Is natural hydrogen the fuel of the future? | Explained

How does hydrogen occur naturally in the environment? Why was it considered unviable to mine or harvest natural hydrogen? Can natural hydrogen as a fuel meet growing global energy demands? Why is it still an untapped industry? Does India have natural hydrogen reserves?

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A 2,500 cubic-metre tank containing liquid hydrogen at Kobe Port Island plant in Kobe, Hyogo Prefecture, Japan. | Photo Credit: AFP

The story so far:

Hydrogen is seen as the fuel of the future — one that would decarbonise world economy and stop global warming. If harvested in a sustainable manner, natural hydrogen may provide a clean and potentially low-cost fuel to satisfy the world's increasing energy needs with a considerable reduction in carbon emissions as well. And it's most likely abundant in India, too.

How is natural hydrogen extracted?

Right now, hydrogen is manufactured mostly from natural gas through an energy-intensive and polluting process. Green hydrogen made with renewable electricity, on the other hand, is still prohibitively expensive and would require vast amounts of wind and solar power to work out at scale.

Natural hydrogen occurs as a free gas in geology, produced by processes such as serpentinisation (the interaction of water and iron-containing rocks), radiolysis of water by radioactive rocks, and from organic matter at depth.

What is the history of its extraction?

In the summer of 1987, drillers arrived at Mamadou's village of Bourakébougou, Mali, to bore for water. After drilling 108m at one site, with no water to be found, one of the crew lit a cigarette — and a jet of flame shot into his face. The flame turned into a huge fire that shone crystal blue during the daytime with no sign of smoke around it. At night, it shone a glowing gold that lit its surroundings. It took weeks for the crew to extinguish the blaze and cap the well.

This unexpected event led the villagers to avoid the site until 2007 when Aliou Diallo, a successful Malian businessperson, politician, and chairperson of Petroma, an oil and gas firm, purchased the rights to prospect in the area around Bourakébougou. In 2012, he hired Chapman Petroleum to figure out what was emanating from the borehole. Protected from the 50°C sun in a mobile laboratory, a team of engineers found that the gas was 98% hydrogen. Hydrogen is rarely recovered in oil operations and was not thought to exist in large reserves within the earth's crust, until then.

While the presence of naturally occurring hydrogen has been known for decades, with the discovery of its presence in gas seeps, volcanic outgassing, and even mine workings being well documented decades ago, for many years, it was viewed as a geological curiosity. Majority of the scientific opinion at the time proposed that hydrogen's small size and extreme reactivity would hinder the formation of substantial underground deposits.

Now, geological environments favourable to natural hydrogen generation and accumulation are being recognised worldwide. Active mountain ranges with tectonic activity, such as the Pyrenees, Alps, and Himalayas, are also being considered as areas for geological hydrogen production. The fact that helium co-exists with hydrogen in a few reserves points towards some geological processes, such as radiolysis, playing a role in its generation.

The presence of hydrogen in coal mines points towards generation from underlying organic matter. What was previously a specialist field of geological study has therefore become a growing field with enormous implications for the future of energy.

What about current reserves?

Although the total size of worldwide natural hydrogen reserves is still poorly known because of a lack of concentrated exploration, recent discoveries and current research indicate considerable potential. In contrast to conventional hydrocarbon exploration, dedicated frameworks for natural hydrogen exploration are still evolving.

In the Indian context, natural hydrogen potential is mostly untapped but found to be promising because of the existence of favourable geological structures like hard rock formations of diverse ultramafic/mafic and basaltic assemblages, Andaman and Himalayan ophiolite complexes, greenstone volcanic-sedimentary sequences in cratons (Dharwar, Singhbhum), sedimentary basis (for example, in Vindhyan, Cuddapah, Gondwana and Chhattisgarh), basement rocks with fractures, and areas where active hydrothermal systems as represented by hot springs exist.

Recent finds elsewhere in the world indicate the scale of these resources. Hundreds of hydrogen seeps have been catalogued globally in various countries, including Australia (Eyre Peninsula and Kangaroo Island), the United States (Kansas, Nebraska), Spain, France, Albania, Colombia, South Korea, and Canada. There could be sufficient natural hydrogen to supply the growing world demand for thousands of years, based on a model run by the U.S. Geological Survey (USGS) that was unveiled in October 2022 at a Geological Society of America meeting.

Close on the heels of the USGS model, scientists, venturing into abandoned mines in France's Lorraine region chanced upon naturally occurring hydrogen in May 2023. Further excavation in March 2025 in the adjacent Moselle region yielded more reserves. Together, the deposits are estimated to be about 92 million tonnes —worth about $92 billion and about half of the current global hydrogen production.

While it's difficult to project with certainty just how much hydrogen is available in geologic stores, the best estimate is on the order of tens of trillions of metric tonnes. If even just 2% of these reserves are commercially exploitable, they would provide about twice as much energy as all the earth's provable natural gas reserves —enough to meet projected hydrogen demand (500 million tonnes per year) for around two hundred years. However, experts note that it is still unclear how much of that potential can be tapped economically, especially if deposits are too scattered.

How has industry reacted?

The promise of so much renewable fuel sitting undiscovered beneath the surface has sparked a veritable gold rush. By the end of 2023, 40 companies, including start-ups, were searching for deposits of natural hydrogen around the world, up from just 10 in 2020, according to research firm Rystad Energy.

They're hunting for natural hydrogen in countries such as Australia, the U.S., Spain, France, Albania, Colombia, South Korea and Canada. Producers claim they can extract the fuel for about $1/kg, or even less — much lower than the production cost for green or even natural gas-based hydrogen.

The American Association of Petroleum Geologists have formed its first natural hydrogen committee, and USGS began its first effort to identify promising hydrogen production zones in the United States.

In the U.S., a start-up called Koloma raised $245 million of venture funding last year to search for and extract geologic hydrogen, attracting investors including Amazon's climate fund and Bill Gates' Breakthrough Energy Ventures, which is also investing in other natural hydrogen companies, such as Mantle 8 in Europe. Even conventional energy and mining companies are in on the rush — both BP and Rio Tinto recently invested in U.K.-based start-up Snowfox Discovery.

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