# Hydrogen: Handle with care

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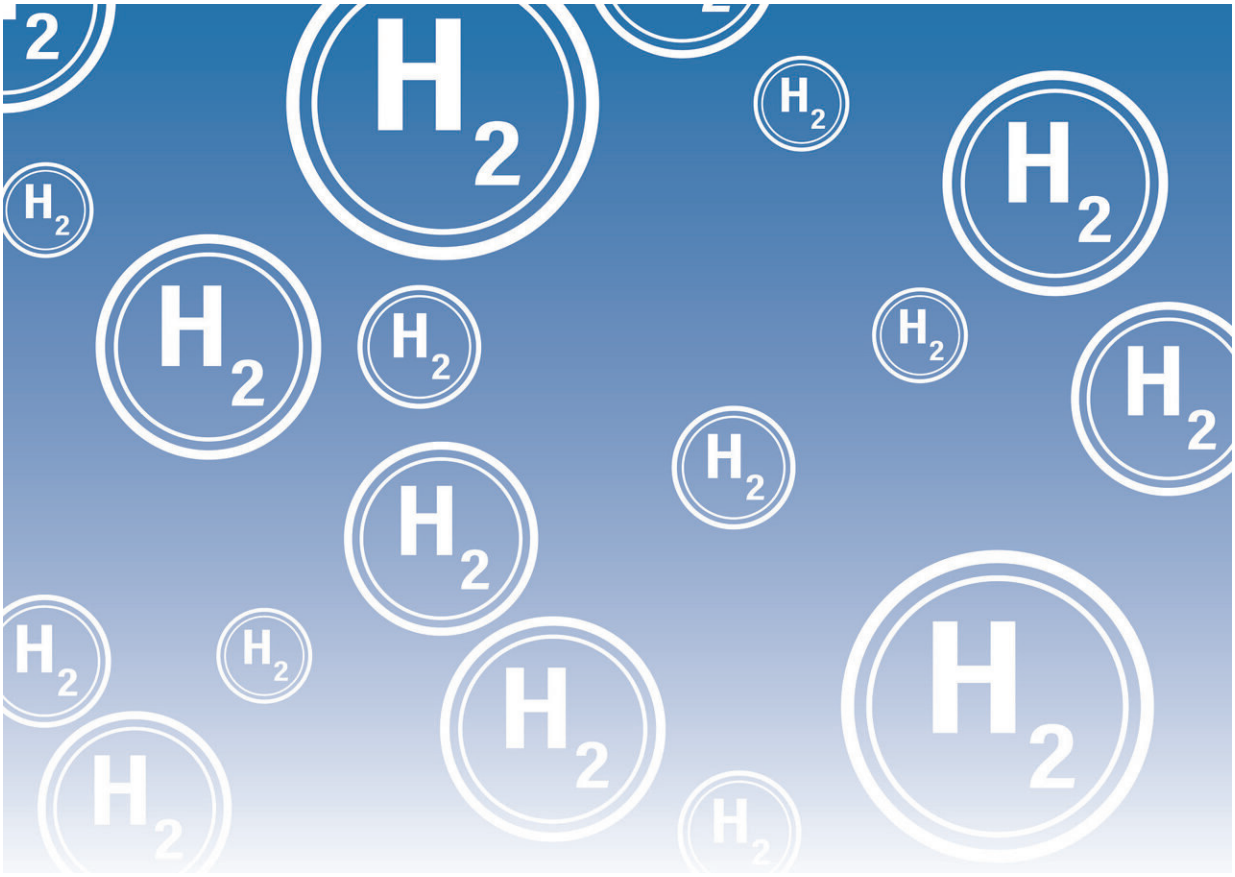


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When produced and used properly, hydrogen can potentially play many roles in the transition toward clean energy and industrial systems. Hydrogen can directly replace natural gas and coal in industrial and manufacturing processes where high temperatures are needed, replace

natural gas and heating oil to keep buildings warm, and replace gasoline and diesel fuel to power cars and trucks.

When combined with $CO_2$ captured directly from the air, hydrogen can be used to manufacture carbon-neutral synthetic fuels, which could replace gasoline, heating oil, diesel and jet fuel, as well as forming the feedstock for carbon-neutral chemicals and plastics.

And hydrogen can be used as a storage medium for electricity, outperforming batteries when it comes to storing large volumes of electricity over monthly or seasonal time scales. But hydrogen also poses several challenges.

The first is storing it. Energy is required to pressurize or chill the hydrogen. The small molecules tend to diffuse through many materials. There are promising new options, making use of nanomaterials and conversion of hydrogen into other chemicals for its storage, but these technologies are not yet mature. For now, storage costs are high.

The second challenge is producing it. Currently, nearly all hydrogen is produced from natural gas, releasing large volumes of $CO_2$ into the atmosphere. This is known as gray hydrogen and must be phased out because of the $CO_2$ emissions it causes.

Blue hydrogen is also produced from natural gas, but the $CO_2$ is captured and permanently stored underground rather than being vented. Unfortunately, this results in large quantities of leaked natural gas, which is primarily methane—a powerful greenhouse gas.

The cleanest solution, green hydrogen, uses electricity from carbon neutral energy sources to split water into hydrogen and oxygen. But this is highly inefficient. By the time the hydrogen is ultimately consumed for heat or electricity, more than half of the energy content of the

original electricity is lost (see also this blog post).

## New concerns over hydrogen

Most recently, a third challenge has come to light: hydrogen leakage. Until recently, leakage had simply been viewed as an economic loss. But there is far more at stake. Leaked hydrogen reacts with scarce OH radicals in the atmosphere. That leaves fewer OH radicals to react with methane. Leaked hydrogen thus extends methane's atmospheric lifetime, worsening its effects on the climate.

Researchers examined these factors together to evaluate the climate benefits of various hydrogen usage scenarios. Scenarios involving only green hydrogen deliver strong climate benefits relative to the fossil fuels that are replaced, assuming hydrogen leakage rates to be low. But as soon as blue hydrogen is introduced to the mix, and hydrogen leakage rates are assumed to be higher, the benefits decline, and in some cases disappear altogether. For example, a scenario with 30% blue hydrogen and leakage rates exceeding 3% would lead to more warming over a 20-year period than the fossil fuels hydrogen replaces.

## How much hydrogen would actually leak?

The answer is that we don't know, because very little research has been done. There is reason to believe that hydrogen would leak more than natural gas, and some estimates of natural gas leakage put it over 3%. The most comprehensive study to date estimates the likely leakage rate for hydrogen to be 2.9%–5.6% but acknowledges that it might be higher.

There are powerful lobbying groups urging policymakers to expand the use of hydrogen as extensively as possible. The fact that these lobbyists are funded by oil and gas producers is no surprise. Not only does blue

hydrogen make use of natural gas, but the business of distributing and selling hydrogen also matches the fossil fuel companies' competitive advantage in the energy industry. Many people, myself included, are extremely concerned about what ambitious plans for hydrogen usage could lead to, both for energy consumers and for the climate.

Anywhere that direct electrification is possible—such as for heat pumps and battery electric cars and trucks—the costs to consumers of electrifying are far lower than switching to hydrogen or hydrogen-based fuels. Our energy models also show that costs for electricity consumers are far lower when policymakers guarantee supply security by maintaining European electricity trade, rather than moving towards independent national systems that require hydrogen storage to overcome local seasonal imbalances.

Across Europe as a whole there is a balanced supply of non-fossil electricity—wind, solar, hydropower and nuclear—that can supply year-round power without losing half of the energy to the conversion losses involved in storage. On top of these concerns come the recent insights into hydrogen's contribution to global warming.

Policymakers are already facing challenges scaling up clean electricity production fast enough to phase out fossil generation over the next 20 years; adding the electricity demand of inefficient green hydrogen production will make this even harder. If energy users become locked into using hydrogen, but the clean electricity isn't there to produce sufficient green hydrogen, then we will have to turn to blue hydrogen as a stopgap measure. That could be a catastrophe for the climate.

## Restricting hydrogen to sensible applications

The Swiss government, to its credit, has been far more reserved than many other European governments in embracing hydrogen. Recently, the

Federal Council clearly stated that it envisioned using hydrogen only where direct electrification is impractical. The government needs to maintain this position and resist the pressure from the hydrogen lobby and fossil fuel industry for hydrogen to take on a larger role. But the government could do more to make sure things don't go wrong.

First, it could pass stronger regulations preventing any future use of gray or blue hydrogen. Second, it could work harder to secure Switzerland's continuing participation in the European electricity market and transmission system, eliminating the need for hydrogen electricity storage, which is inefficient, costly, and potentially harmful for the climate. Third, it could join other countries in funding research on hydrogen leakage and the engineering solutions to prevent it, ensuring that where green hydrogen is used, it will not come at a cost to the climate.

Hydrogen will play a role in cleaning up the energy system and stopping climate change, but it also carries substantial risks. We must handle it with care and avoid using it where better alternatives are available.

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