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POLICY BRIEF: CRITERIA FOR GREEN HYDROGEN AND ITS DERIVATIVES IN EXPORT MARKETS

Scaling Up Renewable Energy Project

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September 2023

Prepared for:
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1 RELEVANCE OF H_2 SUSTAINABILITY CRITERIA

Green hydrogen (H_2) will likely be an important part of the portfolio of technologies and measures needed to achieve climate and energy goals. Global H_2 demand is expected to reach 470 megatons (Mt) by 2050 in the International Energy Agency's (IEA's) Net Zero Emissions by 2050 (NZE) Scenario.[1] The anticipated cost reductions of green H_2 in the next decade[2] and its contribution toward achieving net-zero carbon dioxide (CO_2) emissions in energy-intensive, hard-to-decarbonize sectors like steel, chemicals, long-haul transport, shipping, and aviation have propelled this technology to the forefront of national energy strategies. Although momentum is building, the rate of future cost declines will influence the pace of green hydrogen's global uptake.

Countries that have limited domestic opportunities to produce low-cost, low-emission hydrogen may have to rely on H_2 imports. International trade of green H_2 (including ammonia and hydrogen-based fuels) is set to reach more than 70 Mt of H_2 equivalents (H_2e) by 2050 according to the IEA's NZE Scenario.

Figure 1 presents an overview of expected clean H_2 (blue[3] and/or green H_2) demand in the European Union (EU), Germany, Japan, and South Korea. These jurisdictions are unlikely to meet their future blue and/or green H_2 demand through domestic production alone and will have to rely on imports. H_2 sustainability criteria are therefore critical to ensuring that H_2 is economically, environmentally, and socially sustainable along the value chain, from production through use. Potential exporters of H_2 or its derivatives such as green ammonia or green methanol will need to certify that H_2 or H_2-based derivative volumes comply with the sustainability criteria of the respective importing countries to access these markets and relevant support schemes.

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[1] In the Net Zero Emissions by 2050 (NZE) Scenario, CO_2 emissions fall to 23 gigatons (Gt) in 2030 and to zero in 2050, a trajectory consistent with limiting the temperature increase to less than 1.5 °C in 2100. International Energy Agency (IEA), *Towards hydrogen definitions.*

[2] According to IRENA, up to 85 percent of green H_2 production costs can be reduced in the long term by a combination of cheaper electricity and lower electrolyzer capital costs, along with increased efficiency and optimized electrolyzer operation. IRENA, *Making the breakthrough.*

[3] Blue H_2 refers to H_2 produced by fossil fuels in combination with carbon capture and storage (CCS).

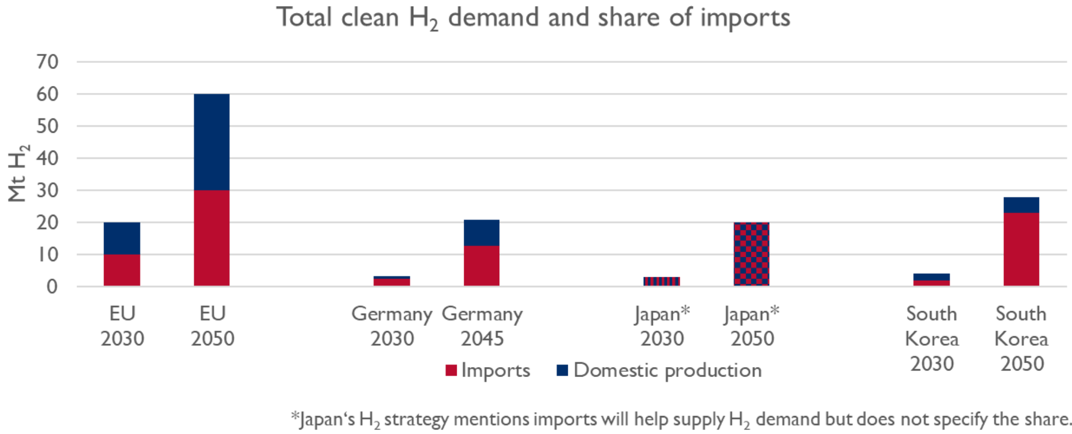

Figure 1: Expected total demand of hydrogen from the EU,[4] Germany,[5] Japan,[6] and South Korea[7] divided into imports and domestic production.

2 INSTRUMENTS DEFINING H_2 SUSTAINABILITY CRITERIA

H_2 sustainability criteria refer broadly to the product specification for H_2 or derivatives regarding environmental (e.g., GHG emissions intensity, electricity and CO_2 sourcing, and impact on water resources) and social sustainability criteria (e.g., land-use rights, labor standards including health and safety, and local benefit sharing).

Regulations, standards, and certification schemes define and enable the implementation of H_2 sustainability criteria. Globally, H_2 regulations, standards, and certification processes are still under development, but key criteria are emerging and there are early efforts to coordinate standards internationally in forums like G7 and organizations such as the IEA.

This policy brief (see section 4) focuses on the sustainability criteria defined in EU regulation because these criteria are more detailed than other jurisdictions and the region is an attractive market for green H_2 and derivatives exports. Other countries are working toward setting H_2 sustainability requirements—the most prominent example is the United States with the Inflation Reduction Act (IRA) passed in 2022. IRA introduced considerable subsidies for clean H_2 production. However, because the IRA is not a standard but rather a support scheme to ramp up investments in domestic clean H_2 capacities, its obligations fall on the U.S. producer and not on the consumer. Therefore, IRA subsidies do not apply to imports of clean H_2 at this stage and are not analyzed in detail in this policy brief.

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[4] Figures for 2030 according to European Commission, REPowerEU plans. Figures for 2050 according to World Energy Council, *Decarbonised hydrogen imports into the European Union*

[5] Figures for 2030 according to National Hydrogen Strategy, 2020. Figures for 2045 according to Fraunhofer ISI (2022). Meta study Langfristszenarien. Available online: https://www.langfristszenarien.de/enertile-explorer-de/

[6] Ministry of Economy Trade and Industry, 2021, *Japan's vision and actions toward hydrogen-based economy*, available at: https://iea.blob.core.windows.net/assets/dc5e783e-c4b4-4878-9534-48e8a6472c98/20211124-IEA-EGRD_HYoshida.pdf

[7] S&P, 2021, *S Korea to provide 27.9 mil mt/year of 'clean hydrogen' by 2050*, available at: https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/112621-s-korea-to-provide-279-mil-mtyear-of-clean-hydrogen-by-2050

Instrument	Country/Jurisdiction	Relevant Regulations/Standards
Regulations (including policies and support schemes)	European Union	• Renewable Energy Directive II (RED II)
	United States	• Inflation Reduction Act (IRA)
	Germany	• H_2 Global
	United Kingdom	• Renewable Transport Fuel Obligation (RTFO)
	International	• Climate Bonds Initiative
Standards (including certification schemes)	International[8]	• TÜV Süd CMS 70 • TÜV Rheinland H2.21 • CertifHy
	California (United States)	• Low Carbon Fuel Standard (LCFS)
	Aichi Prefecture (Japan)	• Low-carbon hydrogen certification scheme
	United Kingdom	• UK Low Carbon Hydrogen Standard
	Australia	• Zero Carbon Certification Scheme
	International (Green Hydrogen Organization)	• Green Hydrogen Standard

Figure 2: Overview of existing H_2 regulations, standards, and certification schemes (Sources: dena 2022,[9] IEA 2023[10])

Figure 2 summarizes existing instruments. **Regulations,** which include **support schemes**, usually introduce definitions of H_2. For instance, the EU's RED II regulation defines renewable H_2 and introduces precise sustainability criteria for compliance purposes, such as the emission reduction requirement.

Standards encompass requirements or criteria that H_2 actors along the value chain are required to fulfill. Standards can exist independently of regulation or be developed to reflect regulatory requirements (e.g., voluntary schemes in the EU). For example, the voluntary standard TÜV Süd CMS 70 (green hydrogen, green hydrogen+) is expected to be updated for alignment with RED II.

Certification schemes establish a framework and process to provide proof that H_2 suppliers operate in line with the requirements specified by regulations or standards. Although certification schemes (such as CertifHy) can introduce specific requirements and criteria for green or clean H_2, in most cases they

[8] TÜV Süd CMS 70, TÜV Rheinland H2.21, and CertifHy are standards based on EU requirements that apply to H_2 consumption in Germany, but they have also certified H_2 produced outside Germany.

[9] Deutsche Energie-Agentur GmbH (dena), 2022, *Global Harmonization of Hydrogen Certification: Overview of global regulations and standards for renewable hydrogen Report*, available at: https://www.dena.de/fileadmin/dena/Publikationen/PDFs/2022/REPORT_Global_Harmonisation_of_Hydrogen_Certification.pdf

[10] International Energy Agency (IEA), 2023, *Towards hydrogen definitions based on their emissions intensity*, available at: https://iea.blob.core.windows.net/assets/acc7a642-e42b-4972-8893-2f03bf0bfa03/Towardshydrogendefinitionsbasedontheiremissionsintensity.pdf

focus on verifying and certifying that certain parts of the value chain adhere to criteria defined by other regulations or standards.

3 GREEN H_2 AS AN ELEMENT OF H_2 SUSTAINABILITY CRITERIA

As with other large infrastructure projects, producing green H_2 and derivatives could have negative environmental and social impacts, including in the communities where these projects are sited. Addressing environmental and social impacts from the project's outset can help avoid or mitigate these harms and is often a requirement to secure project funding from development finance institutions and help access import markets (and their support schemes).

Figure 3 presents an overview of sustainability requirements. This policy brief focuses on green H_2 as defined in EU regulation, namely on the GHG emission intensity of the H_2 value chain and the origin of the electricity used to produce electrolysis-based H_2 and carbon for synthetic fuels ("energy & climate" criteria in Figure 3). Additional environmental requirements address impacts on water and land resources, biodiversity, and air quality. Similarly, social impact requirements refer to land-use rights, labor and safety conditions, and benefit sharing.

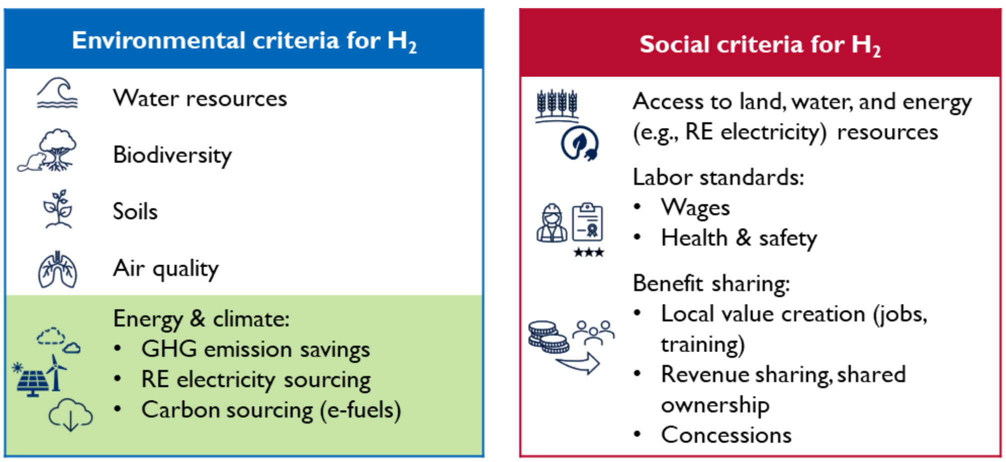

Figure 3: Overview of H_2 sustainability requirements (Sources: SURE, International PtX Hub)

4 CASE STUDY: SUSTAINABILITY CRITERIA FOR GREEN H_2 IN THE EUROPEAN UNION (EU)

4.1 THE REGULATORY FRAMEWORK FOR GREEN H_2 IN THE EU

While many countries are developing their own green H_2 regulations and standards, the EU has adopted the most comprehensive and detailed regulations to date. In principle, these sustainability criteria need to be met for both green H_2 and H_2-based derivatives consumed in the EU. The requirements apply to green H_2 and H_2-based derivatives produced in or imported into the EU to be counted toward the achievement of EU renewables targets delineated in the revised Renewable Energy Directive (REDIII).

The RED is the legal framework for the development of renewable energy across all sectors of the EU economy. The first European Commission proposal of the REDIII was published in

July 2021.[11] A provisional agreement was concluded in March 2023, and its final adoption and publication are expected for summer 2023. Once adopted, the REDIII needs to be transposed into national law by all EU Member States within 18 months from entry into force.

Green H_2 or its derivatives consumed in the EU that comply with EU sustainability criteria can be used to meet the EU-wide binding target for renewables of at least a 42.5 percent share of gross final energy consumption by 2030. Beyond the overall renewable energy target, the REDIII agreement foresees sub-targets on the use of green H_2 and its derivatives[12] in the industry and transport sector. For the industry sector, 42 percent of the H_2 used in 2030 and 60 percent by 2035 should be renewable. In the transport sector, advanced biofuels and green H_2 and its derivatives must together account for 5.5 percent of renewable energy supplied to the transport sector (by energy content). Green H_2 and its derivatives must account for at least 1 percent by 2030. Moreover, the European Commission's RePowerEU plan, published in May 2022, targets 10 million tons of domestic renewable H_2 production and 10 million tons of renewable H_2 imports by 2030.[13]

In the EU regulatory context, the sustainability of green H_2 and its derivatives is defined along two main dimensions, which are spelled out in two commission delegated acts (DA)[14] under the recast Renewable Energy Directive II,[15] i.e., the precursor of REDIII.[16] As outlined above, the requirements of both dimensions need to be fulfilled so that the produced H_2 and its derivatives qualify as green fuel in the EU and can be counted toward the EU-wide renewables target and sector-specific H_2 sub-targets. The two dimensions are

1. The **GHG emission intensity of** H_2 and its derivatives along the whole life cycle[17] and
2. The **renewable origin of the electricity** used to produce H_2.[18]

The two delegated acts were formally adopted in June 2023[19]. Based on the criteria set out in the delegated acts, voluntary schemes to ensure compliance can be established and recognized by the commission. These voluntary schemes consist of concrete standards that set out how companies demonstrate compliance with the criteria, as well as rules on traceability and auditing. The scheme also appoints certification bodies accredited by EU Member States' national accreditation bodies. Independent third-party auditors conduct audits of companies to check that they comply with the criteria. Certification bodies award "certificates of compliance" to companies that successfully pass an audit.

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[11] Council of the EU, "Council and Parliament Reach Provisional Deal on Renewable Energy Directive. Press release, 30 March 2023."

[12] In the EU legal framework's terminology, green hydrogen and its derivatives are classified as "renewable fuels of non-biological origin" or "RFNBOs." For international consistency, we instead use the term "green hydrogen and its derivatives" throughout this paper.

[13] European Commission, EUR-Lex, "Communication from the Commission."

[14] Delegated acts are adopted directly by the European Commission on the basis of a delegation granted in the text of an EU law, in this case the RED II. The commission prepares and adopts delegated acts after consulting expert groups, composed of representatives from each EU country, which meet on a regular or occasional basis.

[15] European Union. EUR-Lex. "Directive (EU) 2018/2001."

[16] Ibid. Delegated acts are adopted directly by the European Commission on the basis of a delegation granted in the text of an EU law, in this case the recast Directive (EU) 2018/2001 of 11 December 2018 on the promotion of the use of energy from renewable sources (RED II). The commission prepares and adopts delegated acts after consulting expert groups, composed of representatives from each EU country, which meet on a regular or occasional basis.

[17] European Commission. "Commission Delegated Regulation (EU) of 10.2.2023."

[18] Ibid.

[19] European Commission. "Renewable hydrogen production: new rules formally adopted."

Figure 4 provides an overview of the EU regulatory architecture on EU sustainability standards for green H_2 and its derivatives.

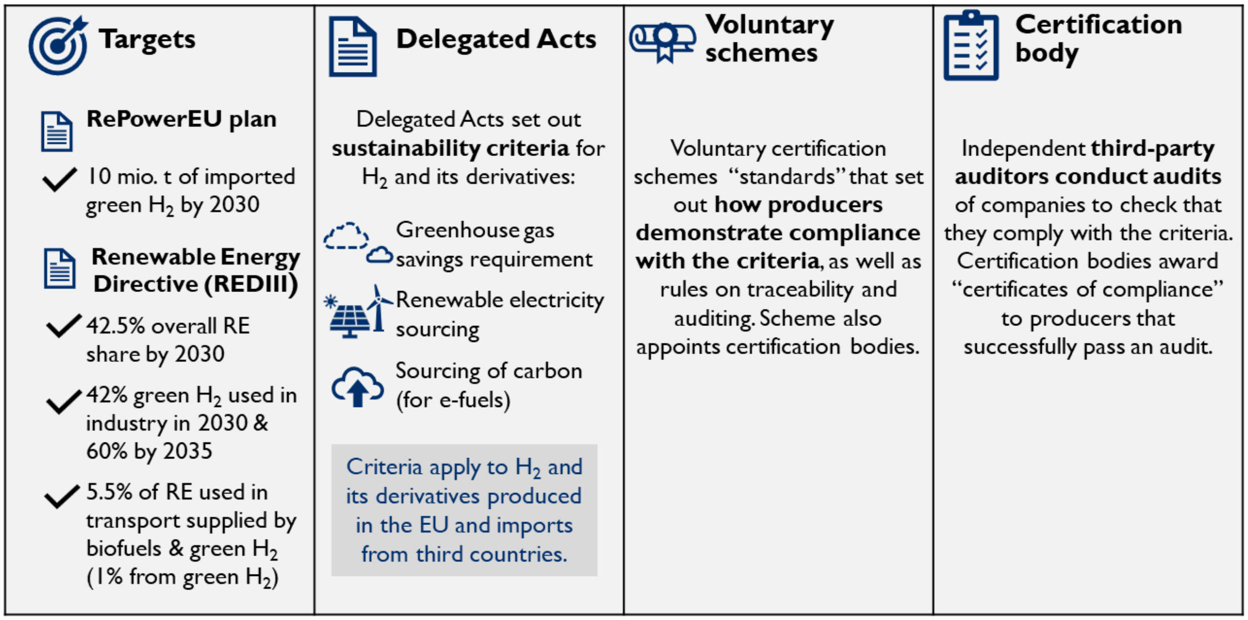

Figure 4. Overview of the EU regulatory architecture on EU sustainability standards for green H_2 and its derivatives.

The EU sustainability criteria set ambitious requirements to be met by producers of green H_2 and its derivatives intending to export to the EU. At the same time, EU renewables and renewable H_2 targets as delineated in the revised REDII are likely to create significant demand for green H_2 and its derivatives in the EU. In turn, this will impact EU off-takers' willingness to pay and thus the attractiveness of exports to the EU. To benefit from these new market potentials and respond to the EU's significant reliance on imports from outside the EU (see Figure 1), producers in exporting countries are likely to have sufficient incentives to comply with the criteria.

The following sections describe the two sustainability dimensions relevant for exports of green H_2 to the EU—their **GHG emission intensity** and **renewable electricity origin**.

4.2 EU CRITERIA ON THE GHG EMISSION INTENSITY OF H_2 AND ITS DERIVATIVES

EU criteria on the GHG emission intensity of low-carbon H_2 and its derivatives define maximum life-cycle GHG emissions of 3.4 kilograms (kg) of carbon dioxide equivalents (CO_2e) per kg of H_2, i.e., across the entire value chain from production to end-use. This emission reduction threshold is equivalent to 70 percent GHG emission savings, compared to a fossil fuel comparator of 94 grams of CO_2e per megajoule, and sets the lower boundary for H_2 and its derivatives to be considered low carbon (see Figure 5). It is also a prerequisite for counting imported H_2 or its derivatives as renewable in the importing country (see section 4.3). One of the key implications is that the lower the carbon intensity of the ship transport, the more easily the threshold would be achieved.

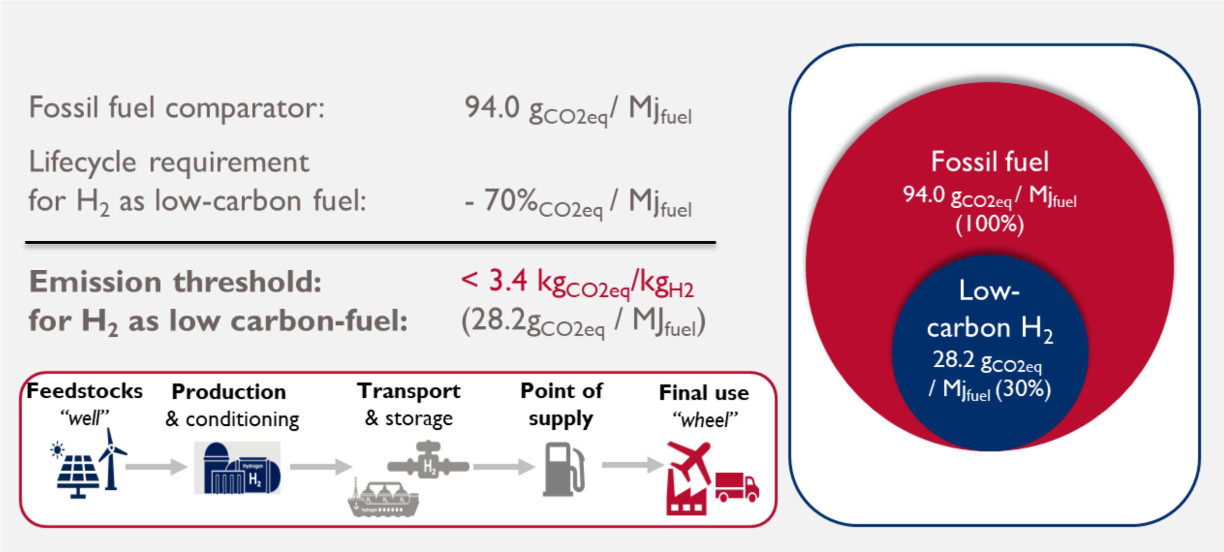

Figure 5: EU GHG emissions reduction threshold for low-carbon H_2 and its derivatives

The GHG emission accounting methodology considers the full life-cycle emissions of (low-carbon) H_2 and its derivatives, i.e., H_2 production, transport, storage, and use. As a result, emissions from electricity used for conversion, liquefaction, and regasification during transportation (via ships, trucks, and/or pipeline) need to be considered because they lower the threshold for (low-carbon) H_2 production itself. However, emissions from the manufacturing of equipment are not considered (e.g., emissions from the manufacturing of electrolyzers). Moreover, for H_2 specifically, emissions resulting from compression and distribution for direct use in vehicles are not included.

The delegated act defines two main cases to calculate GHG emissions arising during the production of H_2:

(1) The carbon footprint to produce H_2 will be zero if the electricity used for the production of H_2 is fully renewable according to the delegated act on renewable energy content (see section 4.3). As discussed above, potential additional life-cycle emissions, such as those arising during transport, will still need to be sufficiently low to fall below the GHG emissions threshold.

(2) If the electricity used to produce H_2 is not fully renewable, more detailed carbon footprint calculations apply (e.g., using the average carbon footprint of the producing country, including upstream emissions). Here, reducing the GHG emissions by at least 70 percent compared to the fossil comparator will imply a relatively low share of fossil fuel in the producing country's electricity supply and thus very high shares of renewable electricity in the power system (> 80 percent).[20]

The EU rules on GHG emission intensity of H_2 and its derivatives also prescribe that CO_2 used in the production process, such as green methanol, must be carbon neutral. This means that it can be deducted from the renewable fuels of non-biological origin (RFNBO) carbon footprint under certain conditions, e.g., if it is captured in industries covered by a CO_2 pricing system, such as the EU-Emissions Trading System if produced in the EU, or through direct air capture (see Figure 6). The use of CO_2 from unsustainable

[20] Alternatively, the GHG emission reduction threshold could also be achieved if H_2 is produced with grid electricity largely based on nuclear energy in the grid mix. In this case, the produced H_2 could qualify as low carbon, but it could not be certified as renewable or green hydrogen according to the additional delegated act on RE content of RFNBO, which requires that H_2 or its derivatives need to be produced with renewable energy (see section 4.3).

(fossil) fuels is permitted only until 2035, or until 2040 if activities are covered by an effective carbon pricing scheme, at which time a complete switch to biogenic CO_2 sources or CO_2 captured directly from the air must occur to comply with EU rules. Figure 6 provides an overview of permissible carbon sources in the medium and long term according to applicable EU rules.

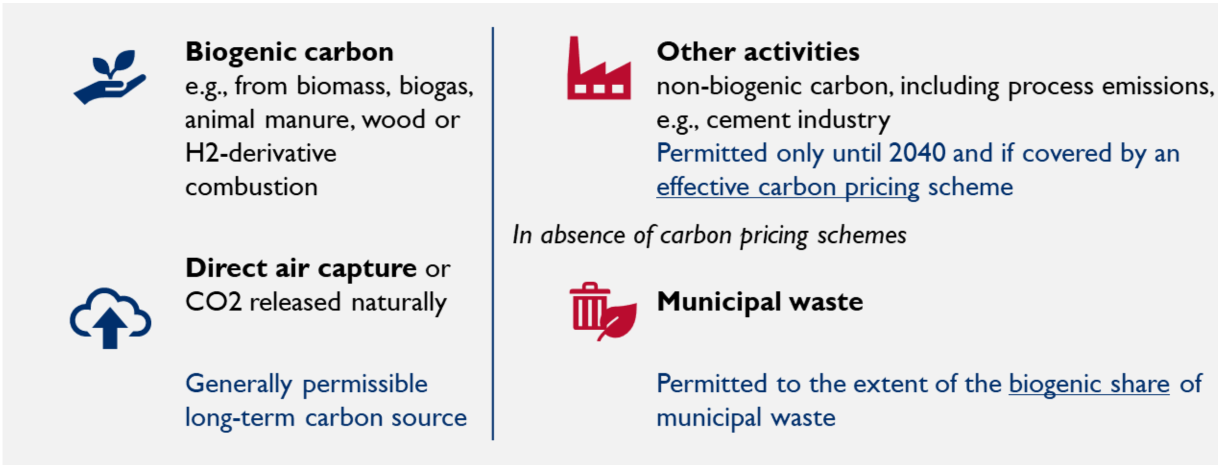

Figure 6: Permissible carbon sources for low-carbon H_2-based derivatives in the EU

4.3 EU CRITERIA ON THE RENEWABLE ORIGIN OF ELECTRICITY USED TO PRODUCE GREEN H_2 AND ITS DERIVATIVES

In principle, H_2 and its derivatives are considered renewable when produced in an electrolyzer that uses renewable electricity. EU criteria on the sourcing of renewable electricity differentiate between two main models:

1. **Electricity to produce H_2 and its derivatives is sourced only from directly connected renewable electricity plants**, i.e., the electrolyzer is not connected to the electricity grid or can prove that power was not taken from the grid via a smart meter ("off-grid model" or "insular electrolyzer").

2. **Electricity to produce H_2 and its derivatives is taken from the grid**, i.e., the electrolyzer is connected to the electricity grid ("on-grid model" or "non-insular electrolyzer").

Figure 7 provides an overview of the applicable criteria in both cases.

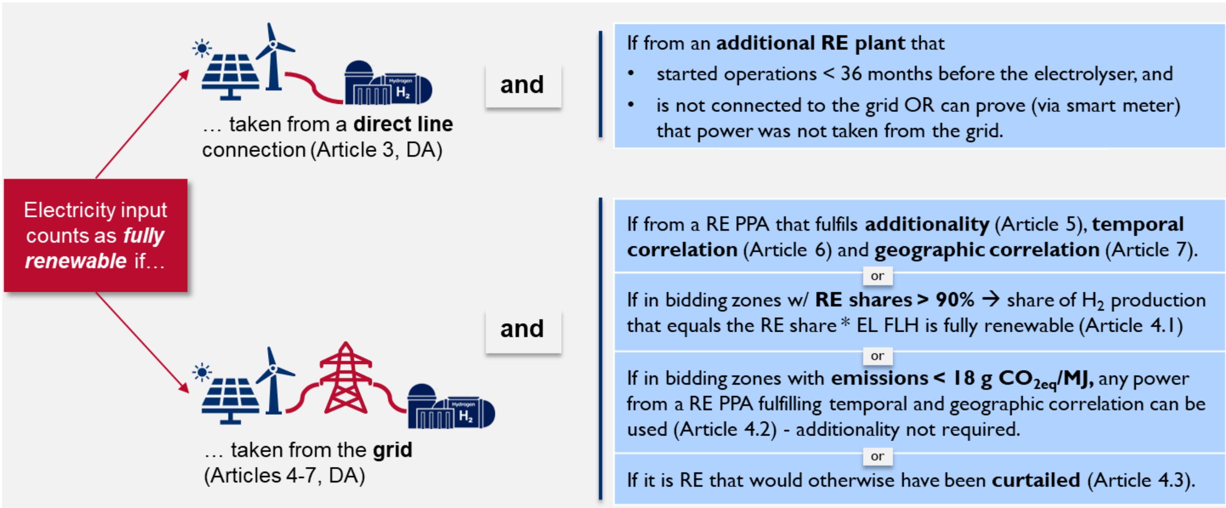

Figure 7: Overview of renewable electricity criteria for renewable H_2 and its derivatives (direct line connection and taken from the grid)

For each of the two models, more specific criteria apply. In general, there are fewer criteria to fulfill for the off-grid model than for the on-grid model. Especially for the on-grid model, the main rationale of these criteria is that electricity taken from the grid to produce H_2 and its derivatives may result in increased GHG emissions if no criteria apply that (1) require H_2 to be produced using additionally deployed renewable electricity capacities (**additionality criterion**) or (2) limit production to times of day and locations with sufficient renewable electricity availability in the system (**temporal and geographic correlation**), e.g., to avoid fossil-based power plants having to ramp up to provide the additional electricity required by the electrolyzer.

The summary below provides the criteria for the RE content of H_2 and its derivatives for the off-grid and on-grid electrolyzer models.

Off-grid model: Rules for counting H_2 produced with electricity from RE plants directly connected to the electrolyzer as fully renewable. If the electrolyzer and the renewable plant are connected through a direct line or are part of the same plant (i.e., as part of an integrated project), the RE plant needs to be commissioned no more than three years before the electrolyzer.[21] This three-year period provides some flexibility for project developers, reflecting the longer lead times for RE commissioning, especially for wind energy projects compared to solar PV projects. Moreover, additional electrolyzer capacity may be connected up to 24 months after the start of operations of the original plant and still be considered part of the original plant. This rule facilitates a modular extension of larger electrolyzer capacities over time.

On-grid model: Rules for counting H_2 produced with electricity from the grid as fully renewable. If the electrolyzer is located in an electricity grid where the renewable electricity share exceeds 90 percent, the H_2 automatically counts as fully renewable, but the maximum amount of full-

[21] According to Article 3 of the delegated act to count electricity used for RFNBO production as fully renewable. See European Union. Commission Delegated Regulation of 10.2.023 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council by establishing a Union methodology setting out detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin.

load hours is capped at the same percentage.[22] Moreover, H_2 counts as fully renewable if renewable electricity is used that would otherwise have been curtailed.[23]

If none of the above conditions apply, three core requirements apply: **(1) additionality,[24] (2) temporal correlation, and (3) geographical correlation**. These criteria refer to H_2 production via electrolysis alone, i.e., excluding the conversion from H_2 to derivatives such as ammonia or methanol. Figure 8 provides an overview of these three principles.

(1) Additionality demands that renewable electricity sourced for renewable H_2 production is "additional" to existing renewable electricity production. Without this, H_2 production could potentially increase GHG emissions because it creates additional electricity demand that might result in increased fossil power generation. The default provision for demonstrating additionality is that green H_2 producers need to source an (at least) equivalent amount of renewable electricity through power purchase agreements (PPAs) with unsubsidized renewable plants,[25] commissioned no more than three years before the electrolyzer.[26] A transitional period exists: Until 2038, green H_2 plants commissioned before 2028 may use renewable electricity from existing and subsidized plants, incentivizing early projects.

(2) Temporal correlation between green H_2 production and renewable electricity production is intended to ensure that the two are synchronized. For every calendar hour, the consumed electricity must either be generated by a renewable electricity plant contracted via a PPA between the green H_2 producer and the renewable electricity producer; come from a storage asset that was charged under these conditions; or be produced in a one-hour period where the clearing price at the day-ahead market is lower or equal to $21.62 (€20[27]) per megawatt-hour (MWh) or lower than 0.36 times the price of an emission trading scheme (ETS) allowance. However, hourly matching is replaced by monthly matching until 2030, eliminating the temporal constraint during this transitional period.

(3) Geographical correlation aims to avoid green H_2 producers being unable to physically source renewable electricity due to electricity grid congestion. The delegated act states that electrolyzers and

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[22] According to Article 4(1) of the delegated act to count electricity used for RFNBO production as fully renewable.
See European Union. Commission Delegated Regulation of 10.2.023 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council by establishing a Union methodology setting out detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin.

[23] According to Article 4(3) of the delegated act, electricity taken from the grid to produce H_2 may also be counted as fully renewable if the fuel producer demonstrates that the electricity is consumed during an imbalance settlement during which it can be demonstrated, based on evidence from the national transmission system operator, that power-generating facilities using renewable energy sources were downward re-dispatched and the electricity consumed for the production of renewable liquid and gaseous transport fuel of non-biological origin is reducing the need for re-dispatching by a corresponding amount. However, this is a specific use case that in itself would not allow for a sufficient business case, i.e., guaranteeing sufficiently full-load hours of the electrolyzer.
See European Union. Commission Delegated Regulation of 10.2.023 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council by establishing a Union methodology setting out detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin.

[24] If the electricity is sourced in bidding zones with emissions < 18 g CO_{2e}/MJ (e.g., in power systems with large shares of nuclear), any power from a RE PPA fulfilling temporal and geographic correlation can be used, i.e., the additionality criterion does not apply and also PPAs with existing or subsidized plants can be used (Article 4 (2) of the delegated act to count electricity used for RFNBO production as fully renewable).
See European Union. Commission Delegated Regulation of 10.2.023 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council by establishing a Union methodology setting out detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin.

[25] In the EU context, these subsidies refer to investment support or operating support on top of market revenues. However, support received prior to repowering or already repaid support is disregarded. In the context of non-existing wholesale markets, the definition of what constitutes a subsidy needs further clarification.

[26] However, the RE plant may renew its PPA with an electrolyzer and still be considered a new plant.

[27] €1 = $1.0808 (European Central Bank exchange rate on May 19, 2023)

renewables plants should be in the same bidding zones, an adjacent offshore bidding zone, or a neighboring bidding zone with equal or higher day-ahead market prices. The latter implies that grid bottlenecks do not constrain the electricity import direction.

Criterion	**European Commission** Delegated Act (DA) on Art. 27	Exemptions
Additionality	• RE PPA plant **< 3 years** old and not **subsidized** (unless in in bidding zones with grid emissions < 18 g CO2eq/ MJ), or • RE that would have been **curtailed**, or • High RE share in the power mix (> 90% in the last 5 years).	**Until 2038, H2-plants commissioned before 2028 may use RE from subsidized plants.**
Temporal correlation	• **Hourly matching*** between RE and H2 production (or charging of storage assets), or • Day-ahead clearing price ≤ €20/MWh or < 0.36 x the price of an EU-ETS allowance.	**Monthly matching until 2030.** * subject to revision upon review in 2028.
Geographic correlation	• **Same** or **interconnected** bidding zone with equal/higher day-ahead prices, or adjacent **offshore** bidding zone • Alternatively: comparable concept, e.g., **interconnection level / country** (in non-EU countries)	

Figure 8: Additionality, temporal correlation, and geographical correlation

There is no detailed guidance from the EU so far on how these criteria would be approached in third countries[28] without an electricity wholesale market or an ETS. Some rules are quite specific to the EU regulatory context, and thus it might be difficult for green H_2 producers in some third countries to demonstrate compliance. For example, some of the options to comply with temporal and geographical correlation refer to the existence of a day-ahead market with liquid market prices.

The applicable EU regulation refers to the possibility of using alternative comparable concepts for imports from third countries. For example, in the absence of bidding zones, compliance with the geographical correlation criterion may be achieved if the renewable electricity is sourced from a country or jurisdiction where there is one interconnected system.[29] However, a concrete definition of what would be considered an "equivalent concept" is not provided nor is it clear whether these "comparable concepts" need formal approval and, if so, by whom. In this context, the evolving certification systems to operationalize EU sustainability standards will likely play a key role in further defining these open issues for third countries. Moreover, bilateral or multilateral agreements between the EU and exporting countries may become necessary to further define standards.

5 KEY TAKEAWAYS FOR GREEN H_2 EXPORTING COUNTRIES

National H_2 strategies can help avoid trade-offs between domestic decarbonization goals and the export of green H_2 and its derivatives. Production and export of these derivatives are poised to become a transformative strategic industry for many countries. National strategies should envision the quantities of renewable energy sources (RES) needed to achieve national climate targets

[28] "Third" countries are those that are not part of the EU, European Free Trade Association, or European Economic Area.

[29] Point 3 of the delegated act to count electricity used for RFNBO production as fully renewable. See European Union. Commission Delegated Regulation of 10.2.023 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council by establishing a Union methodology setting out detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin.

destined for domestic consumption and, for countries with abundant RES, the quantities that are available to produce green H_2 and its derivatives for export. In both cases, countries should weigh the economic benefits that they achieve by participating in green hydrogen development given the tradeoffs.

Exporting countries should identify specific green H_2 derivatives that can be competitively produced and exported. Competitiveness depends on the costs when the derivatives exit the production facility as well as the transport costs to the point of entry in the country of import. Understanding a country's competitiveness also involves assessing how competitive its derivatives are compared to other exporters.

Green H_2 project setup and operation should follow the sustainability criteria of the target market. When defining requirements for green H_2 and derivatives production, producers in export countries should consider the applicable definitions and regulations in target import countries to comply with their respective product specifications and sustainability standards. Defining these requirements ensures that when projects are being built and operated, renewable electricity origin and carbon sourcing, GHG emission intensity, and other environmental and social criteria are aligned with target markets. It may also be useful to understand a country's comparative advantage relative to other would-be exporters in the region.

The EU has adopted the most comprehensive and detailed green hydrogen regulations that might influence standards in other parts of the world (e.g., forthcoming rules for green hydrogen production in the context of the U.S. Inflation Reduction Act). Other relevant import countries (e.g., Korea and Japan) are developing green hydrogen criteria as well, and international efforts to establish common standards are gaining momentum.

In the EU, the sustainability of green H_2 and its derivatives is defined along two main dimensions: GHG emission intensity and the renewable origin of the electricity used during production. The requirements of both dimensions need to be fulfilled so that the produced H_2 and its derivatives qualify as green fuel in the EU. In general, the criteria provide more leeway for producers in the early market phases until 2030. Moreover, different H_2 project setups result in different compliance requirements for the export of green H_2 into the EU.

Compliance with the rules for green H_2 projects with an insular electrolyzer ("off-grid" model) is less complex than for non-insular electrolyzers. Proving compliance with a non-insular electrolyzer ("on-grid" model) with sustainability criteria in the EU is more complex. In most cases, it requires proof that the renewable electricity used during production is backed by capacity additions and that the electricity used is temporally and geographically correlated with H_2 production.

Certain EU rules require further definition regarding their applicability in contexts outside the EU. So far, the EU has not provided detailed guidance on how these criteria would be approached in third countries without an electricity wholesale market or an ETS. The evolving certification systems to operationalize EU sustainability standards will likely play a key role in further defining these open issues. Moreover, bilateral or multilateral agreements between the EU and exporting countries may become necessary to further define standards.

SURE can support partner countries with capacity building on green H_2 sustainability criteria and with identifying domestic policies that support the market ramp-up of green H_2 and its derivatives.

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