Hydrogen
In Focus

About
LAVAUX

We are a leading strategy, operations consulting and organizational transformation firm.

At the heart of everything we do is our unrelenting drive to peek into and make sense of the future.

We are strategists, management consultants and advisors — inspired by transforming clients' businesses so that they can reach escape velocity.

Our teams brainstorm, envision and inspire.

Hydrogen is the lightest and most abundant element in the universe, but it barely exists in a pure form on Earth. Instead, it is abundant in chemical compounds, most notably bonded with oxygen in water or carbon to form hydrocarbons like fossil fuels. For that reason, hydrogen is not considered an energy source but an energy carrier or *vector*.
Once separated from other elements, hydrogen's utility increases: it can be converted into electricity through fuel cells, it can be combusted to produce heat or power without emitting carbon dioxide, used as a chemical feedstock, or as a reducing agent to reduce iron ores to pure iron for steel production.

Global outlook

Hydrogen demand has increased by 55% over the past 20 years, from 58 million tons (Mt) in 2000 to 90 Mt in 2021, a market worth $150 billion. Most of this demand was for pure hydrogen (72 Mt), with 18 Mt for hydrogen mixed with other gasses used in methanol and steel production, resulting in close to 900 Mt of CO_2 emissions.

But there are encouraging signs of progress. Global capacity of electrolysers, which are needed to produce hydrogen from electricity, doubled over the last five years to reach just over 300 MW by mid-2021. Around 350 projects currently under development could bring global capacity up to 54 GW by 2030. Another 40 projects accounting for more than 35 GW of capacity are in early stages of development. If all those projects are realised, global hydrogen supply from electrolysers could reach more than 8 Mt by 2030.

While significant, this is still well below the 80 Mt required by that year in the pathway to net zero CO_2 emissions by 2050 set out in the IEA Roadmap for the Global Energy Sector.

Europe is leading electrolyser capacity deployment, with 40% of global installed capacity, and is set to remain the largest market in the near term on the back of the ambitious hydrogen strategies of the European Union and the United Kingdom.

Australia's plans suggest we could catch up with Europe in a few years; Latin America and the Middle East are expected to deploy large amounts of capacity as well, in particular for export. The People's Republic of China ("China") made a slow start, but its number of project announcements is growing fast, and the United States is stepping up ambitions with its recently announced Hydrogen Earthshot.

Sixteen projects for producing hydrogen from fossil fuels with carbon capture, utilisation and storage (CCUS) are operational today, producing 0.7 Mt of hydrogen annually. Another 50 projects are under development and, if realised, could increase the annual hydrogen production to more than 9 Mt by 2030.

Canada and the United States lead in the production of hydrogen from fossil fuels with CCUS, with more than 80% of global capacity production, although the United Kingdom and the Netherlands are pushing to become leaders in the field and account for a major part of the projects under development.

The Colors of Hydrogen

The difference in carbon intensity led the industry to assign different colors (grey, blue, green and most recently gold) when talking about hydrogen production.

The **Grey Hydrogen** is produced by steam methane reforming (SMR) of natural gas or coal and can yield between 8 -10.5 kg of CO_2 per each kg of hydrogen produced. If carbon capture and storage is added to the process (**Blue Hydrogen)**, the scope 1 emissions can be as low as 0.8-4 kg CO_2/kg H_2. Europe has taken a lifecycle approach to measuring emissions from hydrogen (H2). The EU has set an emissions threshold for hydrogen of 3.38 kg CO_2-eqv per kg-H_2. This is more lenient than some other regions but covers a wider emissions scope: everything from the energy inputs to make H_2 through to consumption.

In contrast with Grey and Blue Hydrogen, **Green Hydrogen** produced by electrolysis of water has minimal GHG emissions footprint.

Green hydrogen featured in a number of emissions reduction pledges at the UN Climate Conference, COP26, as a means to decarbonize heavy industry, long haul freight, shipping, and aviation. Governments and industry have both acknowledged hydrogen as an important pillar of a net zero economy.

The Green Hydrogen Catapult, a United Nations initiative to bring down the cost of green hydrogen announced that it is almost doubling its goal for green electrolysers from 25 gigawatts set last year, to 45 gigawatts by 2027. The European Commission has adopted a set of legislative proposals to decarbonize the EU gas market by facilitating the uptake of renewable and low carbon gases, including hydrogen, and to ensure energy security for all citizens in Europe.

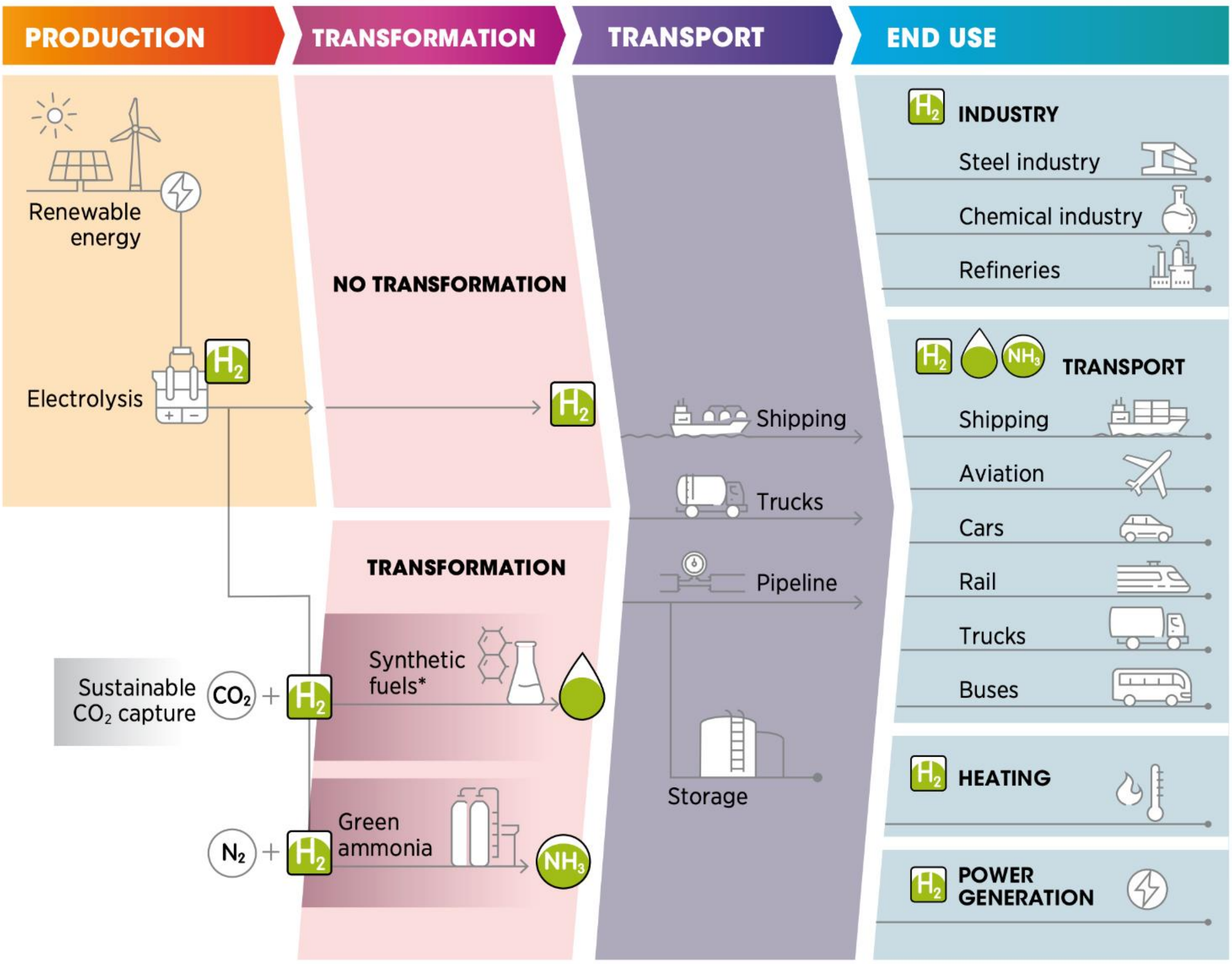
The United Arab Emirates is also raising ambition, with the country's new hydrogen strategy aiming to hold a fourth of the global low-carbon hydrogen market by 2030 and Japan recently announced it will invest $3.4 billion from its green innovation fund to accelerate research and development and promotion of hydrogen use over the next 10 years.

Next Decade Outlook

A key barrier for low-carbon hydrogen is the cost gap with hydrogen from unabated fossil fuels. At present, producing hydrogen from fossil fuels is the cheapest option in most parts of the world. Depending on regional gas prices, the levelised cost of hydrogen production from natural gas ranges from USD 0.5 to USD 1.7 per kilogramme (kg).

Using CCUS technologies to reduce the CO2 emissions from hydrogen production increases the levelised cost of production to around USD 1 to USD 2 per kg. Using renewable electricity to produce hydrogen costs USD 3 to USD 8 per kg.

There is significant scope for cutting production costs through technology innovation and increased deployment.



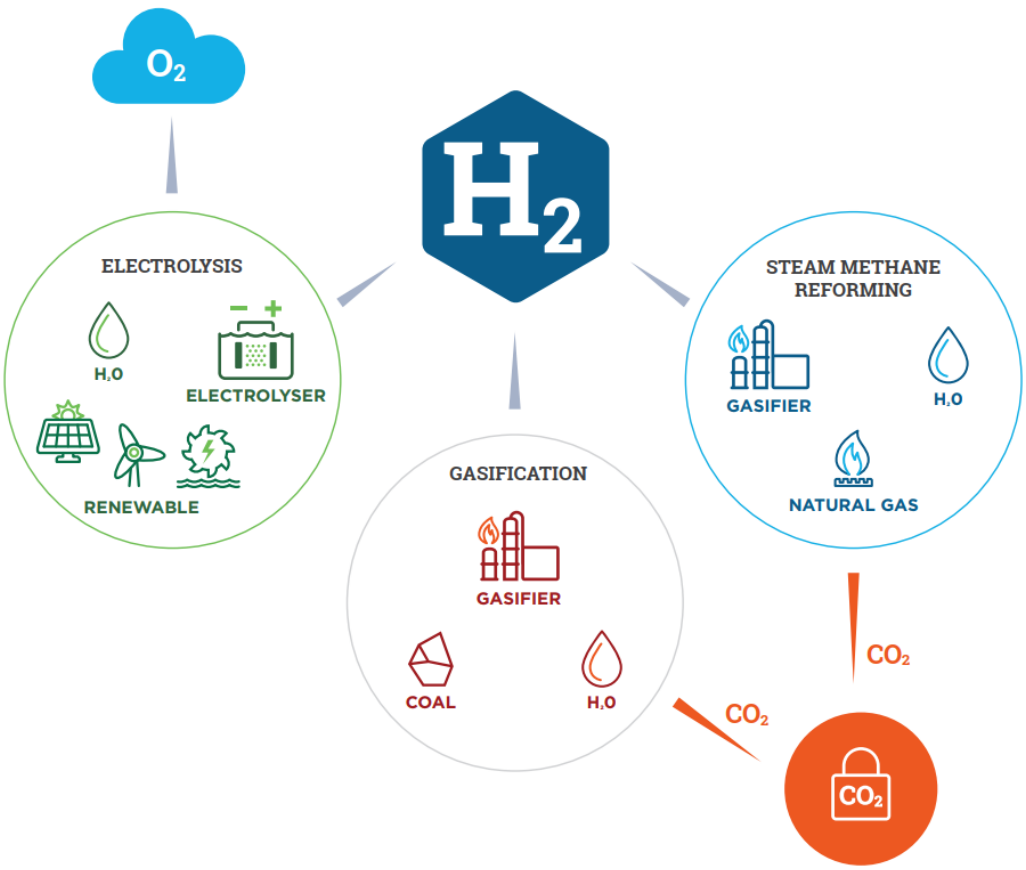
Green hydrogen production, conversion and end uses across the energy system

The potential is reflected in the IEA's **Net Zero Emissions by 2050 Scenario** (NZE Scenario) in which hydrogen from renewables falls to as low as USD 1.3 per kg by 2030 in regions with excellent renewable resources (range USD 1.3-3.5 per kg), comparable with the cost of hydrogen from natural gas with CCUS. In the longer term, hydrogen costs from renewable electricity fall as low as USD 1 per kg (range USD 1.0-3.0 per kg) in the NZE Scenario, making hydrogen from solar PV cost-competitive with hydrogen from natural gas even without CCUS in several regions.

What Is Australia Doing On The Hydrogen Front?

All levels of government are delivering the strategy and taking early actions to overcome barriers facing the industry. So far, the Australian Government has:

- built international relationships, including partnership agreements with Germany, Singapore, Japan, Republic of Korea and the United Kingdom to build hydrogen supply chains and advance technology research
- developed a proposed approach for a domestic hydrogen Guarantee of Origin scheme and helped shape the design of an international methodology
- announced hydrogen funding programs, including $464 million for the 'Activating a Regional Hydrogen Industry: Clean Hydrogen Industrial Hubs' program
- invested over $300 million to support development of carbon capture and storage (CCS) and carbon capture, use and storage (CCUS) projects



• awarded over $100 million to three 10 MW hydrogen electrolyser projects through the Australian Renewable Energy Agency (ARENA)
• fostered industry innovation, collaboration and knowledge sharing
• provided more than $300 million in funding R&D and demonstration activities.

Direct Australian Government support for the hydrogen industry is now over $1.2 billion.
State and territory governments are helping develop the industry by implementing the National Hydrogen Strategy and their own hydrogen strategies.
Together, the federal, state and territory governments have:
• started a review of legal and regulatory frameworks
• agreed to amend the national gas regulatory framework
• started the National Hydrogen Infrastructure Assessment
• commenced work on industry development, including skills and training
• supported analysis to understand community attitudes towards hydrogen

In 2021 the Australian Government announced 5 new **international partnerships**:
• Australia and Germany will work together under a new Hydrogen Accord. The accord includes several new initiatives to accelerate the development of a hydrogen industry. Australia will contribute $50 million and Germany €50 million
• Australia and Singapore will establish a $30 million partnership to accelerate deployment of low emissions fuels and technologies (like clean hydrogen) in maritime and port operations
• The Japan–Australia Partnership on Decarbonisation through Technology will increase our shared focus on priority low emissions technologies, including clean fuel ammonia and clean hydrogen
• The Republic of Korea and Australia will work together to drive increased adoption of low and zero emissions technologies
• Australia and the United Kingdom have agreed to collaborate on research and development across technologies crucial to decarbonising the global economy, including clean hydrogen.

For more information, contact

Dr Dorel Iosif
Managing Partner and Chief Executive, **LAVAUX**
e: diosif@lavauxglobal.com