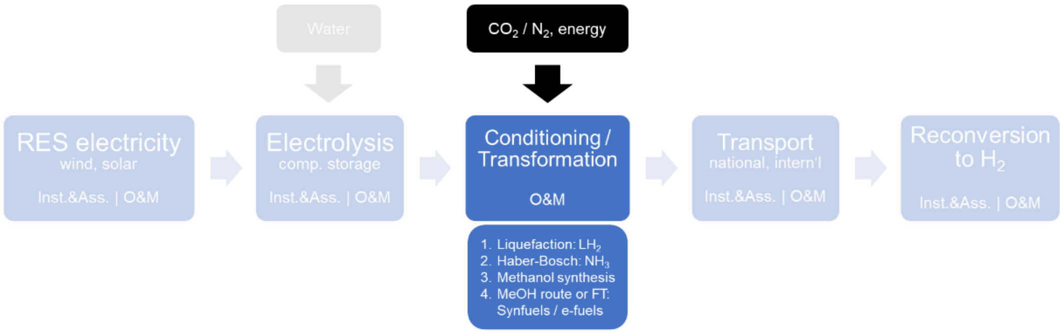
With regard to this context, *water rights* play a relevant role, as the conditioning and transformation process requires cooling water for subsequent operation. In order to be able to use the required water from the environment, corresponding water rights are required, which must be clarified in advance.

Securing *water quality* is potentially relevant for both energy supply, as well as for conditioning and transformation. Construction works may affect local water resources, but impacts remain limited overall.

Air quality

Comparable to the installation and assembly of other infrastructure, the issue of *air pollution* can be considered potentially relevant for conditioning and transformation.

Conditioning / Transformation – Operation and maintenance



8

Biodiversity conservation

Conditioning and transformation are relevant with regard to *biodiversity*, *habitats* as well as *high conservation value areas*. Of particular importance in this context are potential hazards to the environment from leakages of hazardous substances.

The various fuels and chemicals into which hydrogen can be converted, namely ammonia, methanol and synthetic fuels such as gasoline or diesel, can pose a threat to the environment and biodiversity. According to the internationally recognized GHS precautionary statements[28], these substances are classified as hazards for the environment, which is why the leakage of these substances should be prevented as best as possible. Diesel for example is classified as "Toxic to aquatic life with long-lasting effects" (H411), whereas ammonia is classified as "very toxic to aquatic life with long-lasting effects" (H410), [55] showing that both can represent a potential threat to the environment, as those chemicals damage ecosystems and plants with long-lasting effects. Due to their toxic properties, the substances can lead to changes in the species composition of biotic communities and to the death of individual species, even at low concentrations, which is why special caution has to be taken. It should be kept in mind that these substances also pose hazards to workers and population. In this sense, health and safety precautionary measures and the avoidance of environmental damages go hand in hand, as stated by ISCC while referring to ILO 138 and 182 saying that restrictions related to hazardous activities must be followed.

Soil conservation

Soil protection is relevant during conditioning and transformation, namely with regard to the danger of soil contamination. It describes the occurrence of pollutants, particularly man-made chemicals, in soil above a certain level, which leads to a deterioration in or loss of one or more soil functions. This is a potential danger in case of leakages. These leakages are both relevant for the supply of feedstocks (N_2, CO_2) for the transformation, as well as substances produced during the transformation.

Industrial and commercial installations where substances hazardous to the environment are handled as well as sites where waste is treated or disposed of, can therefore pose a threat to soil. If the soil is contaminated in such a way that it becomes hazardous to human health or the environment, these sites are referred to as contaminated sites. Mitigation measures for soil conservation can be mechanical measures, like permanent and semi-permanent precaution structures which should be installed as a precaution in case of emergency [57].

The aspects of *residues* and *waste management* are not relevant for this part.

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[28] The GHS precautionary statements are part of the 'Globally Harmonized System of Classification, Labelling and Packaging of Chemicals' of the United Nations and is a globally uniform system for the classification of chemicals [56].

Sustainable Water

Water rights are a relevant aspect as a result of the water demand like for cooling purposes. In this context, it is necessary to comply with the granted water rights and not to exceed the conceded quantities.

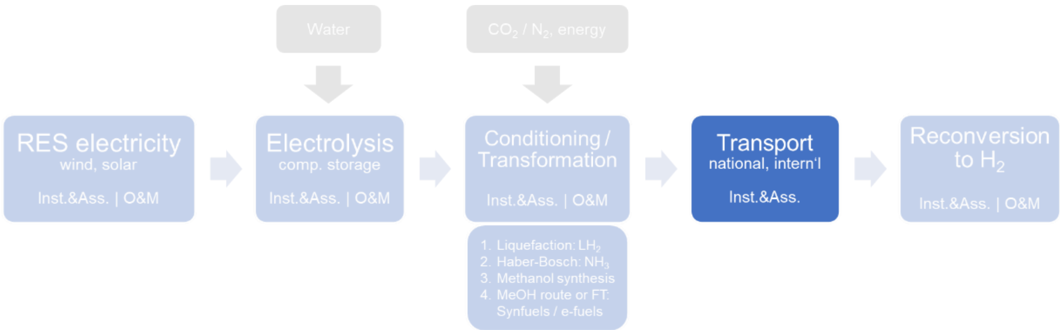
During the operational phase, the criterion of *water quality* is another relevant aspect to consider. If pollutants escape as a result of leakages, they can contaminate ground and surface waters such as rivers, lakes or the sea. For example, in water, nitrogen leakages can lead to the formation of nitrogen-based compounds such as salts and esters.

Likewise, in the case of leakages, the end products of the transformation have a negative impact on water quality as previously described under the aspect of biodiversity.

Air quality

Air pollution is a relevant factor in the operation and maintenance phase of conditioning and transformation. Numerous ecological implications and health risks can be associated with industrial air pollution. The leakage and therefore emission of toxic gases such as ammonia or methanol, can result in respiratory disorders. Ammonia gas for example has similar properties as air, so in case of leakages, ammonia rapidly dissipates into the atmosphere. However, unlike hydrogen, ammonia is not typically explosive. It is a hazardous chemical and it must be handled with care, due to its causticity and toxicity. The liberation of such gases can also cause implications both on human health as well as the ecological balance. This is why for example RSB sets the minimum requirement that “the operator shall investigate and, whenever possible in the local context, implement Best Available Technology (BAT) to reduce air pollution, appropriate to the scale and intensity of operation”.

Transport – Installation and Assembly



Biodiversity

The ecological impacts of the installation and assembly of transport infrastructure, namely the construction of roads and railways, are relevant for *biodiversity*, *natural habitats* and *high conservation value areas*, both regarding national transport and international shipping. The construction of new roads for example often results in deforestation that results when the road makes a remote forested area more accessible.

This relevance also accounts for the installation of a pipeline infrastructure. Pipeline construction consists of acquisition and clearing the Right of Way (RoW) - felling of all trees and the open-cut method requiring use of excavators and other earth-moving equipment. This leads to negative consequences like habitat displacement or deforestation as the RoW clears all vegetal cover along its stretch.

Moreover, the construction of both, roads and pipelines, requires the permanent alteration of the landscape with direct impacts in terms of potential destruction of habitats, disturbance, and fragmentation, which has to be taken into consideration already during the planning phase. Noise and light generated during the construction processes on the other hand may not directly harm individual animals but can affect feeding and breeding behaviours. The materials used and their processing and production should also be taken into account, as the construction of the according infrastructure requires materials like gravel or iron ore, which are potentially harmful to the environment. This is why ISCC for example requires an environmental impact assessment in order to keep impacts as little as possible.

A more sustainable infrastructure would consist of a strategically planned set-up. This requires a wider look into remote, rural and urban areas, and connections between them in order to facilitate movement of species for example. In order to realize these measures, they need to be taken into account already during the planning phase.

According to the European Environment Agency (EEA), mitigation measures of transport infrastructure construction could for example include planning the timing of infrastructure maintenance and construction work in order to avoid particularly sensitive periods, providing crossing structures, or reducing noise and visual impacts through walls, berms or adapted paving [58].

In the case of rail and road networks, the route proposal could also be changed to leave larger areas untouched and to avoid landscape fragmentation. Similarly, tunnels or nature bridges could be planned and built to increase connectivity between protected areas and facilitate the movement of animal populations.

With special regard to international transport, the topic of port construction and development must be taken into account, as it has often been detrimental to seashore ecosystems.

Soil conservation

Soil protection is potentially relevant, as the construction of roads requires heavier equipment, causes light and noise pollution, but with an overall impact remaining limited in general.

Residues and *waste management* are a relevant aspect, in view of the fact that the construction of transport infrastructure like roads generates waste resulting from activities such as foundation works, site clearing, excavation, or also during material delivery. This applies to the development of national as well as international systems, which requires an adequate infrastructure to enable the transition from the national level to the international level.

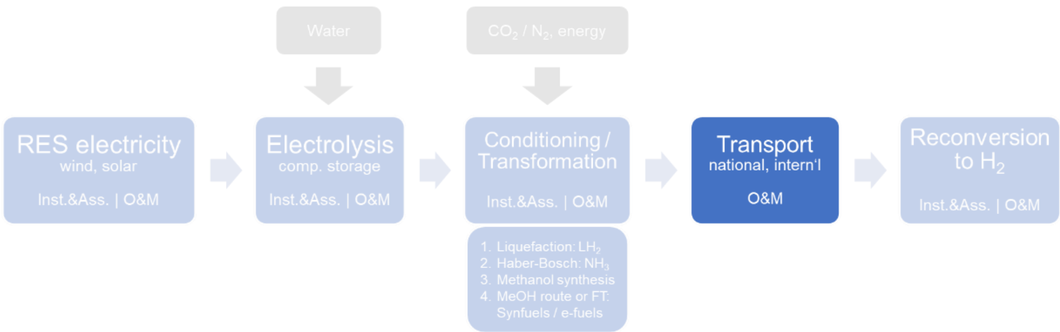
Sustainable water

The criteria of sustainable water can be considered not relevant for the installation and construction phase in relation to transport. Even though fuel spills or residues from road construction can affect the surrounding water resources, their impacts remain usually limited.

Air pollution

During the construction phase, *air pollution* occurs as a result of the construction and the transport of heavy goods vehicles, but this is considered to be only potentially relevant as it is restricted to a relatively short period of time.

Transport – Operation and Maintenance



Biodiversity

The impacts of transport operations represent a relevant issue for all aspects of biodiversity. The impacts on wildlife can be broad and include the loss of habitat, traffic casualties, creation of physical barriers, disturbance by light and other visual cues, spread of chemicals and dust, changes in hydrology and microclimate and accidental spills. Permanent infrastructure, such as roads, alter ecological conditions, cut through natural habitats, and consequently reduce populations of many wildlife species. Particular attention should be paid to the fact that those impacts extend beyond the actual construction site into the surrounding landscape, with the zones ranging from a few hundred meters up several kilometers, which can lead to habitat degradation and reduced wildlife densities within an area that is larger than the actual road or railway corridor. For some species, this leads to restricted movements, increased mortality and avoidance of a zone around the infrastructure. As a result, local species abundance may decline in the proximity of infrastructure and increases with distance from the infrastructure until levelling off at a certain threshold distance.

The physical obstruction caused by pipelines as another form of permanent linear infrastructure can also alter animal movement across landscapes, as well as resource availability and habitat structure, although the impacts caused here can be considered lighter.

For international shipping, the issue of noise disturbance plays a relevant role, as large cargo ships generate significant amounts of noise. Their hulls tend to amplify the mechanical noise from the engine and propellers. Due to its low frequency, this type of noise propagates very far in water and disturbs marine life. Research indicates that whales and other species that communicate and orient themselves through sound are particularly affected [59]. Oil spills or the release of hazardous substances at sea represent another element that can cause considerable damage to marine life and therefore has to be taken into account.

In order to better understand the (long-term) impacts on biodiversity and make them more visible, ISCC calls for evidence which should analyze the biodiversity status of the area, including (historical) remote sensing imagery of the areas, including satellite or aerial photographs, land use maps or vegetation maps.

Soil conservation

Soil protection is potentially relevant for national transport, whereas it is not relevant for international shipping. Regarding the national level and the local transport infrastructure, roads represent a permanent alteration of the ground conditions, just as it is the case for pipelines, even though the impact here is less severe. Overall, these impacts are limited to a narrower area nearby the transportation infrastructure, meaning that no larger surrounding area is affected.

Another risk in transport is the contamination of surrounding soils through abrasion and fuel spills, which can affect the soil, even though impacts are limited.

Sustainable water

The impact on *water quality* with regard to national transport usually remains potentially relevant through individual fuel losses and abrasion.

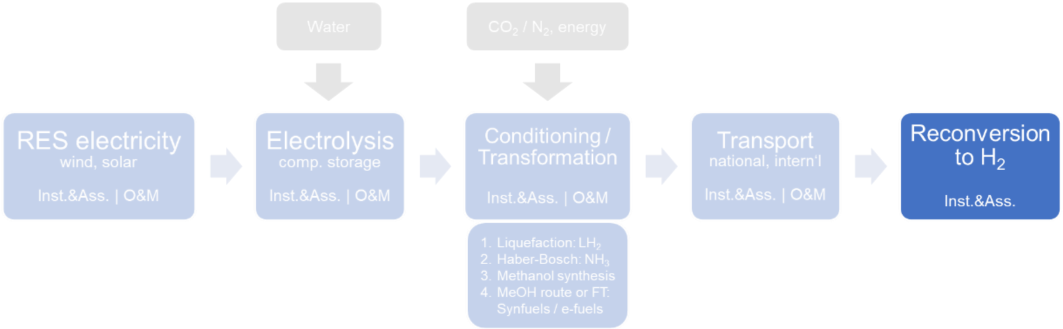
Air quality

Air pollution can be considered relevant for both national and international transport. Road transportation, representing one of the main means of transporting cargo, causes the release of pollutants, which can spread beyond the reach of the transport networks themselves. This can contribute to background concentrations of particulate matter, ozone and nitrogen dioxide, affecting people, plants and animals. Some areas, including mountainous regions, coastal zones and seas, can be particularly vulnerable to pollution from transport. With regard to pipelines in connection with air pollution, it must be taken into account that this type of transport requires hydrogen compression, which is generated by means of compressors. These in turn require energy from electricity or combustion engines, which can have a corresponding impact on air quality.

Transport corridors through valleys or along large rivers in general exert pressure on unique ecosystems. Certain pollutants, such as ground-level ozone, are known to lower crop yields, affect tree growth and cause acidification in lakes. Especially cargo ships used for international transport use highly polluting fuel and emit various pollutants along with CO_2 including black carbon, Sulphur dioxide (SO_2), nitrogen oxides (NOx) and nitrous oxide (N_2O).

Aside from combustion, the progressive wearing-out of types and brake pads can be identified as a relevant source of particulate emissions. Even though, the sustainability schemes do not necessarily always refer to air pollution in relation to transport, the minimization of air polluting emissions can be found as a requirement in almost every scheme, stating that efforts should be made to reduce fossil energy consumption and thus lower greenhouse gas and air pollution emissions.

Reconversion of Hydrogen – Installation and Assembly



Biodiversity Conservation

The reconversion of derivatives into hydrogen in general consumes energy. The installation and assembly of the energy supply needed for the reconversion of hydrogen is a relevant factor regarding the different aspects of biodiversity, similar to the installation and assembly of renewable energy parks. Energy transmission infrastructure can lead to fragmentation of natural habitats, ecosystem destruction and depletion of ecosystem services. The determining factor is whether the energy provided for supply comes from existing plants or whether new wind and PV plants are installed for this purpose, which would raise the same issues as discussed in the relevant section above on the installation of new renewable power plants. Similar to the installation and assembly phase of solar and wind parks, an impact assessment and adequate planned management processes, as required by RSB, should be implemented during the planning phase.

The installation and assembly of facilities for the reconversion of hydrogen are also a relevant aspect to consider. This is primarily due to the fact that setting up the relevant installations requires considerable construction work, with parts of the facilities requiring heavy machinery and equipment. This can have a corresponding impact on the surrounding biodiversity, ecosystems and nearby high conservation value areas in the form of noise and air pollutants. Similar to the operation and maintenance phase for conditioning and transformation, an Environmental and Social Management Plan, as brought forward by RSB, can apply here.

Soil Conservation

Soil protection is for both energy supply and reconversion of hydrogen potentially relevant in the installation and assembly phase. The potential issues are comparable to those mentioned for the buildup of wind and solar plants, namely soil compaction due to heavy machinery and materials, and soil contamination from leakages or fuel spills.

The required infrastructure for the energy supply such as powerlines can lead to land-cover change and soil disturbance which, in turn, can have an influence on natural habitats and ecosystems with particular concern in areas of high biodiversity value, but these impacts are overall limited.

Residues and *waste management* represent a relevant factor. Although no particularly dangerous waste is generated, it is necessary to establish an appropriate management of construction waste generated in the course of installation and assembly works, as construction waste generally poses risks to the environment.

Sustainable Water

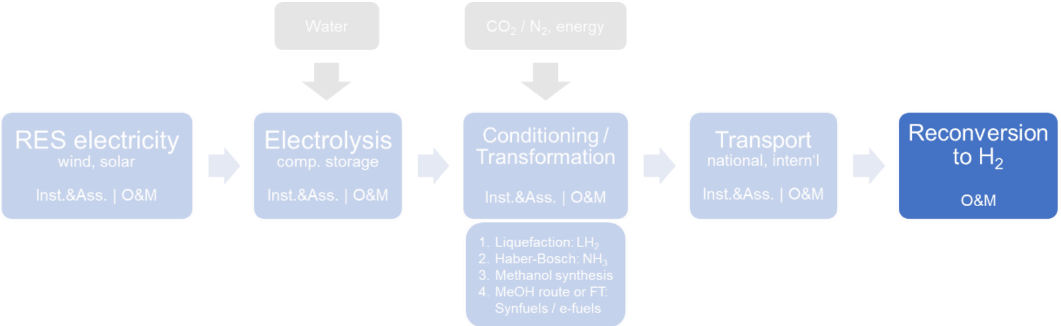
Water rights play a relevant role in this context, as the process of reconversion of hydrogen requires cooling water for subsequent operation, which has already to be taken into account during the planning phase. In order to be able to use available water resources corresponding water rights are required, which must be clarified in advance of the construction.

Water quality is potentially relevant for both energy supply and the reconversion process. Although potential hazards to surrounding water resources may occur during construction and installation (fuel spills or other pollutants released into the environment during the construction process), no major risks are to be anticipated overall.

Air Quality

Air pollution is potentially relevant, comparable to other installation and assembly work phases. The rates of exhaust emissions from construction equipment are notably determined by the type and size of the components to be installed. This accounts for both the energy supply as well as the installation and assembly of facilities for the reconversion of hydrogen.

Reconversion of Hydrogen – Operation and Maintenance



Biodiversity Conservation

Once in operation, the energy supply for reconversion to hydrogen is potentially relevant for the different biodiversity aspects. What needs to be considered is the trajectory and impact of transmission lines. Here, even after commissioning, attention should be paid to ensuring that this does not have too great an impact on habitats.

The reconversion of hydrogen is a relevant factor for the consideration of biodiversity and shows very similar elements as described before for conversion, namely the potential risks to the environment from leakages of hazardous substances being treated on-site. Ammonia is one of the main sources of nitrogen pollution, alongside nitrogen oxides. As mentioned previously, one major effect of ammonia pollution on biodiversity is the impact of nitrogen accumulation on plant species diversity. Beyond that, noise and light pollution can occur for the surrounding environment affecting wildlife.

In addition, the special requirements for transport and delivery for large quantities of substances such as liquid hydrogen, methanol or ammonia must be taken into account. Transport by ship requires an appropriate infrastructure in the form of a port and facilities capable of accepting and loading the substances. Accordingly, additional issues for the immediate (maritime or inland waterway) environment can come up. In this sense, safety precautionary measures and the avoidance of environmental damages have to be taken into account. Similar to the conditioning and transforming phase, restrictions related to hazardous activities must be followed as stated for example by ISCC.

Soil Conservation

Soil protection represents a relevant factor, as the reconversion of hydrogen bears the danger of soil contamination, meaning the occurrence of pollutants and chemicals in case of leakages which can lead to a deterioration or the loss of soil functions. Industrial and commercial installations, like it is the case for reconversion installations, where substances hazardous to the environment are handled, can pose a threat to the soil. Requirements with regard to soil protection is made by several schemes like RSB, which addresses these issues of soil protection in its principles, saying that "operators shall implement practices to maintain or enhance soil's physical, chemical, and biological conditions".

Waste and residues on the other hand are not produced in such quantities to be considered relevant at this point.

Sustainable Water

Sustainable water issues are not relevant during operation and maintenance regarding energy supply.

However, it is relevant regarding the reconversion of hydrogen in relation to *water rights* and *water quality*. Water rights are relevant with regard to the cooling demands of the facilities and must not be exceeded. With regard to the water quality, the situation is similar to the conversion of hydrogen, as the derivatives of hydrogen can affect water quality if they get in touch through leakages, either through direct contamination of rivers or lakes, or by entering soils with subsequent migration into groundwater. These aspects are addressed for example by ISCC in its principle on the environmentally responsible production to protect soil, water and air.

Air quality

Air quality can be judged not relevant for the operation and maintenance of the energy supply.

On the other hand, it represents a relevant factor for the reconversion of hydrogen during operation. Similar to the production of hydrogen derivatives, numerous ecological implications and health risks can be associated with industrial pollution as well as leakages and the emission of toxic substances that may occur during operation. The different aspects of air quality are, similar to the previous paragraph, also addressed by the ISCC principle.

Social/Economic Sustainability Criteria

The Social/Economic Sustainability Criteria aim to ensure that the operations contribute to the social and economic development of local, rural and indigenous people and communities. The scope of the word “Local” is not defined in certification schemes or regulations. This lack of a global definition could be a potential obstacle for certification. For this study, “Local” is considered to be any area within the influence of a project. In this sense, there are companies such as Anglo American whom in their Socio Economic Assessment Toolbox (SEAT) of their operations in Chile consider as “Local” the administrative districts (in Spanish “comunas”) where the projects are located, i.e., for instance, for “Los Bronces” mine SEAT, the districts of Lo Barnechea, Colina, Til Til and Los Andes are considered [60]. The term “Local” does not apply on a country level.

The following sections describe the social/economic sustainability criteria analyzed in this study for each segment of the hydrogen value chain considered, highlighting those criteria which may be relevant for hydrogen certification. The specific criteria discussed, as presented in section Other pertinent certification schemes, along with which certification schemes may be applied for the corresponding criteria, are shown in Table 15. This table may be used as reference for determining which schemes may be applied to which criteria as they are further discussed in the next sections.

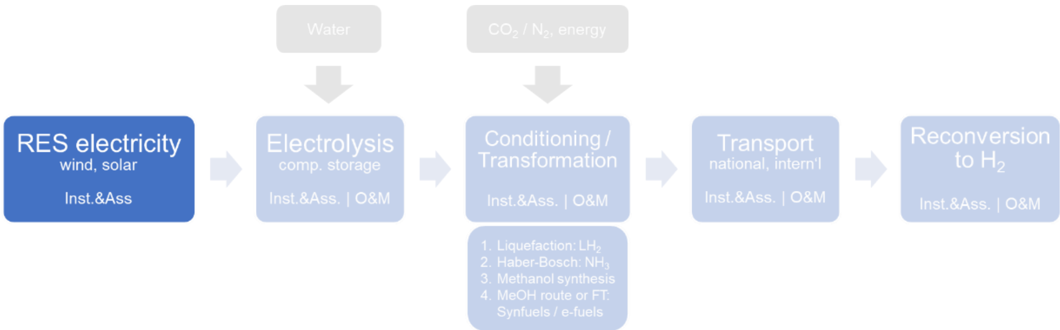
Table 15 Social/Economic Sustainability Criteria evaluated in study

Scheme	GBEP*	RSB	ISCC	CERA4in1	FSC	Fair Trade	REDcert
SOCIAL/ ECONOMIC SUSTAINABILITY							
Community Development							
Local infrastructure and services development	x	x			x	x	
Increase in energy access	x	x					
Local economic development and employment	x	x	x	x	x		
Local professional skills training and education		x	x	x	x	x	
Social Impact							
Social Impact Assessment	x	x	x	x	x		
Indigenous peoples’ rights		x	x	x	x	x	
Lands right issues	x	x	x	x	x	x	x
Labor & Safety							
Working conditions	x	x	x	x	x	x	x
Contracts		x	x		x	x	x
Health and safety		x	x	x	x	x	x

**GBEP is not a certification scheme, and it thus not included in the assessment of certifications schemes below.*

It is worth noting that all labor condition criteria are considered relevant as they address the rights of workers involved in the installation, assembly, operation, and maintenance of all value chain phases, therefore labor conditions are not specifically covered in the following sections individually. Of the certification schemes considered in this study, all cover the base requirements for labor condition criteria, with some schemes covering to a greater extent this topic (for instance Fair Trade, which is focused on working conditions). Minimum requirements for labor conditions are generally required by means of country ratification of the fundamental conventions set forth by the International Labor Organization (ILO) [61]. For instance, in Chile, the ILO's fundamental conventions have been ratified, meaning in principle, proper labor conditions must be met in the development of projects regardless of certification.

RES and transmission – Installation and Assembly



Community Development

Within the scope of community development, *local infrastructure and services development* during the RES and transmission installation and assembly phase is deemed as a relevant criterion as local communities may benefit from the new construction or improvement of construction roads converted to permanent roads for local use, construction of clinics, schools, etc. The ideal sites of many solar PV and wind parks are in rural areas where basic infrastructure is often in poor condition or non-existent. Local infrastructure development plans to go alongside project construction can improve affected communities' well-being, contributing to the public acceptance of the project. It is important that collaboration is established between the RES companies and local authorities in order to establish alliances on behalf of the SDGs.

As 2019, almost 30.000 households in Chile do not have access to electricity or only have partial access (some hours of the day) [62]. It is considered that the criterion of *increase in energy access* is relevant to provide electricity supply to families who do not currently have access or to improve the current supply in case it is partial. Due to the location of RES plants, electricity is generally supplied by generators during the construction stage. Although during the construction stage it is difficult to increase energy access in nearby localities, the project developer must consider during this stage the necessary works so that during the operation and maintenance (O&M) stage the local community can be supplied with energy. These works generally consist of the extension of the distribution network or an isolated solution, as in the case of ACCIONA Energy's El Romero Solar PV Plant, where, for example, solar panels are donated [63]. Of the schemes addressed, RSB and GBEP mention directly *increase in energy access* as a relevant criterion.

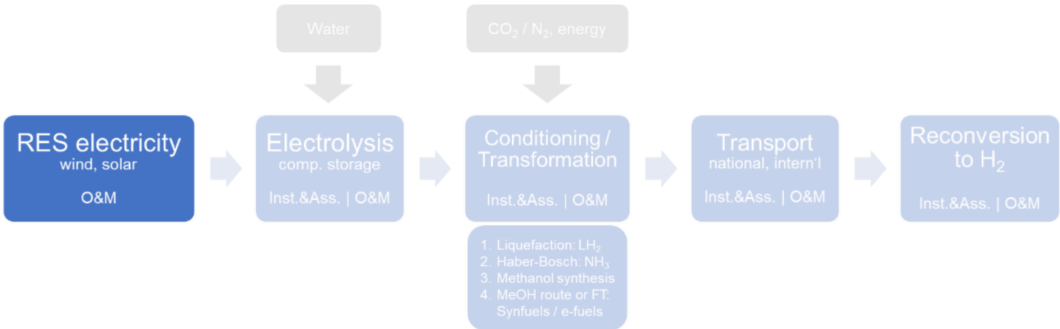
Local economic development and employment is considered as a relevant criterion as construction of PV and wind farms as well as transmission lines may make use of local labor and contractors, as well as purchase regional supplies. Certain RES developers have developed sustainability policies touching on these topics, such as renewable energy company Scatec, whose sustainability policy states "We use a significant component of local labor, professionals and contractors in all our projects." [64] A positive impact on the economy during the construction of RES and Transmission can be triggered indirectly though the creation of local businesses to provide basic services such as food and accommodation for workers.

The *professional skills training and education* criterion is considered possibly relevant as it will depend on the level of worker training required for RES and transmission construction. Generally, for the construction of this type of plant, no further specialization or training of construction workers is required. However, skills training can be incorporated into social initiatives independent of the construction and assembly of the RES plants, for instance during the development of ACCIONA Energy's El Romero Solar PV Plant in northern Chile, funding was allotted for the training of technicians on the installation and maintenance of photovoltaic panels in the city of Copiapó and grants were given to 48 students for development [63].

Social Aspects[29]

Social aspects criteria take relevant roles in the installation and assembly of solar PV and wind farms and transmission infrastructure as construction of these components directly affect the social wellbeing of communities within the area of the project's influence. The *Social Impact Assessment (SIA)* is a relevant criterion as it is a process of evaluation, planning and management of the social change or consequences arising from project development. Certifications schemes such as RSB, ISCC, CERA4in1 and FSC include a SIA in their minimum requirements. Encompassing other socio-economic criteria evaluated in this report, the SIA is used to predict and mitigate negative impacts and identify opportunities to enhance benefits for local communities and broader society [65]. For the installation of PV and wind parks and transmission lines, key social impacts may include public acceptance of the project with regard to physical alterations of the landscape, devaluation of aesthetic and cultural land value, or *land rights* violations and issues. A SIA may be able to identify the proper implementation of visual landscape planning to protect natural beauty or cultural heritage sights, optimizing project construction locations to minimize public resistance and negative attitudes towards the project [66]. It must also address *indigenous people's rights* who may have legal and cultural rights to lands in the project's influence.

RES and transmission – Operation and Maintenance



Community Development

Local infrastructure and services development is not considered as a relevant criterion since the infrastructure will be developed during the construction stage and the relevant service associated to RES and transmission is electric power, which is covered in the criterion analyzed below.

A relevant community development criterion for the operation and maintenance phase of RES and transmission is regional *increase in energy access* for decentralized use of electricity. With the construction of new RES and transmission lines, a certain portion of generated electricity may be allocated to surrounding communities which may not have or may have limited access to electricity. This not only can help electrify rural areas, but also contribute to regional energy independency and diversification and/or security of regional energy supplies [67].

Possibly relevant criteria depending on the amount of labor required for RES and transmission O&M may be *economic development and employment*. In general, the number of jobs created by a RES and transmission O&M is not significant compared to those required at the construction stage, however, the impact of this employment on the community will depend on the number of people employed and the characteristics of the community where the project is located. In case of wind power plants, local jobs are not generally used for maintenance because maintenance is very low and the specialist personnel can attend several plants in the

[29] Depending on EIA of the country, social aspects may be part of the assessment criterium to be analyzed, as e.g., occurs in Chile.

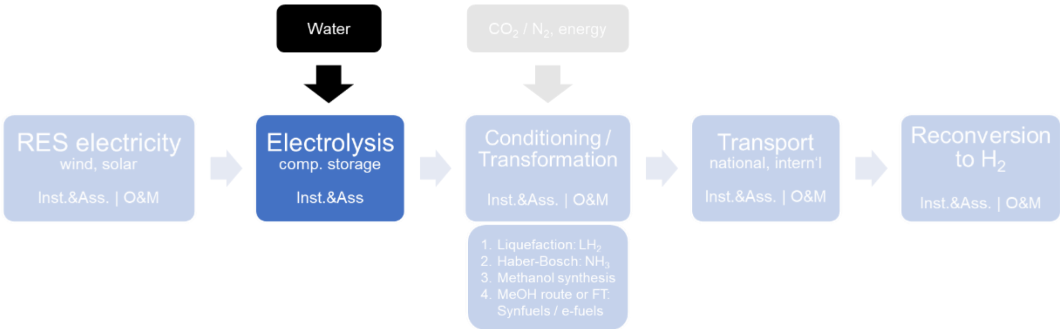
region; nevertheless, this can still lead to economic development in the community through indirect services that these personnel will need during their visits to the plant as accommodation and food.

In case of *local professional skills training and education,* these criteria may depend on the local hiring of operations and maintenance personal or can be part of wider scope project development scheme, therefore it is considered a possibly relevant criterion.

Social Aspects

For the operation and maintenance phase of RES and transmission, the social aspects criteria evaluated were considered relevant as once the plant is in operation, it is important to monitor the management measures proposed in the SIA and their compliance must be communicated in a timely manner in regular meetings with various social actors. Good practice in this regard is to conduct surveys in the communities in the area of influence to ascertain their perception of the project. With the results of monitoring, the plans proposed in the SIA should be adjusted annually. An example of continual social relation monitoring is InterEnergy Holding's (IEH) wind farm project in Penonomé, Panama, where a dedicated community relations coordinator carries out stakeholder analysis, annual stakeholder meetings, monthly bulletins to share news of the projects social and environmental activities, and grievance mechanism monitoring.

Production, Compression, local Storage – Installation and Assembly



Community Development

In Chile currently 47.2% of the non-urban population do not have formal access to drinking water [68], which is why the *infrastructure and services development* criterion is deemed as relevant for the installation and assembly of the water supply systems because it may benefit communities that currently do not have access to this resource. For instance, the company Hero Future Energies (HFE), with their operation in Rajastan-India, had initially planned to provide local residents with electricity but a community needs assessment led to the realization that water access was a greater concern. To address the issue, HFE set up a solar-powered water automated teller machines (ATMs) program, enabling rural access to clean drinking water. HFE tested out the approach in Rajastan and is now replicating the model in two other states near its sites In the case of electrolysis, compression and local storage, during installation and assembly the infrastructure and services development is deemed as a potentially relevant criterion as local communities may benefit from the construction of new infrastructure like schools, health services, roads, among others.

Increase in energy access is not relevant for this part of the value chain.

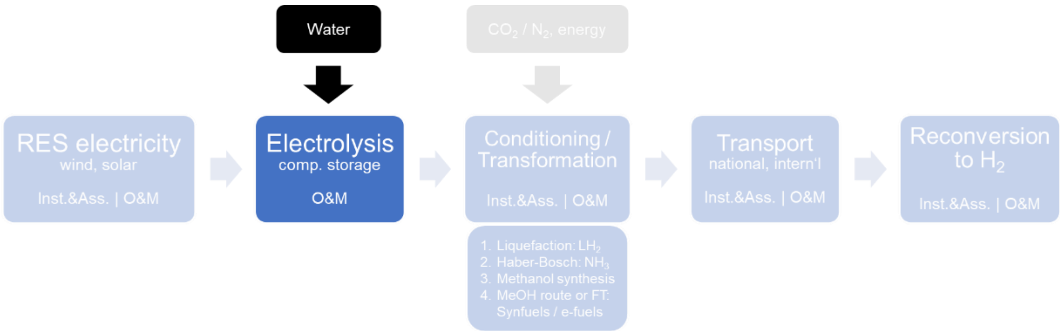
Local economic development and employment are also considered as a relevant criterion as construction of water supply systems as well as electrolysis, compression and storage facilities may make use of local labor and contractors, as well as purchase regional supplies. Moreover, according to the Chilean Ministry of Energy´s national hydrogen strategy "Strong local capacities will give a way to new business, technical innovation, and productive employment" [69].

The use of local labor for the installation and assembly of electrolysis, compression and storage facilities may also translate over to *local professional skills training and education*, therefore this criterion is also considered as relevant. Furthermore, the Chilean national green hydrogen strategy states that "local technicians and specialists with adequate knowledge and skills will consolidate a national hydrogen ecosystem" [69]. Finally, the importance of informing and educating the local communities about the activities to be carried out is emphasized, especially in the case of projects that include technologies that are not well known by the population like electrolysis. In case of water supply, this criterion would depend (possibly relevant) to the type of technology used for water treatment. In case of desalination, the training of local personnel may be required for its construction.

Social Aspects

Social aspects criteria take relevant roles in the installation and assembly of water supply systems and electrolysis, compression and storage facilities as construction of these components directly affect the social wellbeing of communities within the area of the project's influence. For installation of water supply systems, in case of a desalination plant, key social impacts may include public acceptance of the project with regard to brine discharge. For the installation of electrolysis, compression and storage facilities with regard to the use of new technologies, a *SIA* may be able to identify the proper implementation for these systems and facilities. It must also address as an important criterion the rights of indigenous peoples who may have legal and cultural rights to lands in the project's influence. On the other hand, *land rights* are an important issue when acquiring new areas for the installation of new facilities and must be addressed accordingly.

Production, Compression, local Storage – Operation and Maintenance



Community Development

Not considered of relevance is the investment in *local infrastructure and services development* which is included in the installation and assembly phase.

Increase in energy access is not relevant for this part of the value chain.

As well as in the assembly and installation stage, the *economic development and employment* criteria are considered as relevant to the O&M of green hydrogen production, compression and storage facilities. This development could be linked to initiatives of economic benefit to the community[30], the creation of jobs, the creation of companies that provide services to the plant or to companies and indirect services such as accommodation and feeding of the personnel among others. It should be noted that since these types of projects are relatively new, it is likely that the creation of companies that provide specific services will be required. For local economic development, the World Class Suppliers Program (Programa de proveedores de clase mundial PCM) of BHP Billiton and Codelco is an initiative that seeks to promote the development of local productive capacities, thus promoting the strengthening of a knowledge-intensive mining technology and services industry for Chile and the world. Through PCM, each mining company conducts an internal analysis to identify and prioritize challenges that lack satisfactory solutions in the national and international market, and that present a potential quantifiable benefit in economic terms or a positive impact on safety, environmental and community issues. Each mining company then invites on suppliers with high development potential to solve these challenges in a collaborative manner and promotes those selected. Mining companies invest approximately US$ 14 million

[30] An example of economic benefit to the community could be the example of the Kipeto Wind Project's Multi-faceted Benefits-sharing framework in Kenya. In this project, given its commitment to providing benefits to affected communities, the company decided to allocate 5 percent of the project's net profit from the project to a community trust, overseen by a community implementation committee [63].

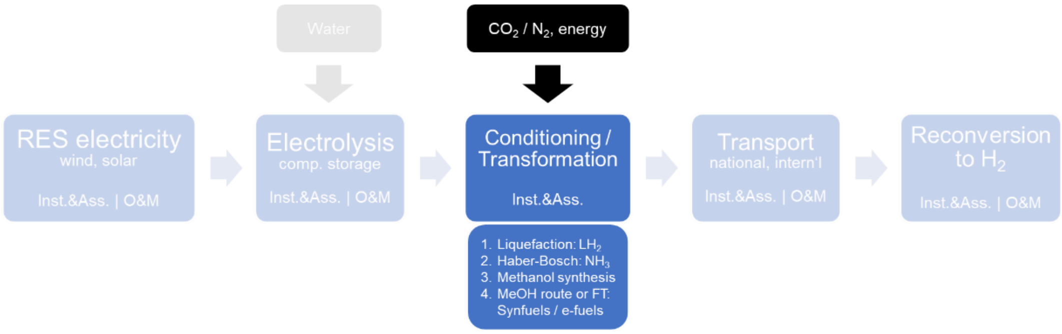
annually in this program [70]. This type of initiative could be implemented for hydrogen projects, where the potential for creating new technologies and process improvements is significant.

Local professional skills training and education is considered a relevant criterion since there is currently no specialized labor force for green hydrogen production plants, and there is an opportunity to train local labor work in the O&M of the plant. As mentioned in the previous criterion, the O&M of production, compression and storage will create local jobs and this leads to the training of personnel.

Social Aspects

For the operation and maintenance phase of production, compression and local storage, the *social aspects* criteria evaluated were considered relevant as once the plant is in operation, it is important to monitor the management measures proposed in the SIA and their compliance must be communicated in a timely manner in regular meetings with various social actors. Good practice in this regard is to conduct surveys in the communities in the area of influence to ascertain their perception of the project. With the results of monitoring, the plans proposed in the SIA should be adjusted annually.

Conditioning / Transformation – Installation and Assembly



Community Development

The conditioning and/or transformation of hydrogen involves for instance the physical process of liquefying hydrogen or chemically transforming hydrogen into another energy carrier such as ammonia, methanol, or a synthetic fuel. These processes require an additional electricity supply as well as a supply of nitrogen (in the case of ammonia production via the Haber-Bosch process) or CO_2 (for instance in the production of methanol, methane, or liquid synthetic fuels). If the supply of additional electricity for these processes comes from the same renewable energy source used for electrolysis, then investments in local infrastructure will be tied to the installation and assembly phase of renewable energy. If electricity is sourced from the grid, then an investment in local infrastructure would not be relevant. Regarding CO_2 supply for the creation of synfuels, CO_2 can be either captured from another process (e.g. from an unavoidable source) or be captured directly from the air. Construction of carbon capture (CC) facilities for unavoidable sources generally take place on already industrialized grounds, for instance a thermal power plant, and therefore will likely not impede to such an extent on the surrounding community as for instance a direct air carbon capture facility (DAC). DAC is more flexible and can be located on non-arable land near geologic storage sites to minimize transportation distances, minimizing possible impact to surrounding communities. However, the footprint of DAC is quite large, requiring roughly 0.4 to 24.7 km^2 for the capture of 1 million tons of CO_2 [71]. In instances where large DAC facilities are to be built, then investment into local infrastructure may be a possibly relevant criterion.

Depending on the respective carbon capture location to the conditioning plant, the CO_2 may have to be transported either by road, pipeline or ship. In the case of new road and pipeline construction, there may rise the need for negotiation between developers and private or public land owners for allowing right-of-way if their land is being crossed by the transport route, which may involve investment in local infrastructure. Air separation for the collection of nitrogen for later ammonia production can be done in several ways, the most common being fractional distillation. During the installation of air separation facilities, investments in local infrastructure can also be made, such as local roads, schools or health centers according to local needs. An example of these good practices is the dialysis center in Los Vilos, which was built by Minera Los Pelambres and equipped by the regional government and has helped patients to avoid having to travel to other localities to receive medical attention [72]. The local infrastructure investments for the air separation facilities may be grouped with the local investment plans from the installation of electrolysis, hydrogen storage, and hydrogen conditioning systems

(Haber-Bosch, methanation, methanol synthesis, etc.) as these systems may be constructed in the same area. Due to the great amount of variability within this value chain step, it is considered as potentially relevant the criterion *local infrastructure and services development* for the installation and assembly of nitrogen, CO_2 and energy supply and conditioning/transformation facilities of hydrogen.

Increase in energy access is not relevant for this part of the value chain.

In order to construct conditioning facilities, local contractors, supplies, and labor may be utilized, therefore the criterion *for local economic development and employment* is considered relevant for this phase.

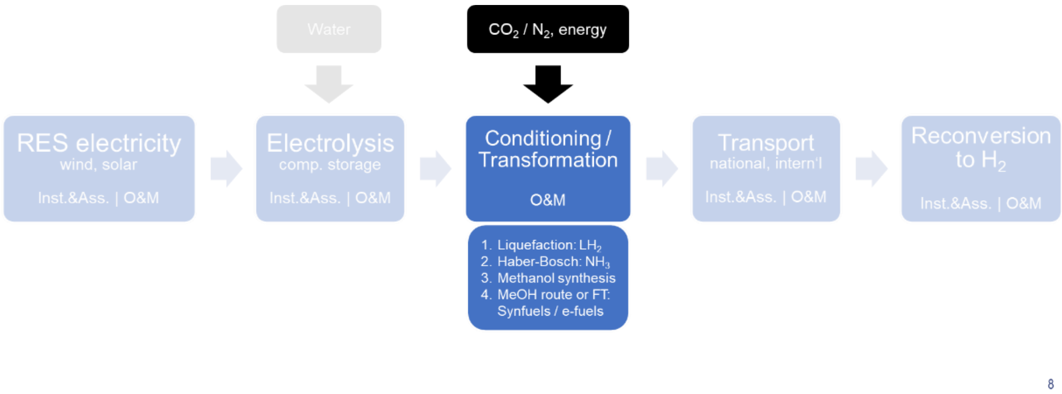
Local professional skills training and education is considered as potentially relevant as there can be a skills transfer in the hiring of local labor for the execution of conditioning facilities. This criterion may be highlighted as there will be a need for trained personal in many of the technologies and processes mentioned above for which are still in the development phases (CC for instance).

Social Aspects

The installation and assembly of infrastructure for the supply of nitrogen, CO_2 and energy for hydrogen conditioning, and the installation of hydrogen conditioning facilities, entail the possible construction of new roads, pipelines, and industrial plants, all of which directly affect local populations and therefore require a SIA. Therefore, the *SIA* is considered a relevant criterion for this phase.

Indigenous people's rights and *land rights* issues are also considered relevant criteria as the construction of conditioning plants, nitrogen and CO_2 supply entail must respect the rightful ownership and cultural heritage of the land on which it is developed.

Conditioning / Transformation – Operation and Maintenance



Community Development

During operation and maintenance of hydrogen conditioning/transformation, the criteria of local *infrastructure and services development* is considered not relevant as this criterion is applied during the installation phase.

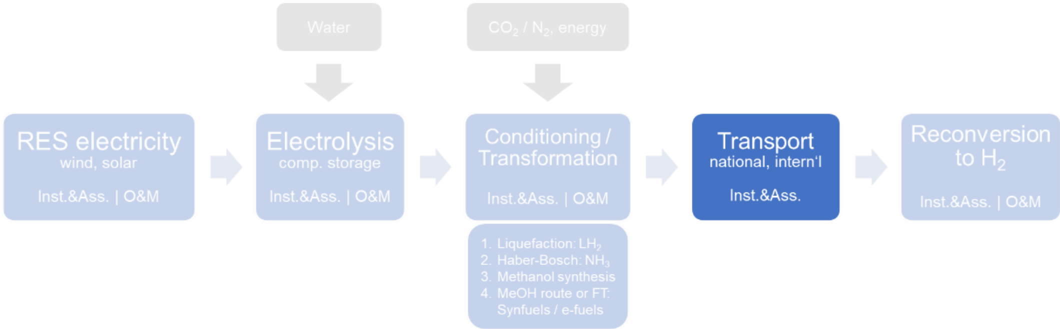
Increase in energy access is considered relevant regarding the energy supply to the conditioning process as a certain portion of the electricity used may be allotted to the electrification of the local community in the case the community lacks electrification. The energy sourced can either be connected via a RES installation or the centralized grid.

Local economic development and employment and *local professional skills training and education* are considered as potentially relevant as local community members may be trained to operate and/or maintain to a certain extent the conditioning plants.

Social Aspects

The *social aspects* criteria evaluated were considered relevant as once the plant is in operation, it is important to monitor the management measures proposed in the *SIA* and their compliance must be communicated in a timely manner in regular meetings with various social actors.

Transport – Installation and Assembly



Community Development

Community development criteria for the installation and assembly of hydrogen transport routes are dependent on the transport mechanism, of which the following have been considered in this report: trucking, pipelines, and shipping. For domestic hydrogen transport, trucking and pipelines will be the primary transport mechanisms, while shipping will most likely be utilized for international export. For trucking and pipelines, either existing roadways and pipelines can be used, or new road and pipeline infrastructure will have to be constructed. In the case of new construction, transport routes may pass through various communities and private land holder properties, requiring strong and transparent communication between developers and community stakeholders. Generally, owners of private and public property negotiate with pipeline companies and sign leases for the use of their land [73], therefore community development criteria may or may not apply as this is dependent on the specific negotiation. For shipping transport of hydrogen, the application of community development criteria is considered not relevant except for the case of port construction.

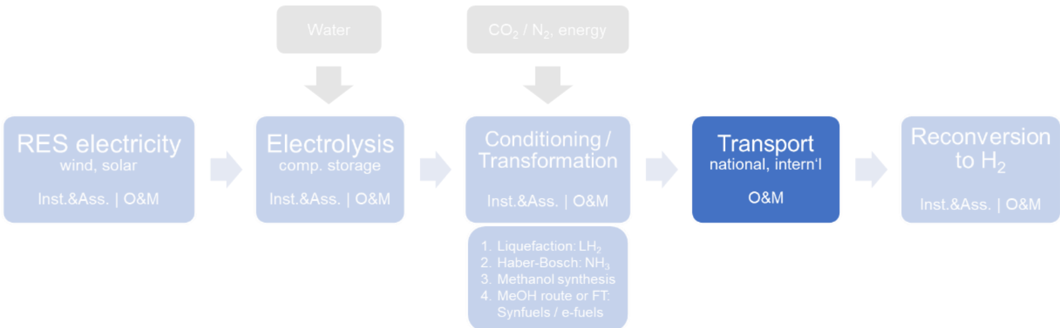
As a result, the criteria considered of possibly relevance are *local infrastructure and services development* and *local economic development and employment*, as these criteria may be of relevance for the negotiations between stakeholders and developers.

Social Aspects

With regard to the social aspects of the transport installation and assembly phase, a *SIA* should be performed for the case of new road, pipeline or port construction, therefore this criterion is considered relevant.

Indigenous peoples' rights and *land rights* issues are also considered relevant criteria as transport routes may intersect indigenous lands, areas of cultural importance, and other private and publicly held terrain (take for instance the Keystone XL Pipeline between Canada and the United States of America, whose development was abandoned in June 2021 after severe environmental and social conflicts, including land rights conflicts with indigenous peoples [74]).

Transport – Operation and Maintenance



Community Development

For the operation and maintenance of hydrogen transport, *local infrastructure and services development, local professional skills training and education* and *increase in energy access* are not considered relevant.

For the operation and maintenance of hydrogen transport, *local economic development and employment* is considered as potentially relevant as drivers of transport trucks may be hired locally from affected project areas. In the case of port construction, port operators and/or service employees may also be hired locally, inciting local development.

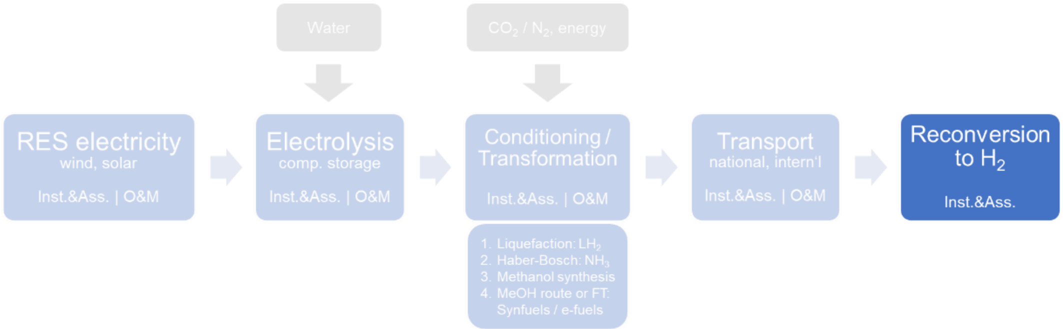
Social Aspects

A type of monitoring of the social well-being of those involved in the transport of hydrogen and its derivatives (employees or affected communities) may be established through a *SIA*, therefore this criterion is considered possibly relevant.

Indigenous peoples' rights are considered possibly relevant for operation of national transport, while for international transport this criterion is not considered relevant.

Land right issues are not considered relevant for the O&M stage of hydrogen transport.

Reconversion to Hydrogen – Installation and Assembly



Community Development

The reconversion of derivates like ammonia back into hydrogen takes place in the target country and is an endothermic reaction and therefore needs a significant energy input. Irrespective of the way in which energy is provided, the local infrastructure is clearly affected. To maintain the green path of hydrogen, energy supply should preferably come from renewable energy sources. Hence, similar influences on the community development may apply as for the RES and transmission sector, therefore *local infrastructure and services development* is considered possibly relevant.

In addition, the installation and assembly of the reconversion plant may enable further contracts to be awarded to local construction companies, hence *local economic development and employment* is considered possibly relevant.

The reconversion site will most likely be located in industrial areas and therefore expand industrial areas rather than open up new areas in rural regions. As a result, an *increase in energy access* is considered unlikely and not relevant.

Local professional skills training as well as investment in local education is considered to be not affected by the installation and assembly phase. However, it is important to remember that reconversion to hydrogen is a relatively new technology and therefore offers many opportunities for new businesses. These could emerge from local projects through specialization in the field of hydrogen. Therefore, *local professional skills training and education* is considered possibly relevant.

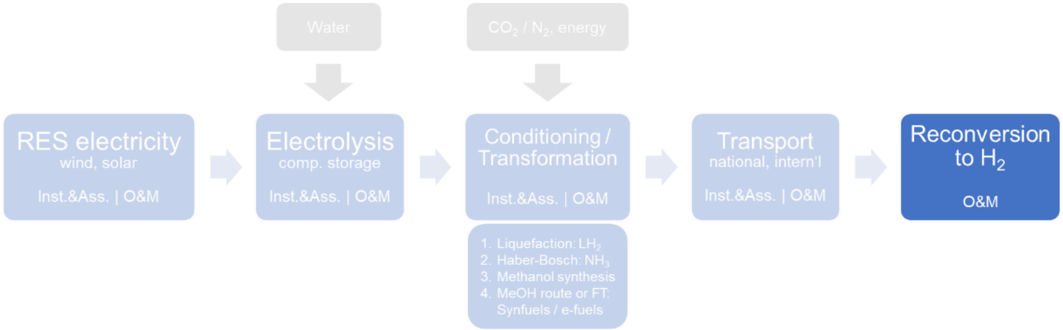
Social Aspects

As stated before, the *SIA* is a relevant criterion as it is a process of evaluation, planning and management of the social change or consequences arising from any project development. As the assessment must be carried out before construction, it affects the installation and assembly phase, although the social impacts are greater during the operation of, for example, a wind farm. Additionally, regarding the power plant, the SIA should consider the impact of the reconversion facility. Important topics may be, for example, the handling of toxic ammonia and the well-being of workers, as well as noise and visual impacts on local residents.

Indigenous peoples' rights are not seen as relevant criterion.

On the other hand, *land rights issues* are an important issue when acquiring new areas for factories and energy production plants.

Reconversion to Hydrogen – Operation and Maintenance



Community Development

Once a renewable energy plant is operational, the impact on the local infrastructure is estimated to be low. Therefore, *local infrastructure and services development* is not considered relevant.

Local economic development and employment and *local professional skills training and education* are expected to be affected only to a minor extent, as the technical management of renewable energy installations is usually centralized, and maintenance is usually carried out by non-resident service teams. Therefore, these criteria are considered possibly relevant.

In contrast, the operation of the reconversion plant may affect the infrastructure in different ways. The transport of the derivatives to the facility has to be taken into account. Also, the industrial location may grow, as the local availability of hydrogen could serve as a magnet for companies with energy-intensive processes. Even assuming that the energy of the power plant is entirely used for the processes of the reconversion, the local infrastructure may profit from an increase in energy access, since hydrogen can be basically seen as stored energy. Especially in the initial phase, when the infrastructure for hydrogen transport is still limited, this can be a great advantage for the local community. Therefore, *local infrastructure and services development, increase in energy access,* and *local economic development and employment* are considered to be relevant criteria.

The operation of the reconversion facility may furthermore provide jobs of all kinds. It may also serve as a research location and thus improve local education, which is *local professional skills training and education* is considered as potentially relevant.

Social Aspects

A type of social relation monitoring should be put in place, which can be established thought the *SIA. Indigenous peoples' rights* are not seen as relevant. Likewise*, land rights issues* are not relevant if it is assumed that the energy will be generated by renewable energy and that no further chemicals will be needed for the conversion into hydrogen and thus no mining will take place.

Relevance of sustainability criteria by hydrogen value chain element

From the analyses performed within the preceding chapters, the following relevance matrix is compiled in Table 16. Within this matrix, each criteria analyzed is listed for each step of the value chain considered. The parameters used in the previous sections for relevance are shown as follows: “relevant criteria” are marked with a “+”, possibly relevant criteria are marked with an “o”, not relevant criteria are marked with an “-“, and criteria to be confirmed if relevant are marked with a “tbc”.

Table 16 Relevance of sustainability criteria by hydrogen value chain element

	Value Chain	RES and transmission (new built)				Production, Compression, Storage, Conditioning / Transformation								Transport				Reconversion to Hydrogen			
						Production, Compression, local Storage				Conditioning / Transformation											
		PV (incl. Transmission)		Wind (incl. Transmission)		Water supply		Electrolysis, Comp., Storage		N2/CO2/aux energy supply		Conditioning / Transformation		National		International Shipping		Energy supply		Reconversion to Hydrogen	
	Criteria	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance
RED II	Additionality	+	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	Temp. Correlation	-	+	-	+	-	-	-	+	-	tbc	-	tbc	-	-	-	-	-	-	-	-
	Geogr. Correlation	+	-	+	-	-	-	+	-	tbc	-	tbc	-	-	-	-	-	-	-	-	-
	GHG balance	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+
	CO_2 Sources	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
ENVIRONMENTAL SUSTANABILITY	**Biodiversity Conservation**																				
	Biodiversity	+	o	+	o	+	+	+	o	o	+	o	+	+	+	+	+	+	o	+	+
	Natural Habitats, ecosystems	+	o	+	o	+	+	+	o	o	+	o	+	+	+	+	+	+	o	+	+
	High conservation value areas	+	o	+	o	+	+	+	o	o	-	o	-	+	+	+	+	+	o	+	+
	Soil conservation																				
	Soil protection	o	o	o	o	o	o	o	o	+	o	+	+	o	o	o	-	o	o	o	+
	Residues, wastes	o	o	o	o	+	o	+	-	+	-	+	-	+	o	+	-	+	o	+	-
	Waste management	o	o	o	o	+	o	+	o	+	-	+	-	+	-	+	-	+	o	+	-
	Sustainable Water																				
	Water rights	-	o	-	-	+	+	-	+	-	-	+	+	-	-	o	-	o	o	-	+
	Water quality	-	-	-	-	+	+	o	+	o	+	o	+	o	o	o	+	o	o	o	+
	Water management, conservation	-	o	-	-	-	+	-	+	-	-	-	-	-	-	-	-	o	o	-	-
	Efficient use of water	-	o	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-
	Air quality																				
	Air pollution	o	-	+	-	o	-	o	-	o	+	o	+	o	+	o	+	o	o	o	+
SOCIAL/ ECONOMIC SUSTAINABILITY	**Community Development**																				
	Local Infrastucture and services development	+	-	+	-	+	-	o	-	o	-	o	-	o	-	o	-	o	-	o	+
	Increase in energy access	+	+	+	+	-	-	-	-	-	+	-	-	-	-	-	-	-	o	-	+
	Local Economic development and employment	+	o	+	o	+	+	+	+	+	o	+	o	o	o	o	o	o	o	o	+
	Local Professional skills training and education	o	o	o	o	o	o	+	+	o	o	o	o	-	-	-	-	o	o	o	o
	Social aspects																				
	Social Impact Assessment	+	+	+	+	+	+	+	+	+	-	+	-	+	o	o	o	o	-	+	-
	Indigenous peoples' rights	+	+	+	+	+	+	+	+	+	-	+	-	+	o	-	-	-	-	-	-
	Land right issues	+	+	+	+	+	+	+	+	+	-	+	-	+	-	-	-	o	-	+	-
	Labor conditions																				
	Working conditions	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Contracts	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Health and Safety	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

Hydrogen value chain and certification schemes

An overview of which certification scheme covers the relevant criteria by value chain element provides further guidance to project developers for preparing for future hydrogen certification.

Combining the list of criteria covered by the various certification schemes with the relevance assessment of criteria per value chain element as developed in the previous section results in an overview for each certification scheme of the coverage of the relevant (or potentially relevant) criteria per value chain element.

The reading of the resulting matrices is as follows:

- An empty cell indicates that this criterion is not relevant for the given element of the value chain.
- A "+" indicates that the criterion is relevant and is covered by the certification scheme in question.
- An "« + »" indicates that the criterion is relevant, but that it is NOT covered by the certification scheme in question. As an example, RED II criteria such as additionality are relevant to several elements of the value chain but are not covered by certification schemes yet as these requirements are new and await detailed definition.
- A "o" indicates that the criterion is potentially relevant and is covered by the certification scheme in question.
- An "« o »" indicates that the criterion is potentially relevant, but that it is NOT covered by the certification scheme in question.
- An "tbc" indicates that the relevance of this criterion is still to be confirmed

The Table 17 provides an overview of which share of the relevant criteria (including criteria potentially relevant and tbc criteria) are covered by each of the certification schemes. It should be noted that CertifHy and TÜV SÜD CMS70 focus on the core criteria required by RED II, while the other environmental and socio-economic criteria are not covered. In the case of CertifHy, which is currently developing a voluntary scheme under RED II, such criteria will be defined in the course of this process.

As an example of the percentage calculation, for PV installation and assembly, REDcert covers 10 criteria ("+" or "o"; see Table 16) of a total of 19 non-empty cells, not including cells characterized by "tbc", which results in a share of 53% of relevant criteria covered by REDcert. The basis for what is relevant or potentially relevant is presented in Table 16.

Table 17 Coverage of relevant criteria by certification scheme

	RES and transmission (new built)				Production, Compression, Storage, Conditioning / Transformation								Transport				Reconversion to Hydrogen			
	PV (incl. Transmission)		Wind (incl. Transmission)		Production, Compression, local				Conditioning / Transformation				National		International Shipping		Energy supply		Reconversion to Hydrogen	
					Water supply		Electrolysis, Comp., Storage		N2/CO2/aux energy supply		Conditioning / Transformation									
	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance
REDcert	53%	55%	53%	53%	67%	63%	58%	58%	65%	54%	67%	67%	69%	64%	73%	64%	72%	71%	69%	60%
ISCC	68%	70%	68%	71%	78%	74%	68%	74%	76%	62%	78%	75%	75%	71%	73%	73%	78%	71%	75%	67%
RSB	89%	90%	89%	88%	100%	95%	89%	89%	100%	85%	100%	92%	100%	93%	100%	91%	100%	94%	100%	93%
CERA4in1	68%	70%	68%	71%	72%	74%	68%	68%	76%	54%	72%	58%	75%	71%	67%	73%	72%	65%	75%	53%
FSC	74%	70%	74%	76%	83%	79%	79%	79%	88%	69%	83%	75%	88%	79%	80%	82%	83%	71%	88%	73%
Fair Trade	63%	70%	63%	65%	78%	79%	68%	79%	76%	62%	78%	75%	75%	64%	73%	64%	78%	71%	75%	73%
CertifHy	Focus on RED II core criteria; further criteria to be defined																			
TÜV SÜD CMS70	Focus on RED II core criteria																			

As an overall average, REDcert covers 63% of the relevant criteria, ISCC 72%, RSB 94%, CERA 4in1 69%, FSC 79%, Fair Trade 71%. This trend is also generally reflected in the individual value chain elements. The detailed overview per certification scheme provided in the coming sections highlights the different profiles of the certification schemes with different focus areas. As an example, REDcert puts an emphasis on environmental criteria while FSC puts a stronger focus on the socio-economic criteria.

CertifHy

CertifHy focuses on the GHG balance, which is a core criterion required by RED II, while the other environmental and socio-economic criteria are not covered. CertifHy is currently developing a voluntary scheme under RED II, which will include covering the other criteria of RED II as well as other environmental and socio-economic criteria.

TÜV SÜD CMS70

TÜV SÜD CMS70 focus on the core criteria required by RED II, while the other environmental and socio-economic criteria are not covered

REDcert

The following table provides an overview of which of the relevant criteria (including criteria of limited relevance and tbc criteria) are covered by REDcert.

Table 18 Coverage of relevant criteria by REDcert

	REDcert	RES and transmission (new built)				Production, Compression, Storage, Conditioning / Transformation								Transport				Reconversion to Hydrogen			
						Production, Compression, local				Conditioning / Transformation											
		PV (incl. Transmission)		Wind (incl. Transmission)		Water supply		Electrolysis, Comp., Storage		N2/CO2/aux energy supply		Conditioning / Transformation		National		International Shipping		Energy supply		Reconversion to Hydrogen	
		Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance
RED II	Additionality	« + »		« + »				« + »													
	Temp. Correlation		« + »		« + »				« + »		tbc		tbc								
	Geogr. Correlation	« + »		« + »				« + »		tbc		tbc									
	GHG balance		« + »		« + »		« + »		« + »		« + »		« + »		« + »		« + »		« + »		« + »
	CO_2 Sources										« + »										
ENVIRONMENTAL SUSTANABILITY	**Biodiversity Conservation**																				
	Biodiversity	+	o	+	o	+	+	+	o	o	+	o	+	+	+	+	+	+	o	+	+
	Natural Habitats, ecosystems	« + »	« o »	« + »	« o »	« + »	« + »	« + »	« o »	« o »	« + »	« o »	« + »	« + »	« + »	« + »	« + »	« + »	« o »	« + »	« + »
	High conservation value areas	+	o	+	o	+	+	+	o	o		o		+	+	+	+	+	o	+	+
	Soil conservation																				
	Soil protection	o	o	o	o	o	o	o	o	+	o	+	+	o	o	o		o	o	o	+
	Residues, wastes	o	o	o	o	+	o	+		+		+		+	o	+		+	o	+	
	Waste management	o	o	o	o	+	o	+	o	+		+		+		+		+	o	+	
	Sustainable Water																				
	Water rights		o			+	+		+			+	+			o		o	o		+
	Water quality					+	+	o	+	o	+	o	+	o	o	o	+	o	o	o	+
	Water management, conservation		o				+		+									o	o		
	Efficient use of water		« o »				« + »		« + »												
	Air quality																				
	Air pollution	o		+		o		o		o	+	o	+	o	+	o	+	o	o	o	+
SOCIAL/ ECONOMIC SUSTAINABILITY	**Community Development**																				
	Local Infrastucture and services development	« + »		« + »		« + »		« o »		« o »		« o »		« o »		« o »		« o »		« o »	« + »
	Increase in energy access	« + »	« + »	« + »	« + »						« + »								« o »		« + »
	Local Economic development and employment	« + »	« o »	« + »	« o »	« + »	« + »	« + »	« + »	« + »	« o »	« + »	« o »	« o »	« o »	« o »	« o »	« o »	« o »	« o »	« + »
	Local Professional skills training and education	« o »	« o »	« o »	« o »	« o »	« o »	« + »	« + »	« o »	« o »	« o »	« o »					« o »	« o »	« o »	« o »
	Social aspects																				
	Social Impact Assessment	« + »	« + »	« + »	« + »	« + »	« + »	« + »	« + »	« + »		« + »		« + »	« o »	« o »	« o »	« o »		« + »	
	Indigenous people's rights	« + »	« + »	« + »	« + »	« + »	« + »	« + »	« + »	« + »		« + »		« + »	« o »						
	Lands right issues	+	+	+	+	+	+	+	+	+		+		+				o		+	
	Labor conditions																				
	Working conditions	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Contracts	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Health and Safety	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

ISCC

The following table provides an overview of which of the relevant criteria (including criteria potentially relevant and tbc criteria) are covered by ISCC.

Table 19 Coverage of relevant criteria by ISCC

	ISCC	RES and transmission (new built)				Production, Compression, Storage, Conditioning / Transformation								Transport				Reconversion to Hydrogen			
						Production, Compression, local Storage				Conditioning / Transformation											
		PV (incl. Transmission)		Wind (incl. Transmission)		Water supply		Electrolysis, Comp., Storage		N2/CO2/aux energy supply		Conditioning / Transformation		National		International Shipping		Energy supply		Reconversion to Hydrogen	
		Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance
RED II	Additionality	« + »		« + »				« + »													
	Temp. Correlation		« + »		« + »				« + »		tbc		tbc								
	Geogr. Correlation	« + »		« + »				« + »		tbc		tbc									
	GHG balance		« + »		« + »		« + »		« + »		« + »		« + »		« + »		« + »		« + »		« + »
	CO_2 Sources										« + »										
ENVIRONMENTAL SUSTANABILITY	**Biodiversity Conservation**																				
	Biodiversity	+	o	+	o	+	+	+	o	o	+	o	+	+	+	+	+	+	o	+	+
	Natural Habitats, ecosystems	« + »	« o »	« + »	« o »	« + »	« + »	« + »	« o »	« o »	« + »	« o »	« + »	« + »	« + »	« + »	« + »	« + »	« o »	« + »	« + »
	High conservation value areas	+	o	+	o	+	+	+	o	o		o		+	+	+	+	+	o	+	+
	Soil conservation																				
	Soil protection	o	o	o	o	o	o	o	o	+	o	+	+	o	o	o		o	o	o	+
	Residues, wastes	« o »	« o »	« o »	« o »	« + »	« o »	« + »		« + »		« + »		« + »	« o »	« + »		« + »	« o »	« + »	
	Waste management	o	o	o	o	+	o	+	o	+		+		+		+		+	o	+	
	Sustainable Water																				
	Water rights		o			+	+		+			+	+			o		o	o		+
	Water quality					« + »	« + »	« o »	« + »	« o »	« + »	« o »	« + »	« o »	« o »	« o »	« + »	« o »	« o »	« o »	« + »
	Water management, conservation		o				+		+									o	o		
	Efficient use of water		« o »				« + »		« + »												
	Air quality																				
	Air pollution	o		+		o		o		o	+	o	+	o	+	o	+	o	o	o	+
SOCIAL/ ECONOMIC SUSTAINABILITY	**Community Development**																				
	Local Infrastucture and services development	« + »		« + »		« + »		« o »		« o »		« o »		« o »		« o »		« o »		« o »	« + »
	Increase in energy access	« + »	« + »	« + »	« + »						« + »								« o »		« + »
	Local Economic development and employment	+	o	+	o	+	+	+	+	+	o	+	o	o	o	o	o	o	o	o	+
	Local Professional skills training and education	o	o	o	o	o	o	+	+	o	o	o	o					o	o	o	o
	Social aspects																				
	Social Impact Assessment	+	+	+	+	+	+	+	+	+		+		+	o	o	o	o		+	
	Indigenous people's rights	+	+	+	+	+	+	+	+	+		+		+	o						
	Lands right issues	+	+	+	+	+	+	+	+	+		+		+				o		+	
	Labor conditions																				
	Working conditions	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Contracts	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Health and Safety	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

RSB

The following table provides an overview of which of the relevant criteria (including criteria potentially relevant and tbc criteria) are covered by RSB.

Table 20 Coverage of relevant criteria by RSB

	RSB	RES and transmission (new built)				Production, Compression, Storage, Conditioning / Transformation								Transport				Reconversion to Hydrogen			
						Production, Compression, local Storage				Conditioning / Transformation											
		PV (incl. Transmission)		Wind (incl. Transmission)		Water supply		Electrolysis, Comp., Storage		N2/CO2/aux energy supply		Conditioning / Transformation		National		International Shipping		Energy supply		Reconversion to Hydrogen	
		Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance
RED II	Additionality	« + »		« + »				« + »													
	Temp. Correlation		« + »		« + »				« + »		tbc		tbc								
	Geogr. Correlation	« + »		« + »				« + »		tbc		tbc									
	GHG balance		« + »		« + »		« + »		« + »		« + »		« + »		« + »		« + »		« + »		« + »
	CO_2 Sources										« + »										
ENVIRONMENTAL SUSTANABILITY	**Biodiversity Conservation**																				
	Biodiversity	+	o	+	o	+	+	+	o	o	+	o	+	+	+	+	+	+	o	+	+
	Natural Habitats, ecosystems	+	o	+	o	+	+	+	o	o	+	o	+	+	+	+	+	+	o	+	+
	High conservation value areas	+	o	+	o	+	+	+	o	o		o		+	+	+	+	+	o	+	+
	Soil conservation																				
	Soil protection	o	o	o	o	o	o	o	o	+	o	+	+	o	o	o		o	o	o	+
	Residues, wastes	o	o	o	o	+	o	+		+		+		+	o	+		+	o	+	
	Waste management	o	o	o	o	+	o	+	o	+		+		+		+		+	o	+	
	Sustainable Water																				
	Water rights		o			+	+		+			+	+			o		o	o		+
	Water quality					+	+	o	+	o	+	o	+	o	o	o	+	o	o	o	+
	Water management, conservation		o				+		+									o	o		
	Efficient use of water		o				+		+												
	Air quality																				
	Air pollution	o		+		o		o		o	+	o	+	o	+	o	+	o	o	o	+
SOCIAL/ ECONOMIC SUSTAINABILITY	**Community Development**																				
	Local Infrastructure and services development	+		+		+		o		o		o		o		o		o		o	+
	Increase in energy access	+	+	+	+						+								o		+
	Local Economic development and employment	+	o	+	o	+	+	+	+	+	o	+	o	o	o	o	o	o	o	o	+
	Local Professional skills training and education	o	o	o	o	o	o	+	+	o	o	o	o					o	o	o	o
	Social aspects																				
	Social Impact Assessment	+	+	+	+	+	+	+	+	+		+		+	o	o	o	o		+	
	Indigenous people's rights	+	+	+	+	+	+	+	+	+		+		+	o						
	Lands right issues	+	+	+	+	+	+	+	+	+		+		+				o		+	
	Labor conditions																				
	Working conditions	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Contracts	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Health and Safety	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

CERA 4in1

The following table provides an overview of which of the relevant criteria (including criteria potentially relevant and tbc criteria) are covered by CERA 4in1.

Table 21 Coverage of relevant criteria by CERA 4in1

	CERA4in1	RES and transmission (new built)				Production, Compression, Storage, Conditioning / Transformation								Transport				Reconversion to Hydrogen			
						Production, Compression, local Storage				Conditioning / Transformation											
		PV (incl. Transmission)		Wind (incl. Transmission)		Water supply		Electrolysis, Comp., Storage		N2/CO2/aux energy supply		Conditioning / Transformation		National		International Shipping		Energy supply		Reconversion to Hydrogen	
		Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance
RED II	Additionality	« + »		« + »				« + »													
	Temp. Correlation		« + »		« + »				« + »		tbc		tbc								
	Geogr. Correlation	« + »		« + »				« + »		tbc		tbc									
	GHG balance		« + »		« + »		« + »		« + »		« + »		« + »		« + »		« + »		« + »		« + »
	CO_2 Sources										« + »										
ENVIRONMENTAL SUSTANABILITY	**Biodiversity Conservation**																				
	Biodiversity	+	o	+	o	+	+	+	o	o	+	o	+	+	+	+	+	+	o	+	+
	Natural Habitats, ecosystems	+	o	+	o	+	+	+	o	o	+	o	+	+	+	+	+	+	o	+	+
	High conservation value areas	+	o	+	o	+	+	+	o	o		o		+	+	+	+	+	o	+	+
	Soil conservation																				
	Soil protection	« o »	« o »	« o »	« o »	« o »	« o »	« o »	« o »	« + »	« o »	« + »	« + »	« o »	« o »	« o »		« o »	« o »	« o »	« + »
	Residues, wastes	o	o	o	o	+	o	+		+		+		+	o	+		+	o	+	
	Waste management	o	o	o	o	+	o	+	o	+		+		+		+		+	o	+	
	Sustainable Water																				
	Water rights		« o »			« + »	« + »		« + »			« + »	« + »			« o »		« o »	« o »		« + »
	Water quality					« + »	« + »	« o »	« + »	« o »	« + »	« o »	« + »	« o »	« o »	« o »	« + »	« o »	« o »	« o »	« + »
	Water management, conservation		o				+		+									o	o		
	Efficient use of water		o				+		+												
	Air quality																				
	Air pollution	o		+		o		o		o	+	o	+	o	+	o	+	o	o	o	+
SOCIAL/ ECONOMIC SUSTAINABILITY	**Community Development**																				
	Local Infrastructure and services development	« + »		« + »		« + »		« o »		« o »		« o »		« o »		« o »		« o »		« o »	« + »
	Increase in energy access	« + »	« + »	« + »	« + »						« + »								« o »		« + »
	Local Economic development and employment	+	o	+	o	+	+	+	+	+	o	+	o	o	o	o	o	o	o	o	+
	Local Professional skills training and education	o	o	o	o	o	o	+	+	o	o	o	o					o	o	o	o
	Social aspects																				
	Social Impact Assessment	+	+	+	+	+	+	+	+	+		+		+	o	o	o	o		+	
	Indigenous people's rights	+	+	+	+	+	+	+	+	+		+		+	o						
	Lands right issues	+	+	+	+	+	+	+	+	+		+		+				o		+	
	Labor conditions																				
	Working conditions	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Contracts	« + »	« + »	« + »	« + »	« + »	« + »	« + »	« + »	« + »	« + »	« + »	« + »	« + »	« + »	« + »	« + »	« + »	« + »	« + »	« + »
	Health and Safety	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

FSC

The following table provides an overview of which of the relevant criteria (including criteria potentially relevant and tbc criteria) are covered by FSC.

Table 22 Coverage of relevant criteria by FSC

	FSC	RES and transmission (new built)				Production, Compression, Storage, Conditioning / Transformation								Transport				Reconversion to Hydrogen			
						Production, Compression, local Storage				Conditioning / Transformation											
		PV (incl. Transmission)		Wind (incl. Transmission)		Water supply		Electrolysis, Comp., Storage		N2/CO2/aux energy supply		Conditioning / Transformation		National		International Shipping		Energy supply		Reconversion to Hydrogen	
		Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance
RED II	Additionality	« + »		« + »				« + »													
	Temp. Correlation		« + »		« + »				« + »		tbc		tbc								
	Geogr. Correlation	« + »		« + »				« + »		tbc		tbc									
	GHG balance		« + »		« + »		« + »		« + »		« + »		« + »		« + »		« + »		« + »		« + »
	CO_2 Sources										« + »										
ENVIRONMENTAL SUSTANABILITY	**Biodiversity Conservation**																				
	Biodiversity	+	o	+	o	+	+	+	o	o	+	o	+	+	+	+	+	+	o	+	+
	Natural Habitats, ecosystems	+	o	+	o	+	+	+	o	o	+	o	+	+	+	+	+	+	o	+	+
	High conservation value areas	+	o	+	o	+	+	+	o	o		o		+	+	+	+	+	o	+	+
	Soil conservation																				
	Soil protection	o	o	o	o	o	o	o	o	+	o	+	+	o	o	o		o	o	o	+
	Residues, wastes	« o »	« o »	« o »	« o »	« + »	« o »	« + »		« + »		« + »		« + »	« o »	« + »		« + »	« o »	« + »	
	Waste management	o	o	o	o	+	o	+	o	+		+		+		+		+	o	+	
	Sustainable Water																				
	Water rights		« o »			« + »	« + »		« + »			« + »	« + »			« o »		« o »	« o »		« + »
	Water quality					+	+	o	+	o	+	o	+	o	o	o	+	o	o	o	+
	Water management, conservation		o				+		+									o	o		
	Efficient use of water		« o »				« + »		« + »												
	Air quality																				
	Air pollution	« o »		« + »		« o »		« o »		« o »	« + »	« o »	« + »	« o »	« + »	« o »	« + »	« o »	« o »	« o »	« + »
SOCIAL/ ECONOMIC SUSTAINABILITY	**Community Development**																				
	Local Infrastructure and services development	+		+		+		o		o		o		o		o		o		o	+
	Increase in energy access	« + »	« + »	« + »	« + »						« + »								« o »		« + »
	Local Economic development and employment	+	o	+	o	+	+	+	+	+	o	+	o	o	o	o	o	o	o	o	+
	Local Professional skills training and education	o	o	o	o	o	o	+	+	o	o	o	o					o	o	o	o
	Social aspects																				
	Social Impact Assessment	+	+	+	+	+	+	+	+	+		+		+	o	o	o	o		+	
	Indigenous people's rights	+	+	+	+	+	+	+	+	+		+		+	o						
	Lands right issues	+	+	+	+	+	+	+	+	+		+		+				o		+	
	Labor conditions																				
	Working conditions	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Contracts	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Health and Safety	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

Fair Trade

The following table provides an overview of which of the relevant criteria (including criteria potentially relevant and tbc criteria) are covered by Fair Trade.

Table 23 Coverage of relevant criteria by Fair Trade

Fair Trade		RES and transmission (new built)				Production, Compression, Storage, Conditioning / Transformation								Transport				Reconversion to Hydrogen			
						Production, Compression, local Storage				Conditioning / Transformation											
		PV (incl. Transmission)		Wind (incl. Transmission)		Water supply		Electrolysis, Comp., Storage		N2/CO2/aux energy supply		Conditioning / Transformation		National		International Shipping		Energy supply		Reconversion to Hydrogen	
		Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance	Installation & Assembly	Operation & Maintenance
RED II	Additionality	« + »		« + »				« + »													
	Temp. Correlation		« + »		« + »				« + »		tbc		tbc								
	Geogr. Correlation	« + »		« + »				« + »		tbc		tbc									
	GHG balance		« + »		« + »		« + »		« + »		« + »		« + »		« + »		« + »		« + »		« + »
	CO_2 Sources										« + »										
ENVIRONMENTAL SUSTANABILITY	**Biodiversity Conservation**																				
	Biodiversity	+	o	+	o	+	+	+	o	o	+	o	+	+	+	+	+	+	o	+	+
	Natural Habitats, ecosystems	+	o	+	o	+	+	+	o	o	+	o	+	+	+	+	+	+	o	+	+
	High conservation value areas	+	o	+	o	+	+	+	o	o		o		+	+	+	+	+	o	+	+
	Soil conservation																				
	Soil protection	o	o	o	o	o	o	o	o	+	o	+	+	o	o	o		o	o	o	+
	Residues, wastes	« o »	« o »	« o »	« o »	« + »	« o »	« + »		« + »		« + »		« + »	« o »	« + »		« + »	« o »	« + »	
	Waste management	o	o	o	o	+	o	+	o	+		+		+		+		+	o	+	
	Sustainable Water																				
	Water rights		o			+	+		+			+	+			o		o	o		+
	Water quality					+	+	o	+	o	+	o	+	o	o	o	+	o	o	o	+
	Water management, conservation		o				+		+									o	o		
	Efficient use of water		o				+		+												
	Air quality																				
	Air pollution	« o »		« + »		« o »		« o »		« o »	« + »	« o »	« + »	« o »	« + »	« o »	« + »	« o »	« o »	« o »	« + »
SOCIAL/ ECONOMIC SUSTAINABILITY	**Community Development**																				
	Local Infrastucture and services development	+		+		+		o		o		o		o		o		o		o	+
	Increase in energy access	« + »	« + »	« + »	« + »						« + »								« o »		« + »
	Local Economic development and employment	« + »	« o »	« + »	« o »	« + »	« + »	« + »	« + »	« + »	« o »	« + »	« o »	« o »	« o »	« o »	« o »	« o »	« o »	« o »	« + »
	Local Professional skills training and education	o	o	o	o	o	o	+	+	o	o	o	o					o	o	o	o
	Social aspects																				
	Social Impact Assessment	« + »	« + »	« + »	« + »	« + »	« + »	« + »	« + »	« + »		« + »		« + »	« o »	« o »	« o »	« o »		« + »	
	Indigenous people’s rights	+	+	+	+	+	+	+	+	+		+		+	o						
	Lands right issues	+	+	+	+	+	+	+	+	+		+		+				o		+	
	Labor conditions																				
	Working conditions	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Contracts	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Health and Safety	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

Conclusions

Conclusions: International Certification Framework

This study has three focus areas: 1) It assesses existing hydrogen certification schemes and selected schemes under development or schemes not related to hydrogen, but which could in principle be applied, in view of such further environmental and socio-economic criteria. 2) It also assesses the relevance of the sustainability criteria identified for hydrogen and derivatives production and supply to Europe broken down by each element of the full value chain. 3) And finally, the study evaluates the coverage of relevant criteria by selected certification schemes broken down by value chain element. In addition, several overview matrices related to the three focus areas described above have been developed within the study: these aim at providing guidance to developers of renewable hydrogen and derivatives production projects for export to Europe, public institutions and certification companies.

In the case of European hydrogen certification schemes, **CertifHy** and **CMS70** schemes are not related to any legislation and their focus is on criteria associated to the electricity input to produce hydrogen, and on the greenhouse gas balance. With the same purpose, hydrogen Guarantee of Origin (GO) schemes are currently being set up in European Union Member States, with CertifHy aiming at supporting harmonization of these systems. GOs guarantee the renewable origin of the fuel and only cover production using a book&claim approach to the chain of custody, while all other schemes have a strong focus on the greenhouse gas balance of hydrogen and derivatives.

Other schemes and standards aim at supporting legal target compliance. This is the case for the voluntary schemes related to the **Renewable Energy Directive**, which will operate world-wide, eventually certifying hydrogen and derivatives for export to Europe. These schemes use a mass balancing approach to the chain of custody covering the full production and supply chain up to the point of consumption. Voluntary schemes according to the European Renewable Energy Directive additionally include in varying degrees other environmental and socio-economic criteria, however, for the time being only for biofuels. Certification of **RFNBO**s (Renewable Fuels of Non-Biological Origin) by voluntary schemes is not established yet, neither for existing schemes which need to adapt for covering RFNBOs, nor for new schemes such as CertifHy which aims at becoming a voluntary scheme for RFNBOs. Voluntary schemes need to take up further criteria generally defined in the Renewable Energy Directive recast of 2018 related to the renewable electricity input, notably "additionality" as well as "temporal and geographic correlation". **Additionality** requires renewable power plants to be additional to the existing fleet of plants. **Temporal correlation** requires hydrogen production to take place at the same time as renewable electricity generation, probably with a quarter-hourly time resolution. **Geographic correlation** requires renewable power plants and hydrogen production plants to be located in a way as to avoid electricity grid congestions. The detailed requirements are still to be defined in delegated acts to be adopted by the European Commission, which were due by the end of 2021.

In the study, **six selected certification schemes** related to the Renewable Energy Directive were assessed in view of criteria suitable for hydrogen sustainability certification. From this analysis, seven criteria, with their respective sub-criteria, were identified as possibly relevant depending on the elements of the hydrogen production and export value chain:

Table 24: Environmental and Social/Economic identified criteria

Field	Criteria
Environmental Sustainability	Biodiversity conservation
	Soil conservation
	Sustainable water
	Air quality
Social/Economic Sustainability	Community development
	Social impact
	Labor & safety

Based on the sustainability criteria identified, **it can be observed that the current hydrogen certification schemes in the market do not include sustainability criteria related with environmental and socio-economic issues.** Nevertheless, from an international perspective, hydrogen certification is in an early, but very dynamic development phase; in addition to methodological and procedural issues as well as GHG thresholds, there are discussions about broader sets of sustainability criteria to be considered in future hydrogen projects. The analysis shows that the sustainability of the projects does not only depend on the source of energy to produce, in this case, hydrogen, and must not only be measured in kilograms of CO_2 per ton of hydrogen produced. In addition, it is necessary to deepen and cover other equally important aspects to measure the impact of the project, such as environmental, water supply/consumption, social and local economic development as well as community and labor conditions criteria.

Regarding the general coverage of relevant sustainability criteria by the six analyzed certification schemes, the results show a diverse picture: some do not cover any further environmental and socio-economic criteria, some cover such criteria to a limited extent, others are rather comprehensive:

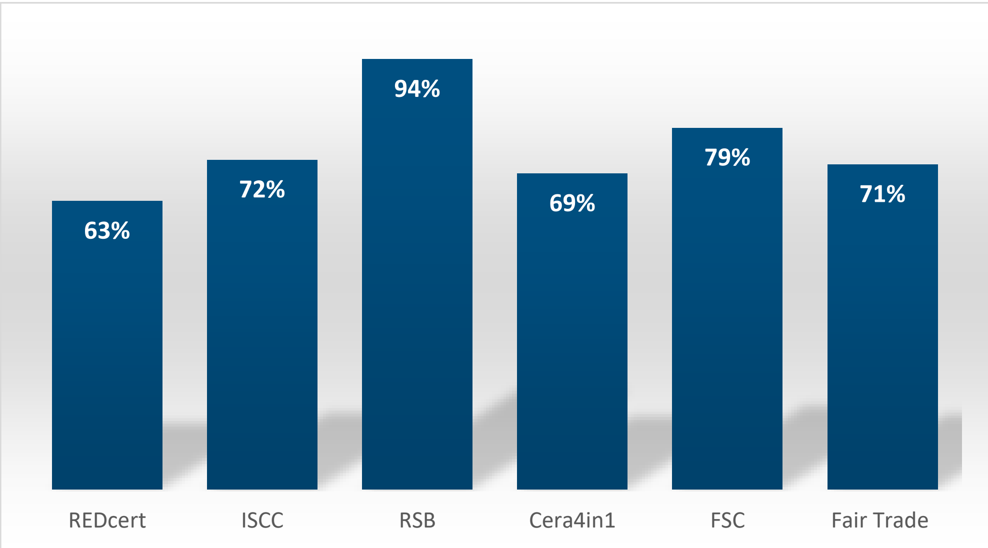
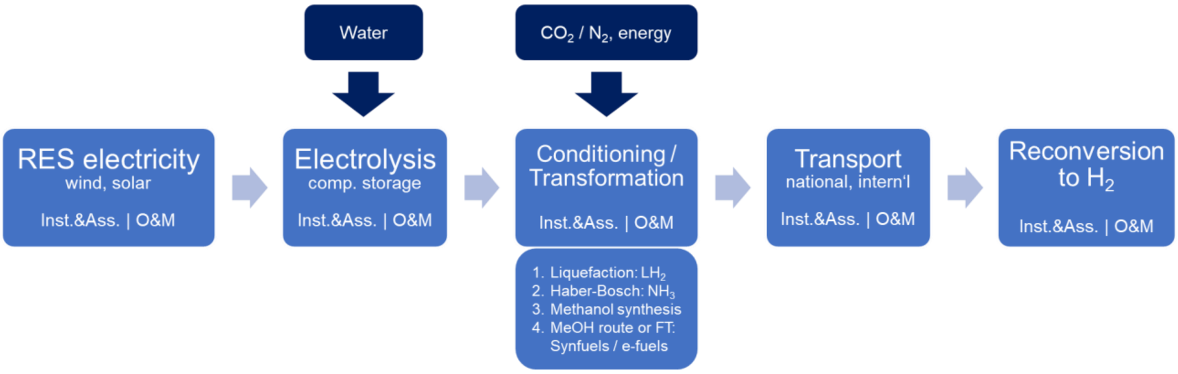


Figure 3 Overall coverage of sustainability criteria

From this analysis can be concluded that **there is no single certification scheme that addresses all the sustainability criteria that were considered**. In this sense, where several certification schemes compete on the market for identical certification purposes, which is notably the case for the voluntary schemes according to the Renewable Energy Directive, an assessment of the market share of the schemes depending on their coverage of such criteria would be helpful in understanding the willingness of fuel producers and consumers to cover such criteria comprehensively, or rather to a limited extent. On the other hand, it is important to notice that in certain cases or countries some of the identified criteria are already covered by international political agreements, as is the case of Chile with the International Labor Organization (ILO), **which could mean an advantage for certain hydrogen exporting countries over others that are not adhered to this kind of agreement**.

Regardless of whether the mentioned criteria are certified or legally required in the future, taking them into account at an early stage will be instrumental in securing the success of the installation and operation of green hydrogen projects. The relevance of sustainability criteria to the various elements of the hydrogen value chain needs to be appraised at the detailed level by going through the respective matrix in this study. Relevance does not necessarily imply that potential negative impacts are severe, or that potential positive impacts are massive. Rather, **impacts are to be expected and need to be assessed in detail for each project. For some criteria and elements of the value chain, relevance may depend on the specifics of individual projects**. The following general trends may be discerned: (i) most of the socio-economic criteria are relevant to many elements of the value chain and should be addressed at an early stage of the project; (ii) sustainable water aspects are relevant notably to hydrogen production and transformation into derivatives; (iii) biodiversity and soil conservation as well as air quality are relevant or potentially relevant, most notably to the installation and assembly phases rather than to the operation phase; (iv) additionally and geographic correlation relate to the installation & assembly phases of renewable energy production, hydrogen production and transformation into derivatives; (v) temporal correlation relates to the operational phases of renewable energy production and hydrogen production, and possibly to transformation into derivatives, which still needs to be confirmed through the delegated acts; (vi) the greenhouse gas balance as required by the Renewable Energy Directive relates to the operational phases of all value chain elements.

Figure 4: Hydrogen value chain



The matrices with the coverage of relevant criteria by selected certification schemes broken down by value chain element highlight the different profiles of the certification schemes with different focus areas. From this relevance assessment it may be concluded that there are many sustainability criteria that should be covered in green hydrogen projects in order to secure the success and sustainability of the installation and operation of the projects. However, given that every element of the value chain of a project is divided into different stages (in this case it was considered installation & assembly, and operation & maintenance) and the impacts related with each one of this stage can vary considerably from one to another (depending on the specific characteristics and timelines of individual projects), **it will probably not be possible to standardize the application of a single certification scheme to a project that covers all the identified sustainability criteria.**

Finally, it should be noted that dedicated hydrogen certification schemes so far only cover a very limited set of criteria, mainly focus on the origin of electricity input and greenhouse gas balance, while other certification schemes, which are not related to hydrogen, cover wider sets of environmental and socio-economic criteria, which are generally relevant to various elements of the hydrogen value chain as well. However, the dynamic nature of the development of hydrogen sustainability certification will change this picture significantly over the coming one to two years.

Conclusions: Survey among German Off-Takers

83 companies from 19 sectors and sub-sectors, of which 12 energy intensive sectors, were taken into account for identifying potential survey participants; of these, 47 companies were actually identified and invited to respond. 18 full responses have been received out of 47 invitees, representing a response rate of 38%.

It must be emphasized that the limited number of responses, which is due to the fact that hydrogen or derivatives off-takers are small in number (although large in terms of hydrogen and/ or derivatives consumption), does not allow for a statistical analysis. The results presented here should be understood as tendencies rather than as representative results based on statistical evidence.

The high response rate and the broad coverage of sectors, both energy intensive and other, demonstrate a strong interest by industry in the topic in line with the German national hydrogen strategy. Furthermore, survey respondents include both current and interested future consumers of hydrogen and/ or derivatives demonstrating the quickly increasing commercial relevance of the topic, which is highlighted by the concreteness of the respondents' preparations of their future consumption installations through feasibility studies, pre-FEED (front-end-engineering design) and FEED studies and even investment decisions taken.

The development of sustainability criteria, and more importantly the development of legal requirements, is very dynamic, even if the long-awaited delegated acts to be adopted by the European Commission are delayed because of a certain level of controversy apparent from publicly available stakeholder comments, which has also become obvious through some comments in the framework of this survey. While political debates are not conducted in the public, industry stakeholders voice fears, including in this survey, that overly strict sustainability criteria may have unintended negative consequences.

Other recent position papers and publications such as that of the German National Hydrogen Council [75] or of Öko-Institut [76] confirm the relevance of a broad set of sustainability criteria for hydrogen and derivatives for import into Germany. Also, they highlight the importance of international harmonization of sustainability criteria for hydrogen and derivatives, which is also emphasized by industry papers such as "Policy Toolbox for Low Carbon and Renewable Hydrogen" by the Hydrogen Council [77].

It is all the more important to understand the sustainability requirements (covered in this study), the off-taker preferences (as analyzed by this study), and the producer realities and challenges (as compiled by the H2Global-related market consultation).

The dynamic development of this field is a challenge to industrial stakeholders. The survey respondents are at very different stages of their own considerations of sustainability requirements from "no considerations yet" to "we have our own/ internal standard". On average, energy intensive sectors are more advanced in their considerations than other sectors in this survey.

As a general result, all sustainability criteria are ranked very important or rather important by many respondents. This demonstrates a high level of acceptance among off-takers for broad sets of sustainability requirements. Nonetheless, there are some differences. Most notably, the RED II requirements of additionality/ new installations, and temporal and geographic correlation, are controversial. Hydrogen off-takers in the survey see some risk that the detailed definition of these requirements through the delegated act may hamper the dynamic development of the hydrogen sectors aspired by politics and society as a whole as a key enabler towards climate neutrality.

Hydrogen certification schemes thus far have mainly focused on greenhouse gas balance and renewable input energies to hydrogen production. An enlargement to cover broader sets of sustainability criteria, similar to existing certification schemes for biofuels, however with different sustainability focus areas, is foreseeable.

The willingness to pay a premium for sustainability criteria that go beyond “greenness” of hydrogen and derivatives cannot be estimated, not even qualitatively, from this survey, as most respondents made no statement on this issue. Possibly, the topic is still too recent for companies to have a robust basis for such assessments. Nonetheless, more targeted research into this topic would be beneficial to all stakeholders.

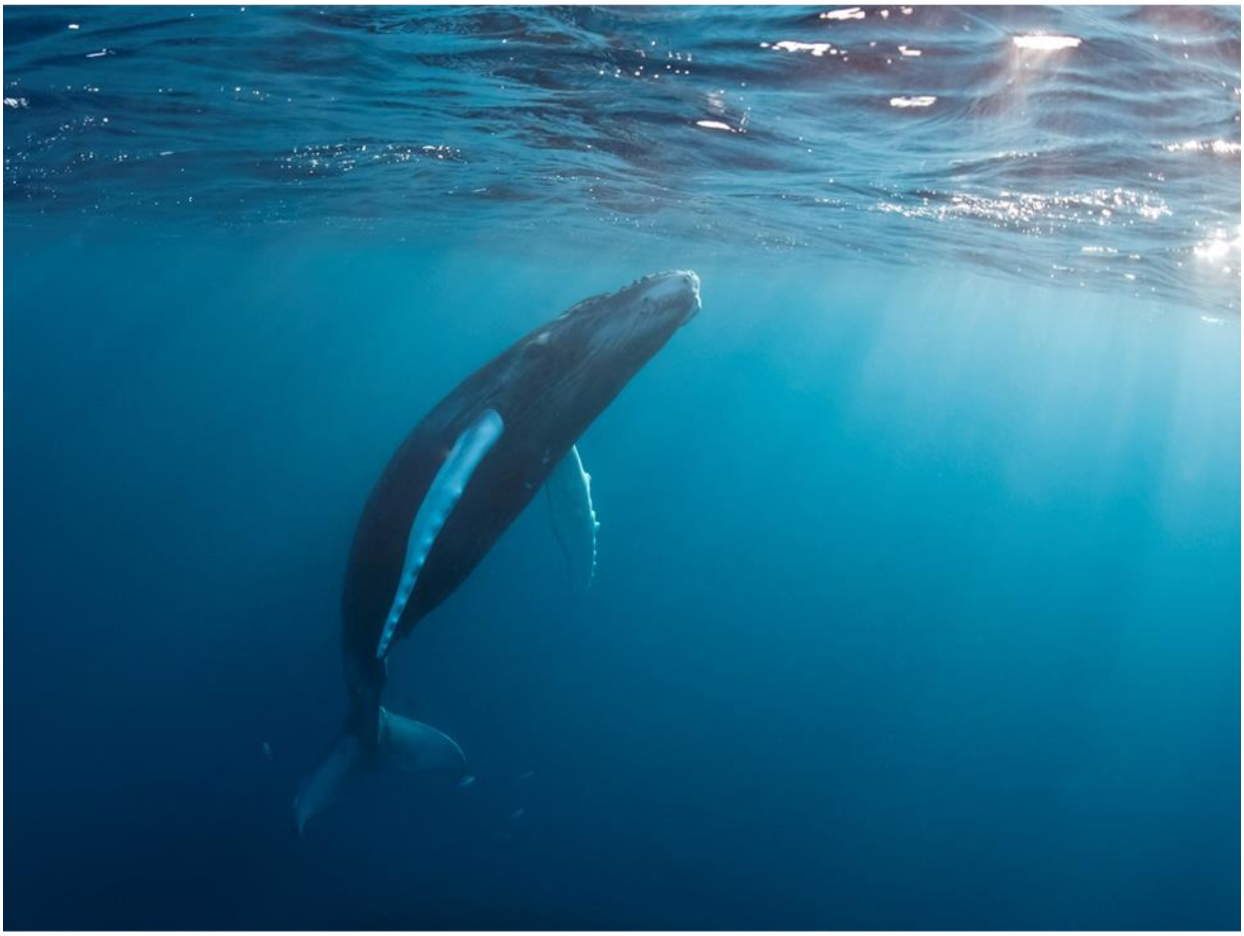
Respondents show a clear preference for a harmonization of sustainability criteria at international level, most notably for a consistent calculation methodology for greenhouse gas balances. Nonetheless, harmonization at European Union level is also desirable for a number of respondents. Although there is a clear interest for an international harmonization of sustainability certification for hydrogen and derivatives, success is not guaranteed given the various individual national and regional developments internationally. Also, while harmonization is a common denominator, the level of ambition and the broadness of criteria are diverging.

This survey shows no or very little differences between energy intensive sectors and other sectors in their rankings of sustainability criteria. This is rather surprising given the different market conditions of energy intensive sectors and other industries.

In contrast respondents representing today’s consumers of hydrogen and/ or derivatives rank a number of sustainability criteria differently than respondents representing future consumers. While today’s consumers rank renewable energies lower than future consumers, they rank legally binding criteria and other environmental criteria higher. Also, today’s consumers rank social criteria substantially higher than those representing future consumers. Differences related to environmental criteria between today’s and future consumers are small in general; the most notable difference is in efficient use of water, which is ranked more important by today’s consumers than by future consumers. Labor and safety aspects are ranked highly by all respondents, which may be an advantage for exporting countries that adhere to relevant international conventions.

One possible explanation for these differences is that today’s consumers are in general more advanced in their consi-derations of sustainability criteria than future consumers. More research to confirm such a trend, and to better explain these differences would be beneficial to all stakeholders.

Recommendations



A number of recommendations can be derived from the results of this study, which are structured into three dimensions targeting government institutions, project developers, and certification schemes.

Government institutions

In general, certification of renewable hydrogen and its derivatives is a critical element as it reliably proves the sustainability quality of the product that is the basis for the price premium compared to non-renewable hydrogen and fuels, and which thus enables economic viability. Therefore, government institutions have an important role to play in ensuring the reliability and transparency of certification schemes, and their acceptance in the market. Where markets are regulated such as by the Renewable Energy Directive recast in the European Union, or by other regulation, the acceptance by the authorities in charge of ensuring compatibility with the regulation is key.

As a consequence, it is highly recommended that the government institutions of the hydrogen producing and exporting countries are in close contact to the relevant government institutions in the receiving/ importing countries. In the case of the European Union, this refers to both the European Commission as well as potentially to government institutions of EU Member States, which transpose the EU Directives into national law possibly defining specific requirements also at national level.

As far as the European RED II is concerned, certain sustainability criteria are defined and need to be complied with, while further criteria which may be deemed relevant by the exporting country. Such further criteria could either be covered by certification schemes on a voluntary basis where the hydrogen off-takers are interested in such criteria to be covered. However, this may only cover a subset of further criteria, and it may only be covered by a certain share of the hydrogen/ derivatives. As an alternative, governments in the exporting countries may consider defining regulatory requirements in view of such further criteria.

Project developers

For project developers intending to establish hydrogen and/or derivatives production facilities for export, it is highly recommendable to be aware of certification requirements by the target countries where the hydrogen and/or derivatives will be consumed, and to make sure to use certification schemes accepted in the target countries. These should be studied in detail. Furthermore, market participants in the target countries may have additional requirements compared to the regulatory requirements, e.g. related to water consumption or social dimensions. These requirements need to be understood in order to be successful on the target markets.

Certification requirements, both legally required and requested by the market, should be studied and taken into account as early as possible in the project development process in order to adequately design the project. Later adjustments required by the certification criteria may be costly and time consuming to implement. Furthermore, certain criteria may require certain studies and assessments which take time. This notably refers to social impact assessments for socio-economic criteria, and environmental impact assessments related to environmental criteria. Furthermore, sustainability aspects of local importance beyond legal and certification/ off-taker requirements should be identified and taken into account in order to ensure the success of the projects.

Certification schemes

The sustainability certification of renewable hydrogen and derivatives is a new concept that is currently evolving dynamically. A limited number of certification schemes specific to hydrogen already exist, while others could be suitable in principle without specific coverage of hydrogen and derivatives so far. All certification schemes have limitations as far as hydrogen and derivatives are concerned, and thus need to evolve. This evolution should be done keeping in mind the results of this study. Most notably, some criteria not required by pertinent regulations may be relevant and should be included in the definition of certification criteria. This notably relates to water consumption criteria as well as to social and community issues. While there is no clear-cut solution as to which criteria in detail should be covered, a discussion and consultation process should be implemented to identify and integrate such relevant criteria.

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