OPINION

A gold mine of clean energy ma

Peter Coy

Sometimes we miss things in front of our faces. We don't see what we aren't looking for. "We can be blind to the obvious, and we are also blind to our blindness," Daniel Kahneman, a psychologist who shared a Nobel in economic science, wrote in his 2011 book, "Thinking, Fast and Slow." A flower, for instance. "Nobody sees a flower — really — it is so small — we haven't time — and to see takes time, like to have a friend takes time," the artist Georgia O'Keeffe once wrote.

You know what else has been hiding in plain sight? Hydrogen, the most abundant element in the universe. Hydrogen, which is heralded as the clean energy carrier of the future *because* its only combustion product is water.

Sure, we've known about the hydrogen that's locked up with oxygen in water molecules and with carbon in fossil fuels like propane. But we — and by "we" I mean everybody except for a handful of scientists and some people in Mali (I'll get to that) — never really saw, and never expected to see, hydrogen floating around on its own in gaseous form.

"Hydrogen does not exist freely in nature," the National Renewable Energy Laboratory confidently states on its website. "Hydrogen occurs naturally on Earth only in compound form with other elements in liquids, gases or solids," the U.S. Energy Information Administration avers.

In fact, though, hydrogen gas does exist in large quantities in Earth's crust, a fantastic bit of news that has gotten altogether too little attention. Right now, hydrogen is mostly produced from methane, releasing carbon dioxide. That's dirty, although there are ways to capture the carbon dioxide. Hydrogen can also be produced from water, but that takes a lot of electricity.

Just think how much cheaper and easier would it be if we could drill for hydrogen the same way we drill for oil and natural gas and thus put to good *use society's* enormous investment in equipment built for the exploration, production and transportation of fossil fuels.

I found out about what scientists call natural hydrogen from reading an excellent article published on Feb. 16 in the journal Science, titled "Hidden Hydrogen," which asks, "Does Earth hold vast stores of a renewable, carbon-free fuel?" I interviewed several of the scientists who are at the forefront of studying natural hydrogen, and I read their academic papers.

To be sure, natural hydrogen isn't a certain thing. While I've become convinced that there is a lot of it, something that's valuable isn't necessarily economically recoverable (as I discussed in my column on the "$10 quintillion asteroid").

But the optimism is welling up. There may be hundreds of millions of megatons of hydrogen in Earth's crust, and even if only 10 percent of it is accessible, that would last thousands of years at the current rate of consumption, Geoffrey Ellis, a research geologist for the U.S. Geological Survey in Denver, told me. He and a colleague, Sarah Gelman, presented their findings to the Geological Society of America in October.

The experts have ignored signs that free hydrogen occurs in nature — until now.

OK, I asked him, but isn't the idea that the future rate of consumption would be much higher than the current rate? True, he acknowledged. Right now hydrogen is mainly used for lightening and sweetening crude oil, making ammonia for fertilizer, treating metals and processing foods. Cheap hydrogen could also be used to generate electricity or power vehicles. "If we found it everywhere, we'd use it for more things, so maybe it would last only hundreds of years," he said. "But hopefully in hundreds of years we have cheap fusion so we don't have to worry about any of this."

As for cost, natural hydrogen from the ground should be producible for less than $1 per kilogram, versus around $5 per kilogram for green hydrogen that's derived from water by electrolysis, said Viacheslav Zgonnik, the chief executive of a Denver-based start-up, Natural Hydrogen Energy. "My opinion is biased, of course, but I believe that it will happen. That's why I'm continuing to work on it," he said.

ILLUSTRATION

Why haven't people been talking about this, since it seems like kind of a big deal? That, aside from the huge commercial potential, is what fascinates me. History is replete with examples of ignored discoveries. Take the observation that sailors could prevent scurvy by eating citrus fruits. According to the BBC, the explorer Sir Richard Hawkins recorded in 1622 that "sower lemons and oranges" were "most fruitful" in preventing scurvy. He added, "I wish that some learned man would write of it." But it took until 1753 for Dr. James Lind to publish research proving Sir Hawkins right. Even then, the BBC wrote, "it was not until 42 years later that the Admiralty first issued an order for the distribution of lemon juice to sailors." Meanwhile, thousands of sailors had died needlessly.

Mr. Zgonnik, a native of Ukraine, spent seven years reading 500 books and papers on natural hydrogen for a review. He found that its presence had been written about as early as 1888 by

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ATION BY SAM WHITNEY/THE NEW YORK TIMES; IMAGE BY LEONELLO CALVETTI

none other than Dmitri Mendeleev, the Russian chemist who laid out the first periodic table of elements. But for a long list of reasons, the knowledge was lost or ignored. One reason is that geologists focused on finding oil and, later, natural gas. Hydrogen gas isn't typically found near hydrocarbons.

Scientists tended to believe that any hydrogen in the crust would be eaten by microbes for food or percolate up to the surface and off into space. Findings of pockets of natural hydrogen were dismissed as anomalies. It didn't help that hydrogen is hard to detect. Chromatographs for detecting various gases used to rely on hydrogen as a medium to carry samples, so any hydrogen in a sample would be indistinguishable from the hydrogen already in the device. And so on.

But as the anomalies accumulated, they got harder and harder for defenders of the standard paradigm to ignore — a precursor of scientific turning points that was described by Thomas Kuhn in his 1962 book, "The Structure of Scientific Revolutions." As far back as 2002, Nigel J.P. Smith, of the British Geological Survey, wrote, "It is time for explorationists to take hydrogen more seriously."

The big break came in 2012, as the article in Science last month recounts. A businessman in Mali named Aliou Diallo hired Chapman Petroleum Engineering, a Canadian consulting firm, to analyze the mysterious gas coming from a borehole on his property. It turned out to be 98 percent hydrogen. The gas was used to fuel an engine that ran a generator. "That gave Bourakébougou" — the town nearest the well — "its first electrical benefits: freezers to make ice, lights for evening prayers at the mosque and a flat-screen TV so the village chief could watch soccer games," the Science article said. What's most exciting is that the hydrogen has continued to flow ever since.

Geologists now believe that hydrogen is being constantly produced from a reaction between water and iron-rich rocks. It's essentially rusting: The rocks capture the oxygen and release hydrogen. Some hydrogen may also be bubbling up from deeper in Earth or be formed by radioactivity, which splits water molecules. Hydrogen has been found on all the continents except Antarctica, which hasn't been checked yet. In the United States, the two most promising places are along the East Coast (onshore and offshore) and along an ancient ridge system extending from Kansas to the Great Lakes, Mr. Zgonnik said.

Isabelle Moretti, one of the leading scientists studying natural hydrogen, told me that when she was chief scientific officer of the French company Engie, "quickly we realized that from an economic point of view, it doesn't make any sense" to use electricity to produce hydrogen, transport the gas and then extract the energy through combustion or a fuel cell. But if hydrogen is available in gaseous form in the ground, the economics suddenly work, she said.

True, hydrogen has some drawbacks. It's costly to liquefy or compress for storage. It's also hard to push through existing gas pipelines because it's so light that it leaks, and it embrittles the pipes. One idea for making it easier to transport is to mix it with natural gas or use nitrogen to make it into ammonia.

Michael Webber, a mechanical engineer and energy expert at the University of Texas at Austin who has worked with Ms. Moretti, wrote in 2021 that he's reminded of the early days of the shale revolution: "By leveraging existing know-how from the oil and gas industry, extraction of hydrocarbons from shale formations went from essentially zero in 2008 to around $150 billion by 2019 and reinvented energy geopolitics along the way." Similarly, he wrote, natural hydrogen is "mostly an idea waiting on better technologies, policies and market conditions for it to prosper."

Nobody sees a hydrogen molecule, really. It's just a pair of atoms, colorless, tasteless and lighter than air. It is so small, and we haven't time. Except maybe now we do have time.

OUTLOOK: MIKE ENGLUND AND BEN ENGEN

The official gauge of productivity soared at the beginning of the pandemic, but not because Americans suddenly got better at doing their jobs. It was because of massive layoffs of low-wage workers, who have lower measured productivity (namely, the output of goods or services per hour of work). The changing mix of jobs made economywide productivity look higher.

Recently, though, productivity growth retreated as low-wage workers returned to their jobs. Mike Englund and Ben Engen of Action Economics in Boulder, Colo., predict that the Bureau of Labor Statistics on Thursday will revise downward its estimates for the annual rate of productivity growth to 0.4 percent in the third quarter of 2022 (from the previously reported 1.4 percent) and to 1.8 percent in the fourth quarter (from 3 percent). And they expect productivity in the current quarter to fall at an annual rate of 2 percent.

QUOTE OF THE DAY

"The fox knows many things — the hedgehog one big one."

— *Archilochus, Greek poet of the seventh century B.C., cited in "The Oxford Dictionary of Quotations," revised fourth edition (1996)*

PETER COY *has been writing about economics for nearly 40 years.*