

The Hydrogen Colour Spectrum - Where We Are & Where We're Going

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According to our article, all hydrogen is colourless and odourless - the hydrogen 'rainbow' of colours simply defines how the hydrogen was produced. The structure and properties of the hydrogen molecule do not change between colours, but the production method significantly affects how carbon-intensive the hydrogen lifecycle is. Understanding these distinctions is critical for organisations assessing hydrogen's role in decarbonisation strategies, as lifecycle emissions vary dramatically depending on whether hydrogen originates from fossil fuels, carbon capture, or renewable electricity.

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Many notable pathways to a net-zero carbon economy involve green hydrogen. This has created quite the buzz around hydrogen and its potential to fill gaps as a fuel source for direct combustion, as an industrial feedstock, or as a high-density fuel for transportation.

But what is green hydrogen? And for that matter, what are all the other colours of hydrogen?

Black hydrogen. Gray hydrogen. Blue hydrogen. Green hydrogen.

All hydrogen is colourless and odourless - the hydrogen rainbow simply defines how the hydrogen was produced. While the structure and properties of the hydrogen molecule do not change between the colours, the production method does play a significant role in how carbon-intensive the hydrogen lifecycle is.

Black & Brown Hydrogen - The Dirtiest

Black and brown hydrogen are both produced from the fossil fuel coal-black hydrogen is from bituminous coal and brown from lignite. These are the dirtiest methods of hydrogen production because it is created through the gasification of coal, which releases CO₂ and other greenhouse gasses into the atmosphere.

Gray Hydrogen - The Most Common

Gray hydrogen is produced from natural gas, and it is the most common type of hydrogen produced and used worldwide. The primary process used in gray hydrogen production is steam-methane reforming, a reaction involving natural gas, steam, and heat that works to isolate hydrogen. In addition to hydrogen gas, the process also creates CO and CO₂ which are released into the atmosphere.

Although using natural gas is not as carbon-intensive as gasification of coal, it is still a fossil fuel. As such, its use in hydrogen production is non-renewable and emits GHG emissions that contribute to climate change.

Blue Hydrogen - Low-Carbon Intensity

Blue hydrogen is also produced from natural gas, but the process involves carbon capture and storage (CCS) technology that prevents the majority of carbon emissions created by the steam reforming process from being released into the atmosphere.

Due to the involvement of CCS technology, blue hydrogen has a reduced carbon intensity and may even be referred to as carbon neutral (although that may be a bit misleading as the CCS technology will not capture 100% of the GHG emissions).

Blue hydrogen production is less carbon-intensive than black, brown or gray hydrogen, but its dependence on fossil fuels does not make it as environmentally sound as green hydrogen.

Green Hydrogen - The Cleanest

Green hydrogen is often referred to as 'clean hydrogen' because it is produced using electricity from clean energy sources - such as solar or wind power - to split water into hydrogen and oxygen atoms through a process called electrolysis.

Because solar and wind power do not emit greenhouse gases when delivering electricity, this green hydrogen method offers a clean alternative to hydrogen production. Although it is not yet economically competitive at a commercial scale, green hydrogen could be a major contributor to decarbonizing hard-to-abate sectors such as steel manufacturing and the chemicals industry, which rely on fossil fuel feedstocks in the production process.

In addition to replacing portions of gray hydrogen, green hydrogen also poses potential as a clean hydrogen source for the transportation, building, and power sectors. Green hydrogen can serve as a key precursor ingredient in producing synthetic jet fuel and derivatives. Adopting this clean fuel would allow the shipping and aviation industries, which have been historically difficult to decarbonise given the infeasibility of direct electrification, to transfer to low-carbon intensive fuels and effectively reduce their GHG emissions.

There are several barriers to the widespread adoption of green hydrogen, such as constructing refuelling infrastructure, lowering costs, and developing storage strategies. The buzz around green hydrogen is growing, and as it becomes a more popular option, analysts assert that it will become more economic than gray hydrogen.

Future Outlook For Hydrogen

Talk on hydrogen is trending, yet it's important to note that hydrogen production is a mature market that has served the international industry for decades. Hydrogen is used as an industrial feedstock in prominent processes such as oil refining and ammonia production. Hydrogen production has increased over the past decade, a trend that is anticipated to continue for the foreseeable future.

Advancements and scaling of green hydrogen technology could play a significant role in replacing gray (black & brown) hydrogen, and it could also provide clean fuel for transportation or stored energy to complement intermittent renewable energy sources. Considering how economic solar and wind power have become, it is now critical that we develop innovative techniques and strategies to drive down capital costs of electrolytic equipment and to effectively interconnect hydrogen solutions into our energy framework. Doing so will open up incredible potential for hydrogen to complement the larger global transition to a clean energy economy.

Australia is actively embracing opportunities around hydrogen. Green hydrogen energy hubs are part of the NSW Renewable Energy Zone (REZ) buildout plan, and The Australian Renewable Energy Agency (ARENA) has secured \$105 million to fund three commercial green hydrogen facilities slated for Victoria and Western Australia.

With national and international commitments to reduce carbon emissions and reach net-zero status by 2050, green hydrogen can play a critical role in decarbonising industry and establishing a reliable clean

energy grid. So as the world transitions to a clean energy economy, green hydrogen may not only be a way for Australia to decarbonise; it could also be the nation's next big export opportunity.

Using this guidance

Check the site's operating conditions, data quality, project stage and current program settings before turning the dated discussion into a scope or investment decision.

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What does the hydrogen colour spectrum actually represent?

According to our article, all hydrogen is colourless and odourless—the hydrogen 'rainbow' of colours simply defines how the hydrogen was produced. The structure and properties of the hydrogen molecule do not change between colours, but the production method significantly affects how carbon-intensive the hydrogen lifecycle is. Understanding these distinctions is critical for organisations assessing hydrogen's role in decarbonisation strategies, as lifecycle emissions vary dramatically depending on whether hydrogen originates from fossil fuels, carbon capture, or renewable electricity.

How are black and brown hydrogen produced, and why are they considered the dirtiest?

Black and brown hydrogen are both produced from coal—black hydrogen from bituminous coal and brown hydrogen from lignite. We describe these as the dirtiest production methods because they involve gasification of coal, which releases CO₂ and other greenhouse gases into the atmosphere. For organisations managing carbon inventories under frameworks like NGER or developing transition pathways, black and brown hydrogen represent the highest-emission production routes and should be phased out in any credible decarbonisation plan aligned with net-zero commitments.

What is gray hydrogen and why is it the most common type?

Gray hydrogen is produced from natural gas via steam-methane reforming, a reaction involving natural gas, steam, and heat that isolates hydrogen. It is the most common type of hydrogen produced and used worldwide, though the process releases CO and CO₂ into the atmosphere, making it non-renewable and GHG-emitting. For industrial users currently relying on hydrogen in oil refining or ammonia production, gray hydrogen dominates supply chains, but organisations seeking to reduce Scope 1 and 2 emissions should evaluate transition pathways toward blue or green alternatives as part of their carbon advisory engagement.

What makes blue hydrogen different from gray hydrogen, and what are its limitations?

Blue hydrogen is produced from natural gas using steam-methane reforming but incorporates carbon capture and storage (CCS) technology that prevents the majority of carbon emissions from being released into the atmosphere. However, we note that the 'carbon neutral' label can be misleading since CCS does not capture 100 per cent of greenhouse gas emissions. Blue hydrogen remains dependent on fossil fuels and represents a transition technology. For organisations evaluating hydrogen as part of their decarbonisation pathway, blue hydrogen offers a lower-emission intermediate option but should not be treated as a final solution aligned with net-zero targets.

How is green hydrogen produced and what makes it suitable for industrial decarbonisation?

Green hydrogen is produced using electricity from clean energy sources—such as solar or wind power—to split water into hydrogen and oxygen atoms through electrolysis. Because renewable electricity does not emit greenhouse gases during generation, this method offers a clean alternative to fossil-fuel-based production. For industrial facilities seeking to decarbonise processes that require hydrogen as a feedstock, green hydrogen eliminates Scope 1 emissions from the hydrogen production step, though Scope 2 implications depend on the electricity source. We can assist organisations in assessing renewable heat and electrification feasibility, including hydrogen production integration into transition plans.

What barriers does the article identify to widespread green hydrogen adoption?

The article notes several barriers to widespread green hydrogen adoption, including constructing refuelling infrastructure, lowering costs, and developing storage strategies. For industrial operators and transport fleet managers, these barriers translate to practical constraints: hydrogen supply chains remain immature, upfront capital costs for production and storage facilities are substantial, and commercial viability depends on supportive policy and carbon pricing. Organisations considering hydrogen as part of their decarbonisation strategy should assess these implementation risks alongside technical feasibility and work with advisors to identify realistic deployment timelines and funding pathways.

What hydrogen-related developments are currently underway in Australia?

Australia is actively embracing hydrogen opportunities through several initiatives. Green hydrogen energy hubs are part of the NSW Renewable Energy Zone (REZ) buildout plan, and the Australian Renewable Energy Agency (ARENA) has secured \$105 million to fund three commercial green hydrogen facilities slated for Victoria and Western Australia. These investments signal growing policy support for hydrogen production infrastructure. For Australian organisations in Victoria, NSW and Western Australia, these regional developments create emerging opportunities to access green hydrogen supply and participate in hydrogen-based decarbonisation projects, with potential to reduce reliance on imported hydrogen or support domestic industrial competitiveness.

What role could green hydrogen play in Australia's decarbonisation and economic future?

The article suggests that as the world transitions to a clean energy economy, green hydrogen may help Australia decarbonise hard-to-abate industrial processes while establishing a significant export opportunity. Hydrogen could play a critical role in decarbonising industry and supporting a reliable clean energy grid amid commitments to reach net-zero by 2050. For Australian industrial operators and exporters, hydrogen represents both a strategic input for decarbonisation pathways and a potential competitive advantage. Our carbon advisory services, including transition planning and feasibility assessment, can help organisations evaluate hydrogen's role within their specific operational and financial contexts as part of broader net-zero strategies.

What existing industrial applications currently depend on hydrogen?

Hydrogen production is a mature market that has served international industry for decades, with hydrogen used as an industrial feedstock in prominent processes such as oil refining and ammonia production. Hydrogen production has increased over the past decade, a trend expected to continue. For organisations operating in these sectors or dependent on hydrogen-derived products, understanding hydrogen's production method—and its associated carbon intensity—is essential for Scope 3 emissions accounting and supply-chain decarbonisation. Our carbon advisory services can help assess hydrogen sourcing impacts on organisational emissions inventories and identify opportunities to transition toward lower-carbon hydrogen pathways.

How should organisations incorporate hydrogen considerations into their decarbonisation strategy?

Organisations should evaluate hydrogen's role within their specific operational context by assessing which processes require hydrogen as a feedstock, current sourcing methods, and feasibility of transitioning to green hydrogen. This requires understanding lifecycle emissions across the hydrogen colour spectrum and aligning hydrogen choices with net-zero commitments. Our carbon advisory services—including diagnostic workshops, transition planning, and opportunity assessment—can help organisations establish their current hydrogen position, identify decarbonisation pathways, and develop realistic implementation timelines that balance technical feasibility, cost, and supply-chain maturity.