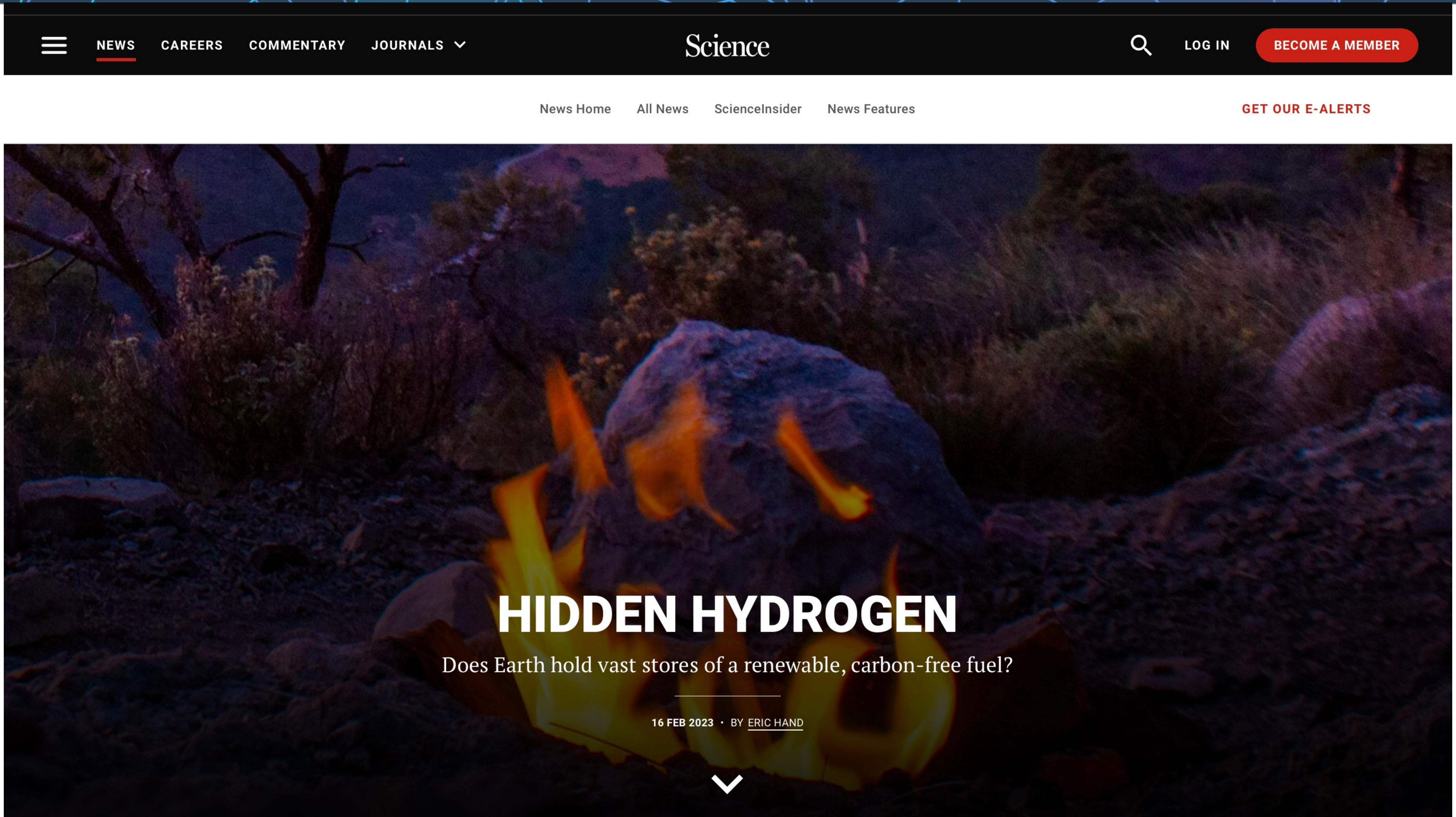
GeoH2 – Stimulating a new Primary Energy Source



What am I going to talk about

Background

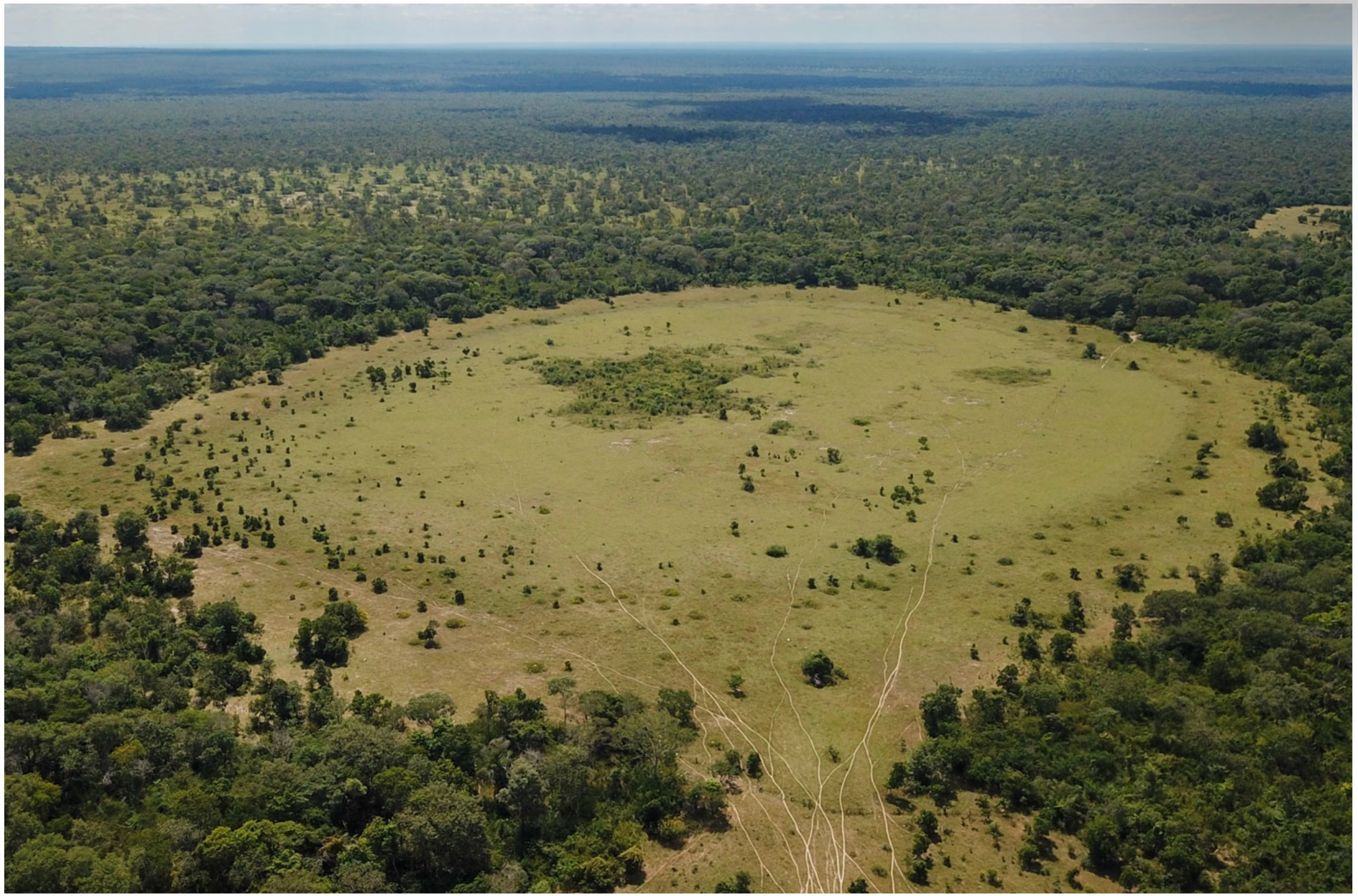
Potential Structure

Potential Outcomes

Potential Metrics

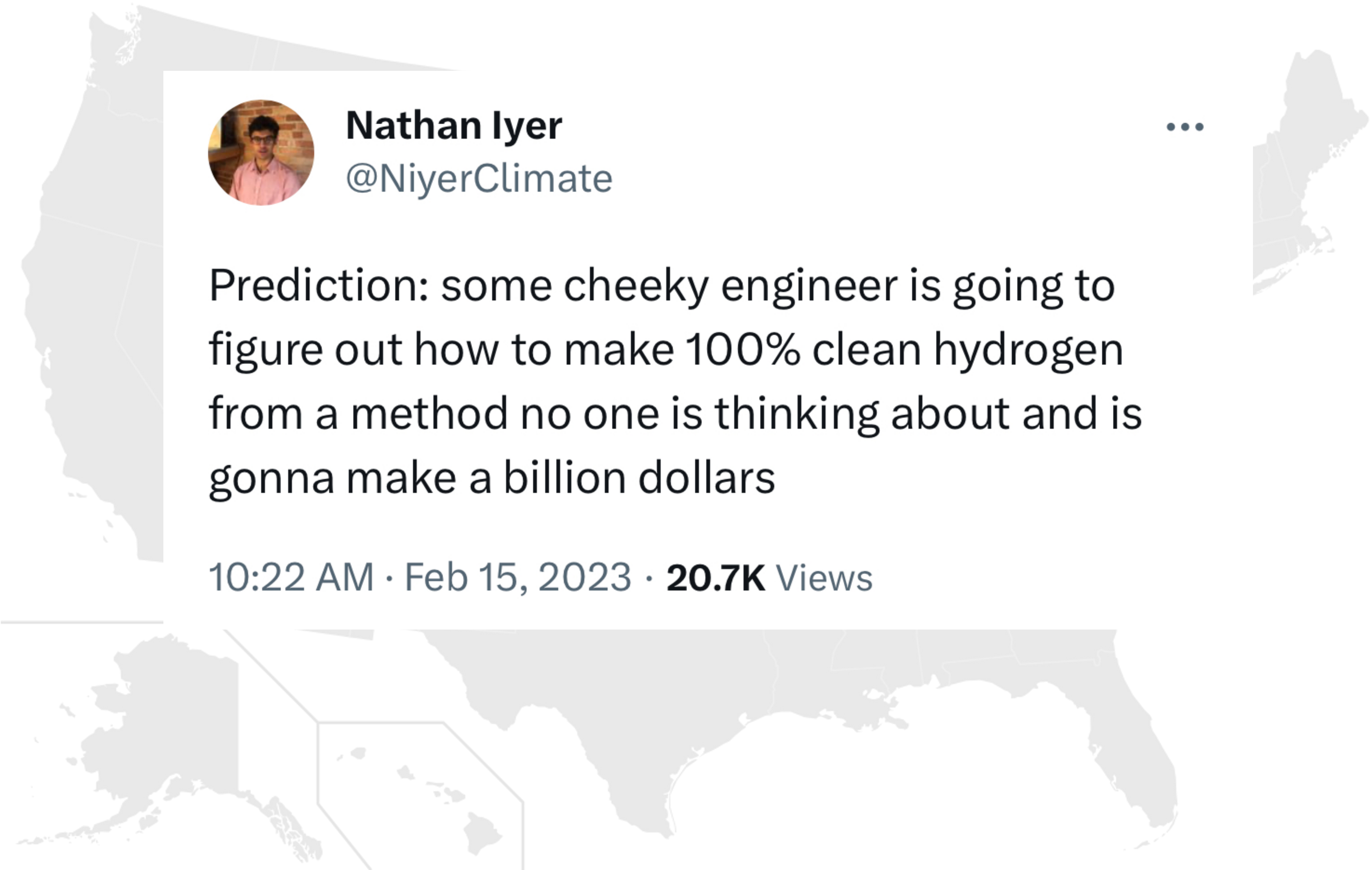
Potential Timing

So where is this leading to?

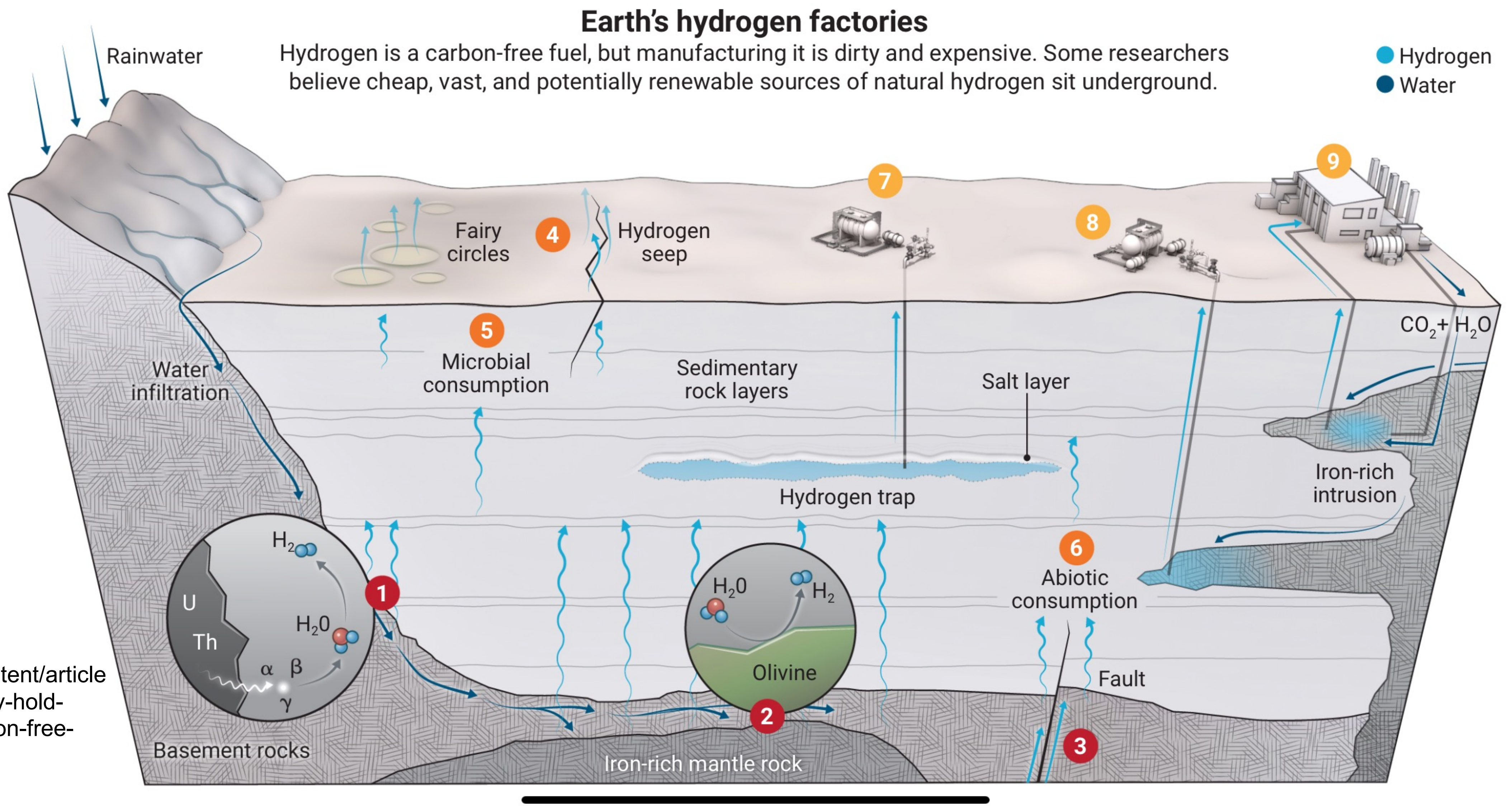


A large fairy circle in Brazil that leaks hydrogen is curiously devoid of vegetation. ALAIN PRINZHOFER

Someone here can make Nathan’s prediction come true

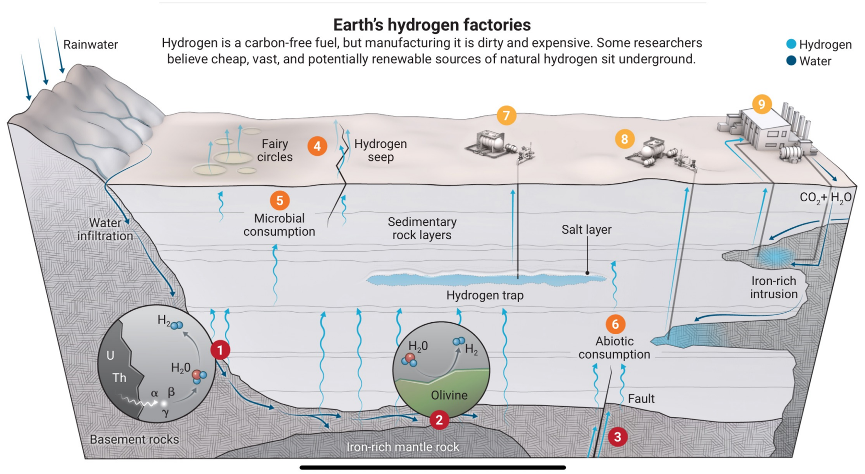


We know what lays beneath our feet



https://www.science.org/content/article/hidden-hydrogen-earth-may-hold-vast-stores-renewable-carbon-free-fuel

Ww know what’s happening beneath our feet



These can be avoided

https://www.science.org/content/article/hidden-hydrogen-earth-may-hold-vast-stores-renewable-carbon-free-fuel

Generation

1 Radiolysis

Trace radioactive elements in rocks emit radiation that can split water. The process is slow, so ancient rocks are most likely to generate hydrogen.

2 Serpentinization

At high temperatures, water reacts with iron-rich rocks to make hydrogen. The fast and renewable reactions, called serpentinization, may drive most production.

3 Deep-seated

Streams of hydrogen from Earth’s core or mantle may rise along tectonic plate boundaries and faults. But the theory of these vast, deep stores is controversial.

Loss mechanisms

4 Seeps

Hydrogen travels quickly through faults and fractures. It can also diffuse through rocks. Weak seeps might explain shallow depressions sometimes called fairy circles.

5 Microbes

In shallower layers of soil and rock, microbes consume hydrogen for energy, often producing methane.

6 Abiotic reactions

At deeper levels, hydrogen reacts withrocks and gases to form water, methane, and mineral compounds.

So, what do we expect from YOU today?

Listen to what we have to say

Share some of your thoughts

Meet potential partners

Start to build a US community of practitioners

Potential Structure - Draft

Will most likely be two exploratory topics

Technologies that stimulate hydrogen production from mineral deposits found in the subsurface -including developing our understanding of hydrogen-producing geochemical reactions (*e.g.*, serpentinization) and of how to enhance or control the rate of hydrogen production through external stimuli (*e.g.*, physical, chemical, or biological)

Technologies relevant to the extraction of geologic hydrogen - including improvements in subsurface transport methods and engineered containment, reservoir monitoring/modeling during production and extraction (strain, leakage, and/or other risks).

Topics of Interest - Draft

Stimulation and generation: Technologies which enhance the natural rate of serpentinization or other equivalent hydrogen producing geochemical reactions (*e.g.*, reduction of iron bearing minerals in banded iron formations, clinkers).

Subsurface engineering: Technologies which are related to engineering or creating subsurface hydrogen reservoirs, or technologies which can achieve a higher concentration/pressure of hydrogen prior to the well-head.

Down-hole gas separation: Down-hole/upstream-of-wellhead systems capable of separating gases to enable transport of higher purity hydrogen (in the case of production of coevolved or liberated gases). An example includes low cost, high flux, high selectivity membrane systems.

Risk mitigation methods: Technologies that can predict, model, or prevent harmful side effects associated with enhanced stimulation of hydrogen generating mineralogical processes (*e.g.*, serpentinization of ultramafic rocks). Focus should be given to understanding and addressing volumetric expansion, seismicity, hydrogen leakage and associated impact on GHG emissions, biological effects, and subsurface contamination.

Modeling approaches: Methods to predict the viability of subsurface resources for stimulated hydrogen generation, inform reservoir management, or assist with stimulation efforts.

Characterization: Methods to map subsurface and ocean floor resources (ultramafic formations or other candidate formations) and quantify physiochemical properties of interest, specifically total Fe content, Fe(II) concentration, Fe(II)/Fe(III) ratio, specific surface area, permeability, or other parameters relevant to stimulated hydrogen generation.

Topics not of interest - draft

- Gasification of existing hydrocarbon storages in the subsurface (*e.g.*, coal, oil reserves).
- Subsurface conversion of methane into hydrogen.
- Technologies focused solely on extraction of naturally occurring/accumulating hydrogen.
- Methods of producing hydrogen that will require carbon sequestration to meet the program-wide GHG metric.
- Proposals focused on generating subsurface hydrogen through electrolysis of water.
- Technologies that are fully mature in other sectors (*e.g.*, geothermal or oil & gas) and do not require substantial innovation to support subsurface hydrogen production.

Potential Program Wide **Aspirations**

Metric	Program Goal
H_2 cost at the well-head	<$1/kg H_2
H_2 GHG (from production)	<0.45 kg CO_2e/kg H_2
Hydrogen purity	>20% (volumetric) at the well-head
Deposit potential	>10 Mt H_2
Deposit production (from formation)	>1 million m^3 H_2 per day H_2 (>30,000 tonnes per year H_2)

Potential Metrics

Cat. 1. Stimulation

1a. Increase of reaction rate by *>10^5×* over the rate found in the native ore being evaluated at an equivalent starting *T* and *P* (generic rate reported as 5×10^4 kgs^{-1} for 1 km^3)

Cat. 2. Engineering

2a. Demonstrate the potential to transport H_2 to the well-head with a purity of *>20% by volume* (or at a justified concentration that is economical for conventional gas separation methods)

2c. Demonstrate sustained and controlled production from target stimulation method with a *loss of output <25% over 1 month* (equivalent to hypothetical production loss of ~3 months of unconventional natural gas production)

Cat. 3. Modeling/Characterization

3a. Increase the success of finding enhanced serpentinization candidate formations.

Cat. 4. Risk management

4a. Predict volume expansion for enhanced H_2 producing mineralogical processes based on stimulation methods proposed in **Cat. 1** (enhanced serpentinization of ultramafic rocks or *other* proposed method)

4b. Model induced seismicity associated with H_2 stimulation methods proposed in **Cat. 1** (enhanced serpentinization of ultramafic rocks or other proposed method)

When?

Keep your eyes on the ARPA-E website

Sign up for the ARPA-E news letter

Conclusion

You've got to have a dream
If you don't have a dream
How you gonna have a dream come true

Rogers and Hammerstein