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Argus White Paper:

Hydrogen, awash in colours, in search of definition

Executive summary

Hydrogen (H2) as a fuel offers a crucial decarbonisation pathway, emitting no carbon dioxide (CO2) when burned. But while it can be produced CO2-free, using renewable energy and water, most existing production routes entail emissions, and lots of them.

Proper classification of H2 is necessary to assess any relative merit over fossil fuels, as well as the decarbonisation value of H2 from differing sources. Yet the current naming convention (green, blue, grey) and new prefixes ("clean", "sustainable") is at best unfit for purpose and at worst misleading. All fail to capture the variable that matters — carbon intensity.

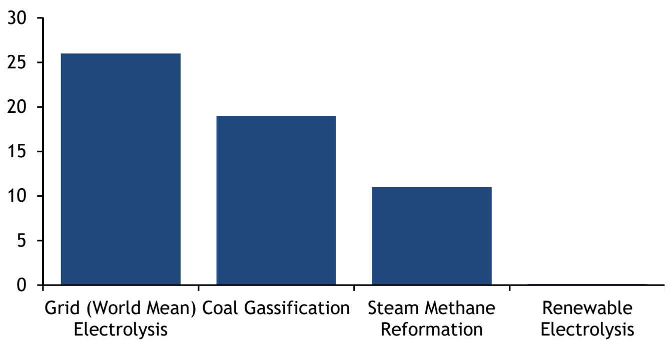
This definitional quagmire poses obstacles to market development and threatens public confidence. Argus proposes breaking the impasse, classifying hydrogen by the amount of carbon generated in its production, not its production route.

Virtue is in the process (not the product)

Despite being regularly touted as a wonder fuel, there is nothing inherently virtuous about hydrogen. As an element, it is rarely found in isolation, requiring liberation from whatever it is bonded to, often carbon. To release it, energy is required, which is not always green. The liberation process can also release CO2 along with H2. Its utility in decarbonisation is directly related to the environmental cost of its production.

As an example, producing H2 by water-based electrolysis and renewable energy is CO2-free. But switching the energy source to a coal-intensive (China, India) grid would be a more carbon-intensive production path than unabated steam reformation or coal gasification.

Carbon efficiency: KG of CO_2, per 1 KG of H2



Recent studies such as Howarth/Jacobson state overall emissions from some hydrogen propositions are not always lower than those from existing sources. H2 offers a poor use case, where it is less carbon efficient than existing fossil fuels.

As the industry looks to scale production, quantification of the overall emissions involved is therefore necessary for hydrogen projects to be directly compared with alternative fuels and hydrogen produced using different routes.

Colour blind: H(2)azards ahead

A large part of the naming challenge is that hydrogen production technology, feedstocks and processes are complex. Not only are there many multiple opportunities to switch in lower carbon feedstocks (e.g. biomethane for natural gas), but there are new energy sources becoming available, such as concentrated solar power. Technology can also be applied not just to the production process but its outputs too, with carbon capture and storage (CCS) being the obvious example.

Current Hydrogen 'Colour' Classification		
	Process Route	**Abatement?**
Black	Bitumous coal gasification	Unabated
Brown	Lignite coal gasification	Unabated
Grey	Steam methane reformation (SMR)	Unabated
Blue	SMR + Carbon Capture and Storage	Abated
Turquoise	Methane pyrolysis	Unabated
Purple	Nuclear water electrolysis	Carbon-free
Green	Renewable water electrolysis	Carbon free

All of these radically alter the overall emissions of H2 production, yet none are captured in the existing 'colour code', which describes process route only.

Because of this, the naming convention in table 1 is already redundant and lacks future proofing. How would new combinations be described? If grey H2's feedstock is switched to biomethane, what colour would it become? And how would the taxonomy cope if CCS was added?

Gaping holes yawn within the existing classification system too. The largest being the amount of latitude awarded to the term 'blue hydrogen'. The combination of steam methane reforming (SMR) with CCS sees carbon capture rates of between 56-90pc. Yet 'blue' also describes Autothermal Reformation with CCS, which can achieve up to 98pc capture.

Hy-jacked

Naming chaos is worsening as novel, non-colour terms are introduced. Projects describe their hydrogen as 'sustainable' or 'clean'. These definitions are looser than colours: not defining the process route is excessively vague. For example, 'clean' has been used to describe coal gasification with partial CCS and unabated methane steam reformation, with carbon offsets.

While guarantees of origin and certification will close chain-of-custody opportunities for abuse, they do not address the naming structure. A common language around hydrogen must emerge.

Waiting for a definition has proven unsuccessful. Associations have diverse memberships with divergent bias, as do nations. Agency has hampered attempts to 'join-up' conversations.

But given the hopes pinned on hydrogen in decarbonising the economy, this lack of a clear taxonomy is unacceptable.

Any improvement would prove impactful. A more holistic way of looking at hydrogen would raise transparency, market efficiency and improve industry communication. All are needed, as capital flows are being directed towards projects based on carbon intensity and the amount of investment seeking a home, according to US Treasury of the Secretary at the UN's COP 26 climate conference, is measured between $100 trillion-150 trillion.

Argus hydrogen taxonomy proposal

Effective classification requires clear metrics, as well as standardisation of quality and physical state.

Argus proposes dumping colour definitions, one of which is in fact trademarked. In their place, Argus suggests a descriptor applying to all hydrogen falling within a CO2e range, production route irrespective.

The table highlights the proposed naming conventions and the terms they would displace. It uses scope one and two definitions to gauge total production emissions. Instead of colours, CO2e 'bands' would be used to describe large market segments of hydrogen supply.

Baseline is the most polluting hydrogen production with high carbon inefficiency. A decarbonising world should be moving away from it. Whether it is ultra-high (coal gasification) or at the lower-end (SMR), markets will prioritise driving this production offline.

BAT+ is superior to EU-defined Best Available Technology and represents the minimum viable product as we move towards 2030, essentially adding CCS to existing SMR plants.

Low-C is aligned with CertifHy's proposal of a 60pc reduction in EU-defined BAT emissions.

No-C means no CO2 emissions at point of production, encompassing renewable and nuclear electrolysis.

C-negative describes H2 production that takes CO2 out of circulation.

	Proposed Argus Hydrogen Taxonomy (Green Box) vs Current (Pink Box)						
Traffic Light	Proposed Descriptor	H2 Purity	CO2 kg/kg of H2*	Pressure	Current Descriptor	H2 Purity	CO2 kg/kg of H2*
	Baseline	99.9%	>10.9	20 bar	Grey, Brown, Black, Clean	Unknown	Unknown
	BAT+	99.9%	4.4-10.8	20 bar	Blue, Clean	Unknown	Unknown
	Low-C	99.9%	0.011-4.3	20 bar	Blue/Turqouise, Clean	Unknown	Unknown
	No-C	99.9%	<0.01	20 bar	Green/Purple	Unknown	Unknown
	C-negative	99.9%	<0	20 bar	Deep Green	Unknown	Unknown

*Scope 1 & 2

Why a band and not a precise, defined quantity? Variability between facilities using the same process route will be significant, where the inputs are not water and renewable energy. Additionally, the bands can be tightened as the hydrogen industry itself decarbonises.

The purity metric is sub fuel-cell grade, expecting offtakers to further purify offtake for their market. Pressure is set at the alkaline electrolyser average. The names of five proposed classifications are aimed to be relatively self-explanatory:

This proposed taxonomy also lends itself to the ‘traffic-light’ system being proposed by several market actors as a consumer-friendly ‘at-a-glance’ check of the products environmental credentials. The framework aims to make a start in clearly defining hydrogen according to the standard that matters.

We seek market feedback to optimise it further. Please reach out to the contacts listed below, in the box.

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