HYDROGEN'S DECADE

The global race for clean hydrogen means new geopolitical realities and interdependence

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If the 1990s were the decade of wind, the 2000s the decade of solar, and the 2010s the decade of batteries, the 2020s could launch us toward a next frontier of the energy transition: hydrogen. Hardly a week goes by without a major new hydrogen project or breakthrough. In just the past five years, more than 30 countries have developed or started to prepare national hydrogen strategies (IEA 2022). The Paris climate goals have been a key driver, but Russia's war in Ukraine and soaring gas prices have also driven a shift to greener fuels. Economic development and industrial policy loom large as well.

Clean hydrogen has the potential to upend the geopolitics of energy as we know it. New geographies of trade may emerge around clean hydrogen and its derivatives, such as ammonia. Countries blessed with abundant sun and wind could emerge as major exporters of green fuels or sites of green industrialization. Industrial competition could intensify as countries aspire to technology leadership around key segments of the hydrogen value chain. In general, scaling up clean hydrogen could foster intense geo-economic competition, spur new alliances and collaboration, and beget new nodes of power along future centers of hydrogen production and use.

The hydrogen promise

It is the smallest molecule in the universe, but hydrogen has immense potential as a clean fuel for the global energy transition. It is a gas that can be burned in an engine or used in a fuel cell to power vehicles, produce electricity, or provide heat. It can serve as a feedstock and as a building block for other chemical products, such as ammonia (a key fertilizer input) and methanol (used in plastics production). Hydrogen and its derivatives can be stored indefinitely in tanks and salt caverns, which means they might be one of the key solutions for long-term energy storage.

Crucially, hydrogen can replace fossil fuels for all those purposes without emitting carbon dioxide. It is a zero-carbon energy carrier, just like electricity,

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but it has an edge when it comes to decarbonizing sectors that are hard to electrify—think of heavy industry, long-haul transportation, or seasonal storage. Most decarbonization scenarios anticipate a key role for hydrogen in achieving net-zero emissions by mid-century. The International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA), for example, expect hydrogen to meet 12–13 percent of final energy demand by 2050, up from virtually zero today.

Hydrogen is already a major industry, but the current hydrogen market has three traits that are about to be radically transformed: hydrogen today is still made largely from unabated fossil fuels, used almost exclusively as a feedstock, and is produced and consumed mostly on-site. Each of these steps in the value chain must undergo a massive overhaul if hydrogen is to live up to its potential as the missing piece of the clean energy puzzle. Its production must shift to cleaner sources and its consumption expand to new sectors—and hydrogen and its derivatives could become internationally traded energy commodities.

Hydrogen battles

The pathway for clean hydrogen growth remains contentious, however. Two primary fault lines have emerged: how to produce it and in which sectors to deploy it.

In terms of production, the two main routes to clean hydrogen are "green" hydrogen from renewable electricity and "blue" hydrogen from natural gas equipped with carbon capture technologies. Green hydrogen was once two to three times more expensive than blue hydrogen, but that was before the current gas price crunch. Moreover, green hydrogen offers the greatest potential for cost reductions. A growing number of projections now foresee green hydrogen that is cheaper than both blue and "gray" hydrogen (from unabated fossil fuels) before the end of the decade.

Both pathways spur their own debates. The production of green hydrogen could divert renewable electricity from other end uses, which prompts debate about whether "additionality" criteria should apply—that is, whether hydrogen can be called green only if it is produced from renewable capacity that would not otherwise be commissioned or used. It could also exacerbate water stress in some regions. After all, the sunniest places also tend to be the driest. Blue hydrogen, for its part, raises concern over potential methane leakage, insufficient carbon dioxide capture, and lock-in of fossil gas infrastructure. Other production pathways, such as from nuclear or biomass sources, are equally controversial.

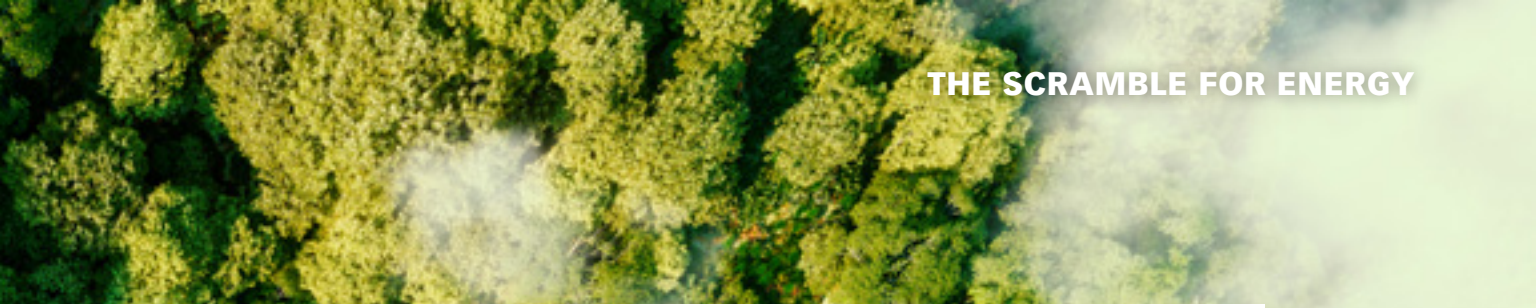
In terms of consumption, similar debates rage. Hydrogen is sometimes called the Swiss army knife of the energy transition because you can do pretty much everything with it, although it might not always be the best tool for the job. Using hydrogen is often a less energy-efficient route than direct electrification. For instance, to drive the same distance with a hydrogen car, you need two to three times more wind farms than you do for an electric vehicle (Transport & Environment 2020). Certain hard-to-abate sectors such as steel, shipping, and aviation will need hydrogen or a derivative—that's not up for debate. These are the no-regrets sectors. Yet indiscriminate use of hydrogen could slow the energy transition.

Technology leadership

Policy support for clean hydrogen has grown in recent years, bolstered by post–COVID-19 recovery spending and Russia's invasion of Ukraine. Clean-hydrogen-focused companies are raising more money than ever, and annual investment in clean hydrogen now stands at half a billion dollars a year, according to the IEA. Countries are jockeying for mastery over what is set to become a multibillion-dollar international industry in a decade or two.

This geo-economic calculus is already influencing hydrogen policies. In Europe, for example, there are fears that China might come to dominate the hydrogen industry, just as it dominates solar photovoltaic (PV) manufacturing, battery production, and rare earth mining. Many national hydrogen strategies are therefore as much an instrument for industrial policy as a tool for decarbonization. Countries have a strategic interest in being technology makers, not technology takers, in such critical areas of the energy transition.

The biggest prize in the hydrogen value chain may be the electrolyzers needed to produce green hydrogen. Like solar PV, electrolyzers are a very modular technology subject to a steep learning curve. Electrolyzers may today be where solar PV



technology was 10–15 years ago, on the cusp of moving from niche to mainstream. While this emerging industry is still very much in flux, electrolyzers made in China are 75 percent cheaper than those manufactured in the West, according to Bloomberg New Energy Finance.

Many countries and regions have support measures for clean hydrogen, but the United States recently upped the ante with the passage of the Inflation Reduction Act. Its generous tax credits ($3/kg) will make US renewable hydrogen the cheapest form of hydrogen in the world. The US law probably influenced the European Parliament's decision in September to relax the rules on additionality for green hydrogen, amid warnings from the sector of a mass exodus of the industry to the United States.

Export dreams

Hydrogen and its derivatives could usher in a reconfiguration of energy trade relations. Some regions, notably in Europe and northeast Asia, are gearing up to become major importers of hydrogen; others dream of being major exporters or even, as in the case of Australia, renewable energy superpowers.

Fossil fuel exporters like Australia and countries in the Middle East and North Africa have several advantages: they can build on their existing energy trade relations, skilled workforce, and established infrastructure to become exporters of clean hydrogen. It is an attractive way for them to diversify their economies while retaining their roles as energy exporters.

Yet it would be foolish to think that hydrogen rents will replace fossil fuel rents or give these countries the same geopolitical leverage. Unlike oil and gas, hydrogen is a manufactured product. It can be produced wherever you have electricity and water. Even when it is produced from natural gas, it is a conversion business rather than an extraction business. Hydrogen is therefore *not* a zero-carbon version of oil.

Hydrogen could be more of a geopolitical game changer for countries that currently depend on fossil fuel imports but have ample renewables potential—for example, Chile, Morocco, and Namibia. A German consortium is developing a green hydrogen project in Namibia worth $9.4 billion, roughly equivalent to the country's GDP. Egypt, the host of the COP27 climate change summit, has attracted investment pledges of more than $40 billion this year alone for green hydrogen and green ammonia projects. No continent has better technical potential for producing cheap green hydrogen than Africa.

Governing hydrogen

Many obstacles need to be overcome to bring clean hydrogen to scale, and these require international governance. I will highlight just three.

First, costs must come down further and production must ramp up. Governments can help de-risk investment in clean hydrogen supply by creating durable demand in no-regret sectors through policy instruments such as public procurement and carbon "contracts for difference."

Second, there is a need to establish harmonized standards, certification, and monitoring processes for safety, interoperability, and sustainability along the entire clean hydrogen value chain. These should not focus only on preventing hydrogen leakage or reducing emissions but also on other areas, such as the impact on water security.

Third, developing economies should get financial and technological assistance so they can benefit from the green hydrogen boom. A pitfall is that developing economies blessed with abundant wind and solar energy are regarded solely as suppliers of green energy molecules to serve the industrial demand centers of the Global North, rather than as potential sites of green industrialization in their own right.

Hydrogen has long been touted as the fuel of the future. This decade, it could finally turn into a fuel of the present. There are still major challenges to overcome, but done right, the clean hydrogen revolution could unlock a triple prize: more climate stability, energy security, and global equity. FD

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