Global Hydrogen Label Standards

Analysis of Carbon Intensity Thresholds and Policy Use

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HydroNet and the Case for Harmonised Hydrogen Labelling

Hydrogen is poised to play a key role in the cleanenergy transition, but not all hydrogen is produced sustainably. Governments are thus establishing hydrogen labels – *green, renewable, low-carbon* or *clean* – to distinguish hydrogen with low life-cycle greenhouse gas (GHG) emissions from conventional high-emission fossil hydrogen. These official labels set standards for climate-friendly production, build investor and public confidence and align incentives with environmental goals. Yet each jurisdiction defines labels and their respective fulfilment criteria differently, creating a patchwork of rules that complicates investment and cross-border trade.

As part of the publicly funded research project "HydroNet", a working group consisting of P3 energy solutions, Fraunhofer FIT, Westnetz and TÜV NORD is building an end-to-end digital chain for the traceability of hydrogen's GHG emissions and those of its derivatives. Work Package 10 (WP10) aims to deliver a production-to-use Digital Product Passport that travels with each batch, ensuring data availability, authenticity and integrity across international value chains. By automating auditable data capture and verification, WP10 seeks to reduce the cost and complexity of compliance while strengthening confidence in labels and certifications – ultimately improving hydrogen's competitiveness on global energy markets.

This whitepaper situates HydroNet WP10's work within the global hydrogen labelling landscape. We compare label standards across ten major economies and regions, focusing on carbon intensity (CI) thresholds and the policy mechanisms that employ these labels – such as grants, tax credits, procurement and trade. We explain why thresholds diverge (e.g. India's very strict 2 kg CO₂e/kg H₂ limit versus China's higher 14.51 kg "low-carbon" threshold) and we outline two complementary paths forward: greater international harmonisation of labels and fulfilment criteria, and CI-based incentive models that reward continuous decarbonisation rather than binary pass-fail thresholds.

Hydrogen Labels: Definition and Purpose

In policy and industry, hydrogen labels refer to officially recognised categories that classify and certify hydrogen based on how it is, the energy sources used, and its respective climate impact. Traditional colour terms – green hydrogen (from renewable energy), blue hydrogen (from fossil fuels with carbon capture), grey hydrogen (from unabated fossil fuels), etc. – have helped communicate the source of hydrogen. Increasingly, governments are formalising these concepts by defining labels in legal or regulatory terms, often tied to a maximum GHG emission value per kilogram of hydrogen produced. For example, hydrogen produced via electrolysis using renewables and emitting below a certain CI threshold may earn a "green" or "renewable" label, whereas hydrogen from natural gas with carbon capture might be labelled "low-carbon" if it stays under a different emissions limit.

The purpose of such labels is to signal environmental integrity – ensuring that the hydrogen truly offers substantial carbon savings over fossil hydrogen. Official labels typically come with verification and certification schemes so that producers can prove compliance. Once certified, the label can unlock policy benefits: governments use these labels to determine eligibility for incentives (like grants, tax credits or feed-in tariffs), to set procurement or blending mandates and to facilitate trade by providing a common definition of clean hydrogen. Hydrogen labels function as a policy tool to differentiate hydrogen by its climate impact, guiding both producers and consumers toward lower-carbon options.

3. Scope of Jurisdictional Comparison

This paper focuses on ten jurisdictions that are members of the Clean Energy Ministerial's Hydrogen Initiative (H2I) and that have established formal hydrogen labelling standards with defined CI thresholds. These are:

- European Union (EU)
- United Kingdom (UK)
- United States (US)
- Canada
- . China
- India
- . Japan
- South Korea
- Brazil
- . Saudi Arabia

All of the above have either enacted or officially proposed hydrogen classification standards as of 2025. Focusing on this group allows a representative survey of major hydrogen economies across Europe, North America and Asia, plus Brazil and Saudi Arabia as key emerging players. Countries that have not yet introduced a government-recognized label with a quantitative CI threshold are not included in this analysis. For example, Australia or Chile (also active in H2I) do not appear since their standards remain informal or qualitative for now. By limiting the comparison to H2I participants with defined labels, we ensure each jurisdiction in our analysis has a directly comparable metric (kg CO₂e/kg H₂) to examine. This selection also aligns with countries likely to engage in future trade of low-carbon hydrogen, highlighting the importance of understanding each other's standards.

4. Criteria for Hydrogen Labels and Cl Thresholds

Not all hydrogen-related initiatives count as a *label standard*. For this analysis, we consider a hydrogen label to mean a government-issued or legally codified classification of hydrogen that includes a defined CI threshold. In practice, this means the label is backed by law or regulation (or an officially endorsed voluntary industry standard) and specifies a maximum kg of CO₂-equivalent emissions per kg of H₂ for production. Purely colloquial labels or private certification schemes are excluded. For example, a government official may informally refer to "green hydrogen" in speeches, but until the government issues a rule defining what qualifies as "green", we do not count it as a label.

It is important to note that different jurisdictions set different system boundaries for measuring emissions, which affects how the thresholds are applied. Key variations include:

- Well-to-gate vs. full lifecycle: Some standards count emissions up to the point hydrogen leaves the production plant (well-to-gate). Others adopt a well-to-wheel approach, including downstream transport and even end-use combustion. In practice, end-use of hydrogen itself emits no GHG emissions, so the major difference is whether emissions from delivery and dispensing are counted. The EU methodology, for instance, includes transport to the point of use in its lifecycle assessment for "renewable" or "low-carbon" hydrogen, in line with its fuel substitution goals. By contrast, the UK's Low Carbon Hydrogen Standard counts emissions up to production (gate) and does not include use-phase transport or combustion.
- Scope of emissions included: All standards cover direct GHG emissions from production (e.g. from steam methane reforming or electrolysis electricity use). But treatment of upstream emissions (like natural gas leakage or coal mining emissions) and downstream transport can differ. South Korea's draft clean hydrogen criteria, for example, would calculate emissions from feedstock extraction through hydrogen production, but initially exclude emissions from international shipping of hydrogen. The UK and India count all production-related emissions including electricity generation and any inputs, but since they focus on domestic production, transport is limited to on-site compression and other processes.

Emission accounting methodology: Most jurisdictions base their calculations on a life-cycle assessment (LCA) or a specific GHG accounting framework. For instance, the EU uses a detailed methodology (Delegated Regulation under the Renewable Energy Directive) to account for electricity-related emissions, additionality of renewables, etc., ensuring a 70% emissions saving versus a fossil baseline. China's standard, meanwhile, was developed by the China Hydrogen Alliance using an LCA approach consistent with ISO 14040 series, but the thresholds chosen are relatively high. International harmonisation efforts like the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) and a new ISO standard (ISO/TS 19870 series) are in progress to standardise GHG accounting methods, but jurisdictions still differ in what they include or exclude (e.g. biofuel origin emissions, renewable energy "additionality" criteria, etc.).

By screening for official labels with set CI thresholds, we focus on comparable metrics, but the differences in scope must be kept in mind. A 4 kg CO_2e/kg H₂ threshold in one country may not be directly equivalent to 4 kg in another if one counts upstream methane leakage and the other does not, for example.

Comparative Analysis of Hydrogen Labels

Despite a common goal of defining "renewable", "low-carbon" or "clean" hydrogen, the ten jurisdictions show wide variation in label categories and stringency of CI thresholds. Some governments have multiple categories of hydrogen defined by different thresholds, while others use a single cutoff. Figure 1 provides a summary of each jurisdiction's label categories and their associated CI limits. The annex expands this with the complete overview, including the policy benefits associated with each label.



Figure 1: Global comparison of CI thresholds for hydrogen labels in jurisdictions participating in the Hydrogen Initiative (H2I) of the Clean Energy Ministerial.

5.1. Analysing Carbon Intensity Thresholds by Jurisdiction

As Figure 1 illustrates, the strictness of CI thresholds varies by nearly an order of magnitude across these jurisdictions. At the most ambitious end, India's newly announced green hydrogen standard of ≤2 kg CO₂e/kg H₂ is the tightest in the world, essentially restricting the label to hydrogen produced from near-100% renewable energy or equivalent lowemission feedstocks. The UK's 2.4 kg standard and the Green Hydrogen Organisation's voluntary 1 kg standard (not government, but influential) are similarly stringent. By contrast, China's official "low-carbon hydrogen" category allows up to 14.51 kg, which is well above the emissions of unabated fossil hydrogen from natural gas (~9-10 kg) and corresponds to roughly half the carbon intensity of China's typical coal-based hydrogen production (~29 kg). Brazil's 7 kg threshold is also relatively lenient, enabling a wide array of production methods to qualify as "low-carbon". Most other regions converge around 3-4 kg as the definition of clean hydrogen. The EU's implicit threshold of ~3.4 kg (for 70% savings) and Japan's 3.4 kg mirror each other, reflecting a common 70% reduction target. South Korea and North America (US/Canada) choose roughly 4.0 kg as a practical upper limit, likely for consistency with each other and recognition that this represents a substantial (>60%) reduction from grey hydrogen.

The number of label categories also differs. China and Brazil have multi-tier systems, distinguishing renewable vs. other low-carbon hydrogen. In China's case there are three tiers (renewable, clean, low-carbon) with two numerical thresholds, while Brazil defines three labels but with the latter two nested within the low-carbon threshold. This reflects an intent to acknowledge the best (zero-carbon renewable) hydrogen without excluding improved fossil-based hydrogen entirely. In contrast, the US, Canada and South Korea have essentially a single category of hydrogen that is acceptable (meet the threshold or not) – though they apply graduated incentives within that category as discussed later. The EU for now emphasizes the renewable hydrogen category (for meeting renewables targets) and has recently developed a parallel recognition of low-carbon hydrogen with the same 70% emissions cut requirement. Meanwhile India sticks to one label ("green") and explicitly ties it to renewable sourcing, effectively excluding non-renewable pathways entirely regardless of carbon intensity beyond the strict 2 kg limit.

5.2. India vs. China: Opposite Ends of the Spectrum

The stark contrast between India's and China's thresholds exemplifies how policy objectives and baseline emissions influence these standards. India's decision to set $2 \, \text{kg CO}_2 \text{e/kg H}_2$ as the cap for green hydrogen was driven by a desire to show climate leadership and ensure the "green" label denotes truly minimal emissions. At $2 \, \text{kg}$, India's standard represent a ~80% reduction from conventional grey hydrogen. Indian officials indicated this strict definition will help the nascent industry focus on genuinely clean production and boost international confidence in Indian green hydrogen. It also leverages India's huge renewable energy potential – effectively mandating that green hydrogen be made from renewables (or biomass) with negligible grid or fossil input. By being one of the first countries to legally define green hydrogen, and with an aggressive threshold, India aims to position itself as a premier supplier of high-purity green H₂.

China's low-carbon hydrogen threshold of $14.51 \text{ kg CO}_2\text{e/kg H}_2$, on the other hand, reflects a more gradual, pragmatic approach, shaped by the realities of China's hydrogen production. China is the world's largest hydrogen producer, with its vast majority coming from coal gasification, which has a very high carbon footprint even in comparison to gas-based production. Instead of immediately requiring ultra-low emission levels, the 2021 China Hydrogen Alliance standard set the limit at 14.51 kg, corresponding to a 50% reduction from the ~29 kg of coal-based hydrogen. This value was chosen to be attainable for coal plants equipped with carbon capture or efficiency upgrades, while still sending a signal to reduce emissions. The threshold remains well above natural gas-based hydrogen (~9-10 kg) and is therefore regarded internationally as a relatively lenient definition of "low-carbon".

Chinese policy has so far put less emphasis on strict CI limits and more on scaling up hydrogen use for industrial growth and energy security. The existence of the "clean hydrogen" category at 4.9 kg in the same standard shows that China recognises a more ambitious level (4.9 kg aligns with natural gas SMR + CCS or electrolysis with low-carbon power). But calling anything under 14.51 kg "low-carbon" signals that China's priority is to start reducing the very high emissions of its current hydrogen production, even if the result is still above other countries' clean hydrogen definitions.

India set the bar high to leap directly into near-zero-carbon hydrogen, whereas China set the bar low to begin inching down from very high-emission hydrogen – reflecting their differing baseline realities and policy drivers.

5.3. Policy Applications of Hydrogen Labels

Hydrogen labels are not just abstract definitions – they are embedded in various policy mechanisms and market instruments. Across the surveyed jurisdictions, hydrogen labels are used in at least four key ways:

- Eligibility for Grants and Subsidies: Governments often require projects to meet a hydrogen label standard to receive public funding. For example, the UK's Low Carbon Hydrogen Standard (2.4 kg) is a prerequisite for producers bidding for government contracts-for-difference subsidies under the Hydrogen Business Model. Similarly, the EU's Innovation Fund and national hydrogen funding programs prioritise projects producing "renewable hydrogen" (meeting the EU's criteria) to award grants. Brazil plans to give tax credits and priority permitting to certified low-carbon hydrogen producers, effectively subsidising those who meet the ≤7 kg standard. Tying funding to labels ensures public money supports genuinely low-carbon hydrogen, not high-emission variants.
- Tax Credit Qualification: A number of countries use hydrogen labels in their tax code to provide production or investment tax credits. The clearest example is the United States, where the Inflation Reduction Act's hydrogen production tax credit (45V) only applies to "qualified clean hydrogen" defined as ≤4 kg CO₂e/kg H₂. Within that, the credit amount scales in CI tiers incentivising producers to beat the minimum. Canada's investment tax credit (ITC) for clean hydrogen similarly only covers projects under 4 kg, with higher credit rates for lower CI bands. In South Korea, the government is considering tax incentives for clean hydrogen use once the certification system launches. If hydrogen does not meet the defined standard, it does not receive these lucrative credits, which strongly incentivises developers to design for low emissions.
- Export Market Access and Trade: Common standards are emerging as a ticket to participate in the future hydrogen export market. The EU has included hydrogen in its Carbon Border Adjustment Mechanism (CBAM) plans, meaning imported hydrogen with high embedded emissions could face carbon tariffs. Thus, exporters like Saudi Arabia are aligning their production to meet EU (and Japanese/Korean)

criteria for low-carbon hydrogen. Having a recognised label can also facilitate bilateral trade agreements: e.g. a cargo of "green hydrogen" certified under India's 2 kg standard could be attractive to a Europe or Japan buyer looking for verifiable low-carbon fuel. Japan and Germany have discussed using mutual recognition of hydrogen certifications to enable trade. In summary, to sell into certain markets or count toward buyers' national targets, hydrogen must qualify under the relevant label, effectively making labels a trade currency. Countries not adopting robust standards may find their hydrogen excluded from key markets in the future.

Domestic Regulation, Mandates and Certificates: Governments also deploy labels on the consumption side – for example, setting quotas or offering premiums for using certified hydrogen. The EU's Renewable Energy Directive will mandate a share of industry hydrogen consumption to be "renewable hydrogen" by 2030, forcing consumers to buy certified RFNBO (Renewable Fuel of Non-Biological Origin) hydrogen. In India, the government is instituting "green hydrogen consumption obligations" for certain industries, meaning e.g. fertiliser plants must use a minimum percentage of Green Hydrogen (as defined by the 2 kg standard) in their hydrogen feedstock mix. South Korea is launching a Clean Hydrogen Power Generation Obligation scheme, where power generators must gradually blend or use a certain amount of clean hydrogen/ammonia; only certified clean hydrogen (≤4 kg) will count, and a certificate trading system will likely develop. To implement such schemes, robust certification systems are needed. Thus, many countries are creating guarantee of origin and certification frameworks alongside the labels (e.g. Brazil's SBCH2 system, the EU's RFNBO scheme, Australia's Guarantee of Origin scheme). These allow the attributes of "clean" or "green" hydrogen to be tracked and traded, enabling producers to earn a premium if they exceed the standard. In some cases, infrastructure incentives also come into play: for instance, priority grid connections or dedicated hydrogen pipeline capacity might be offered for lowcarbon hydrogen projects, effectively giving certified producers an advantage in infrastructure access.

With regard to these applications, we see that a hydrogen label is not merely an environmental accolade – it is a gateway to financial, legal or market benefits. Conversely, hydrogen that fails to meet the defined standards may be legal to produce but will

increasingly be treated as "less valuable" hydrogen – facing economic penalties (no subsidies or credits, carbon fees) and market limitations. This dynamic is intended to accelerate the transition to clean energy: over time, as standards are introduced in more countries and ratchet tighter, more of the hydrogen market will be comprised of certified low-carbon product, supporting global emissions goals.



6. Conclusion and Outlook

The comparison above makes clear that while the concept of "renewable", "low-carbon" or "clean" hydrogen is global, current frameworks vary widely in their ambition and policy function. Each country or region has tailored its hydrogen labels to national circumstances. The number of categories, the exact emissions thresholds and the uses of those labels in policy differ significantly. This patchwork of definitions could become a barrier as the hydrogen economy globalises: without harmonisation, a producer might be "clean" by one country's test but not by another's, complicating international trade and investment decisions.

A harmonised global standard – or at least **mutual recognition of equivalent standards** – could greatly improve the efficiency of hydrogen markets. It would enable apples-to-apples comparison of hydrogen from different sources and countries, give investors clarity on what to aim for and prevent "label shopping" where developers might lobby for looser rules in one jurisdiction. Initiatives like the Green Hydrogen Standard (from the Green Hydrogen Organisation) and discussions in the G7/G20 point toward interest in a common baseline for clean hydrogen. Even without a single global rule, increased transparency and **convergence around emissions accounting methods** (such as the ISO standard or IPHE guidelines) will help bridge the gap. Over time, one could envision an international system where a unit of hydrogen carries a certified CI value that is accepted universally – much as a carbon credit can be traded globally under common verification rules.

In the meantime, an alternative approach to strict label definitions is gaining traction: using **carbon intensity as a continuous metric rather than a binary label.** Instead of rigidly siloing hydrogen into "green" or "not green" based on a single cutoff, policymakers can reward incremental improvements in carbon intensity along a sliding scale. The United States, Canada and South Korea already apply tiered incentive models – a project that achieves 1 kg CO₂e/kg H₂ in the US gets a higher credit than one at 3 kg, but even the 3 kg project (well under the 4 kg limit) still gets partial support. This avoids the pitfall of everything just below a threshold being treated the same and everything just above being disqualified. The UK and Germany have also explored contracts that pay more for deeper carbon cuts rather than a simple yes/no eligibility. **Using carbon intensity directly**

as the metric for incentives and reporting can improve transparency – each producer is accountable for their actual emissions per kg and policy can flexibly adapt (for instance, ratcheting down the carbon intensity required for full subsidy over time). It also dovetails with the idea of carbon border adjustments and global trade: if everyone reports emissions, a buyer can decide what level they need, rather than relying only on disparate labels.

Ultimately, the vision for the future is that carbon intensity itself becomes the universal language of hydrogen sustainability. Rather than juggling colour codes and national labels, producers would simply declare (and certify) the emissions footprint of their hydrogen, and that number would determine its treatment in any market. A tonne of hydrogen at 1.0 kg CO_2e will be recognised as cleaner (and perhaps more valuable) than one at 5.0 kg CO₂e, no matter where it comes from – just as a barrel of oil or an MWh of electricity can be compared on emissions. Achieving this vision will require trust in methodologies and robust verification, but early moves by governments to incorporate quantitative thresholds and tiered incentives are a strong step in this direction. A globally harmonised approach, or at least interoperable standards, would boost trade, improve comparability and give investors and developers a clearer target. In the coming years, as nations revisit their hydrogen strategies and collaborate through forums like the Clean Energy Ministerial, we may see progress toward that common framework. In the meantime, the "tiered" models in North America and Asia suggest that we are already pivoting from static labels toward a more nuanced, data-driven system - one where emissions intensity alone might define the currency of clean hydrogen in a low-carbon economy.

7. Annex: Hydrogen Label Thresholds and Policy Benefits

This annex provides a jurisdiction-by-jurisdiction reference for the ten H2I economies analysed. Carbonintensity thresholds are presented as defined in each instrument and normalised to kg CO₂e/kg H₂; methodologies and system boundaries may differ across jurisdictions. See footnotes for tiered schemes (*) and derived values (**). Entries reflect the position as of September 2025.

No.	Country/ Region	Label	Legislation/ Policy	Legal status	Threshold (kg CO ₂ e/ kg H ₂)	Policy Benefits
1	European Union	Renewable	Renewable Energy Directive (RED II/III)	Legislation	3.384	Export/quota eligibility; counts toward EU renewable fuel targets; certification acceptance
2	European Union	Low-carbon	Hydrogen & De- carbonised Gas Market Directive	Legislation	3.384	Quota eligibility (sectoral); prefer- ential gas market treatment; certifica- tion acceptance
3	United Kingdom	Low-carbon	UK Low Carbon Hydrogen Stan- dard (v3)	Govern- ment-issued standard	2.4	Grant/subsidy eligibility; certification for UK schemes
4	United States	Clean	Inflation Reduc- tion Act §45V	Legislation	4.0*	Tax credit (45V PTC, tiered by CI); certi- fication for federal programmes
5	Canada	Clean	Income Tax Act – Clean Hydrogen Investment Tax Credit	Legislation	4.0*	Investment tax credit (15–40% capex, tiered); Cer- tification for federal programmes
6	China	Renewable	T/CAB 0078-2020	Industry vol- untary stan- dard	4.9	Certification (voluntary, industry-issued)
7	China	Clean	T/CAB 0078-2020	Industry vol- untary stan- dard	4.9	Certification (voluntary, industry-issued)

No.	Country/ Region	Label	Legislation/ Policy	Legal status	Threshold (kg CO ₂ e/ kg H ₂)	Policy Benefits
8	China	Low-carbon	T/CAB 0078-2020	Industry vol- untary stan- dard	14.51	Certification (vol- untary, industry-is- sued)
9	India	Green	MNRE Green Hydrogen Stan- dard	Govern- ment-issued standard	2.0	Grant/subsidy eligibility; compliance with domestic green H ₂ obligations
10	Japan	Low-carbon	Hydrogen Society Promotion Act	Legislation	3.4	Grant/subsidy eligibility (price support/ CfD-style); regulatory facilitation
11	South Ko- rea	Clean	Hydrogen Economy Promotion & Hydrogen Safety Act	Legislation	4.0*	Access to 15-year power offtake auc- tions (CHPS); cer- tification (graded tiers)
12	Brazil	Renewable	Law No. 14,948/2024	Legislation	7.0	Tax incentives; future production credits (PHBC)
13	Brazil	Green	Law No. 14,948/2024	Legislation	7.0	Tax incentives; future production credits (PHBC)
14	Brazil	Low-carbon	Law No. 14,948/2024	Legislation	7.0	Tax incentives; future production credits (PHBC)
15	Saudi Ara- bia	Renewable	KSA Green Fi- nancing Frame- work	Govern- ment-issued standard	5.5**	Finance eligibility (green bonds/loans)
16	Saudi Ara- bia	Blue	KSA Green Fi- nancing Frame- work	Govern- ment-issued standard	3.6	Finance eligibility (green bonds/loans)

Footnotes:

- *Tiered scheme by carbon intensity; the value shown is the eligibility cut-off
- ** Electricitybased threshold: original rule is ≤ 100 g CO₂e/kWh; the displayed carbon intensity assumes 55 kWh/kg H₂

Do you need more information regarding the labelling of hydrogen?



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