These are two versions of our hydrogen economy article. The more in-depth one is 'Hiding behind hydrogen'. The shorter one is further down. The URLs:
https://theconversation.com/green-hydrogen-why-low-carbon-fuels-are-not-benefiting-from-high-fossil-fuel-prices-195774
https://theecologist.org/2023/jan/13/hiding-behind-hydrogen

Hiding behind hydrogen

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The buzz around the hydrogen economy is shifting up a gear. But is hydrogen the spearhead technology in a green transition, or an elaborate bait-and-switch orchestrated by Big Oil and Gas?

The hydrogen economy appears to enjoying its great leap forward. Assuming its construction goes to plan, a €2.5bn undersea pipeline will from 2030 convey "green hydrogen" from Spain to France. It is one element in a hydrogen infrastructure package that the European Commission announced earlier this year.

In the USA, some power stations are being upgraded to allow hydrogen to be blended with fossil gas, and the Norwegian oil company Equinor is teaming up with Thermal SSE to build a 1,800MW "blue hydrogen" power plant in Britain. China, earlier this year, unveiled a long-term hydrogen plan which includes major technological and infrastructure investments.

If the number of projects is growing at pace, one may suppose, a large supply of the resource must exist somewhere. Well, it does and it doesn't.

Decarbonise

Hydrogen is produced in multiple ways. A colour spectrum is used to render it simple. "Grey" and "brown/black" refer to hydrogen produced from fossil gas (methane) and coal (brown or black coal) respectively—a process that, for every ton of hydrogen, emits between ten and twelve tons of carbon dioxide for grey hydrogen or eighteen to twenty for brown.

"Blue" is the same process but filed under "low carbon" because the carbon dioxide is supposed to be captured and stored underground. "Green" hydrogen is conventionally defined as generated from renewable electricity passed through water to split it into hydrogen and oxygen.

When you zoom in on hydrogen's "colours," however, they appear slippery. The hydrogen economy is not a palette of technological options but a grey-brown oil refinery behind an eye-catching blue-green front gate. All the chatter is of the latter.

Green and blue hydrogen yield 11 million and 320,000 Google hits respectively, as against 95,000 for grey and 49,000 for brown. The reality curves in the opposite direction: only 0.04 per cent of hydrogen is green, and blue hydrogen is also less than one per cent. At least 96 per cent is grey or brown, most of which is used in oil refineries and for manufacturing ammonia and methanol.

The hydrogen economy is not a palette of technological options but a grey-brown oil refinery behind an eye-catching blue-green front gate. All the chatter is of the latter.

It's an enormous industry, responsible for emitting more carbon dioxide than all of Britain's and France's emissions combined. The test of any government or corporate hydrogen agenda, then, is the nature—or even the existence—of its plans to decarbonise the 96 per cent. In some cases this is beginning to happen. But if the focus is on producing more 'blue' and more 'green' *for other purposes*, something is amiss.

Failures

When you look closely at green hydrogen, some of it resolves into shades of grey. It's not simply that its production is extremely energy-intensive or that in its double transformation—from electricity to hydrogen and thence to its final usage—so much energy is wasted.

It is partly that, if combusted, it emits nitrogen oxides, and also that, if scaled up to play a significant economic role by 2050 (as in recent projections by the International Energy Agency), its freshwater requirements could exceed one quarter of today's global annual consumption, causing water stress in some regions.

Above all, green hydrogen is *meaningfully* green only if the renewable energy that generates it cannot be fed into the grid to replace power from gas or coal plants.

A similar but much more harmful trick of the light occurs with blue hydrogen. Look closely and you see that in reality it's either chequered blue/grey or even blank, a mere fiction.

For hydrogen to be true blue, the emissions must be captured and securely stored. In theory, CCS is workable but nearly all plants use the captured carbon to pump more oil and many have been shut down as failures.

Costs

Only a handful operate to store carbon rather than using it to produce oil, and even here it is highly energy intensive and captures only a part of the carbon dioxide. It can also leak once in storage.

Moreover, blue hydrogen's main feedstock is methane, a powerful greenhouse gas that is notorious for leaking: at the drilling wells and from the pipelines. Recent research suggests that blue hydrogen is even worse for the climate than fossil gas.

Blue hydrogen is still in its infancy and we don't yet know whether most of the CCS costs will be loaded onto taxpayers, as the gas companies demand.

Price projections should be treated with the utmost scepticism. One boosterish paper cites blue hydrogen from Alberta (Canada) at $1.50 to $2.0 per kg. It adds that blue hydrogen production will help Canada achieve its decarbonisation goals.

In fact, research at Shell's CCS plant in Alberta discovered that it emits more carbon than it captures. For the foreseeable future, this is not a "low carbon" product in any sense of the term. It is a

hypothetical solution the costs of which remain unknown, as the development of projects has been slow and costly with few realised, while future operating costs are also unclear.

Electrolysers

Given the question marks that surround blue hydrogen, it's widely hoped that a silver lining of today's high gas prices will be that green hydrogen becomes cost competitive.

In terms of inputs, the green-blue price difference boils down to the cost of electricity versus fossil gas. With the global energy crisis exacerbated by Russia's war on Ukraine, many are asking: will high gas prices favour green hydrogen? Spoiler alert: probably not.

In the EU, as in many economies, electricity pricing is based on the principle of marginal costs, and that usually means the price of power from fossil gas plants. When it is high, renewable electricity generators will seek to sell to the grid. In this way, blue and green prices are largely interwoven in the current market setup; their inputs move in sync.

Of course, there are geographical and temporal differences. During sunny spells, electricity prices may collapse as solar PV-based generation picks up.

This unlinks electricity and natural gas prices, but only momentarily, often only for a few hours—not enough to justify investment in electrolysers to produce green hydrogen. On the whole, the price gap between blue and green will remain fairly narrow until electricity markets are fundamentally restructured.

Transition

There's worse. The high price of hydrocarbons has turbocharged the industry's expansion. The US government is exhorting oil and fracking firms to 'drill baby drill.' Britain's government has issued over one hundred additional licenses to drill. Colossal new fossil fuel investments have been announced across the Middle East and Africa.

All this will have long-term ramifications. First, in a few years when the new production comes on stream, and particularly if the current growth slowdown substantially depresses demand, gas and oil will again become cheaper—until the next price spike prompts new rounds of investment, and the infernal cycle continues.

Second, the owners of the new-drilled wells and other infrastructure will fight tooth and nail to defend those assets, and to stall the decarbonisation agenda. The peculiarity of hydrogen is that it is a means to both the stalling *and* the decarbonisation.

The latter can be simply stated. Green hydrogen will be important to the decarbonisation of certain sectors such as steel, and ammonia for fertilisers, and possibly shipping and trucking.

The role of hydrogen in *stalling* the transition is complex but no less important. It begins with the recognition that the fossil fuel corporations are rebranding themselves as agents of "carbon management."

Ramping

The goals are to prevent their assets from getting stranded by repurposing them, above all by marketing grey and blue hydrogen as "bridge" fuels; to lock in hydrocarbon production for decades to come; and to defray the costs onto taxpayers.

For this, hydrogen offers the perfect vehicle, in view of its confusion of shades and colours. Fossil fuel interests use it to counter opposition to new investments in fossil gas through an aggressive marketing and lobbying campaign that presents a largely fictional substance, blue hydrogen, as a low-carbon "bridge" to an unspecified future genuinely-green transition.

Other sectors have joined the oil-led coalition. As the engineer Tom Baxter observes, it is seen by gas network operators and boiler manufacturers as their survival route.

Likewise, power utility companies are keen, as hydrogen's inefficiencies mean they'll sell more power. Relatively conservative trade unions, such as Britain's GMB (General, Municipal, Boilermakers), are onboard too.

To tackle this stalling operation, a strong role for public policy is indispensable. Governments will need to regulate or tax blue carbon out of the market while simultaneously ramping up renewables.

Malign

Fiscal and subsidy schemes need to pivot from supporting fossil fuels to supporting renewables. The approach to electricity pricing must shift, to decouple the prices of electricity and fossil gas.

Instead of the marginal pricing system, it requires incentivising rewards for generators according to their average costs plus a slight surplus, either through a robustly regulated market system or by nationalising the energy companies and setting prices and production.

Such interventions would give green hydrogen a competitive advantage, one that can be furthered by other subsidies, such as tax credits on the model of the US Inflation Reduction Act. Above all, energy demand needs to be scaled down. The lower the demand, the less the upward pressure on price.

In any future energy system, hydrogen will have a role. But its expansion needs to be carefully designed, to prevent the promise of green hydrogen being mis-used, in opening the back door to its ecologically malign blue and grey cousins.

Green hydrogen: why low-carbon fuels are not benefiting from high fossil fuel prices

Published: January 12, 2023 12.12pm GMT

The number and scale of projects using and making hydrogen, a gas that releases energy when burned without emitting carbon dioxide, is rapidly growing. If its construction goes to plan, a €2.5 billion (£2.18 billion) undersea pipeline will convey "green hydrogen" from Spain to France from 2030.

In the US, some power stations are being upgraded to allow hydrogen to be blended with fossil gas, and the Norwegian oil company Equinor is teaming up with Thermal SSE to build a 1,800 megawatt (MW) "blue hydrogen" power plant in Britain.

Meanwhile, China unveiled a plan in March which includes deploying 50,000 hydrogen vehicles by 2025 and early December saw the first hydrogen-fuelled tractors and forklifts leave the assembly line at a new plant in Guangdong province.

Hydrogen is produced in multiple ways. A colour spectrum is used to render it simple. "Grey" and "brown/black" hydrogen come from fossil gas (methane) and coal (brown or black coal) respectively – a process that, for every tonne of hydrogen, emits between ten and 12 tonnes of CO_2 for grey hydrogen and 18 to 20 for brown.

"Blue" is the same process except the carbon dioxide is supposed to be captured and stored underground. And "green" hydrogen is conventionally defined as generated from splitting water into hydrogen and oxygen using renewable electricity.

But only 0.04% of hydrogen is green, and blue hydrogen is less than 1%. The rest is grey or brown, most of which is used in oil refineries and for manufacturing ammonia and methanol. It's an enormous industry which emits more CO_2 than all of Britain and France combined.

It is widely hoped that a silver lining of today's high gas prices will be green hydrogen becoming a cost-competitive alternative to dirty fuels in boilers, shipping tankers and steelworks furnaces. Unfortunately, without electricity market reform, this opportunity is likely to be squandered.

And while the buzz around the hydrogen economy intensifies, a closer look suggests the fuel is less a spearhead for a green transition and more the subject of an elaborate bait-and-switch operation by oil companies.

Hydrogen's true colours

Green hydrogen is essential for decarbonisation: to replace fossil fuels in steelmaking, ammonia production for fertilisers and possibly shipping and trucking – processes which are difficult to electrify.

Much of the world's steel is currently produced by burning coal.

Some green hydrogen is crosshatched with dirtier hues. It's not simply that in its production a lot of energy is wasted in the double transformation from electricity to gas and then fuel. But burning hydrogen also emits nitrogen oxides, air pollutants linked to respiratory illnesses and acid rain.

If green hydrogen production is scaled up to play a significant economic role by 2050, its freshwater demand could exceed one-quarter of today's global annual consumption, risking water scarcity in

some regions. Above all, hydrogen is meaningfully green only if the renewable energy that generates it cannot be fed into the grid to replace power from gas or coal plants.

Blue hydrogen relies on a similar – but much more harmful – trick of the light. For hydrogen to be true blue, the emissions must be captured and securely stored.

In theory, carbon capture and storage works but nearly all plants use the captured carbon to pump more oil and many have been shut down as failures. Only a handful store carbon indefinitely and even these consume lots of energy and capture only some of the CO_2, which can leak.

Blue hydrogen's main source is methane, a powerful greenhouse gas that is notorious for escaping drilling wells and pipelines. Research suggests that these issues make blue hydrogen worse for the climate than fossil gas.

In the EU, as in many economies, electricity pricing is based on the principle of marginal costs, which means that the most expensive source (typically fossil gas) sets the wholesale power price. During sunny or windy spells, a glut of renewable energy generation can slash electricity prices, freeing them from the grip of natural gas prices for a few hours at a time.

This is often not enough to justify investments in the electrolysers which produce green hydrogen. Green hydrogen won't gain the necessary price advantage over blue hydrogen and fossil gas until electricity markets are restructured.

Hydrogen's contribution to decarbonisation remains theoretical.

Meanwhile, the high price of oil and gas has turbocharged the industry's expansion. The US government is exhorting oil and fracking firms to "drill baby drill". Britain's government is to award more than 100 licenses to drill for oil and gas and colossal new fossil fuel investments have been announced across the Middle East and Africa.

In a few years when these new sources come onstream, and particularly if economic growth continues to slow and depress energy demand, gas and oil will become cheaper again – until the next price spike prompts new rounds of investment, and the infernal cycle continues. The owners of newly-built wells, pipelines and terminals will fight to defend those assets and stall decarbonisation.

Now fossil-fuel firms are rebranding themselves as agents of "carbon management." The aim is to prevent their assets from getting stranded by repurposing them, presenting a largely fictional substance, blue hydrogen, as a low-carbon "bridge" to an unspecified green future.

Other sectors have joined the oil-led coalition. As the engineer Tom Baxter observes, gas network operators and boiler manufacturers see their survival in this ploy. Utilities are similarly keen, as hydrogen's inefficiencies allow them to sell more power.

Tackling this stalling operation requires public policy. Governments will need to regulate or tax carbon out of the market while simultaneously ramping up renewables.

The approach to electricity pricing also needs to shift, to decouple the prices of electricity generated from renewables and fossil gas. The marginal pricing system hugely benefits renewable project owners, since they profit from high electricity prices and effectively zero input costs.

An alternative market structure would set rewards for generators according to their average costs plus a slight surplus which could be reinvested into deploying more renewables and other green technologies, providing consumers with cheap electricity. This can only be achieved through a robustly regulated market or by nationalising energy companies and setting prices and production.

These interventions would give green hydrogen a competitive advantage over blue or grey variants, one that could be furthered with other subsidies, such as tax credits on the model of the US Inflation Reduction Act. Above all, energy demand must be reduced to ease upward pressure on price.

In any future energy system, hydrogen will have a role. But its expansion must be carefully designed, to prevent the promise of green hydrogen disguising the risks of its blue and grey cousins.