Our Principles

Climate science tells us we need to decarbonise the global economy by mid-century at the latest to avoid the worst climate impacts.

This warning from scientists and the Paris Agreement's call for temperature rise to be limited to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C" has led to a raft of countries to pledge to reach net-zero around mid-century. These pledges encompass about two-thirds of the global economy, while hundreds of cities, scores of states and regions, and thousands of companies across most sectors have made similar pledges.

The International Energy Agency has shown that to reach this global goal of net-zero emissions the priority needs to be shifting away from fossil fuels towards electricity-based, energy efficient heating and transport systems.

It's no small challenge, but if done well decarbonisation can create jobs, future proof industrial sectors of the economy, improve air quality and cut bills for the public.

Innovative solutions like hydrogen are an important piece of this puzzle.

However, the production of hydrogen itself is a significant decarbonisation problem we have barely begun to tackle, given that almost all hydrogen in the world today is made from fossil fuels without Carbon Capture and Storage (CCS).

There is some confusion about which kind of hydrogen should be prioritised and for which end use sectors. Many governments are considering widespread use of hydrogen in sectors where there are already cheaper, more efficient solutions available today. This is despite the Intergovernmental Panel on Climate Change recognising that hydrogen will represent, at best, 2 percent of total energy consumption in 2050.

Because near zero emission hydrogen is essential but is very energy inefficient and does not yet exist at scale, we cannot expect a hydrogen industry to have a significant impact on emissions or jobs within the next decade.

Developing a hydrogen economy is a long path forward, yet climate science shows us we need to act today to reach our net-zero goals.

In light of this confusion, our aim with the Hydrogen Science Coalition is to bring an evidence-based viewpoint into the global discussion on hydrogen's role in the energy transition.

We are a group of independent academics, scientists and engineers who are specialists in hydrogen on production, transportation and potential end use sectors. We aim to ensure that hydrogen policy decisions reflect the most effective way forward in our path towards net-zero emissions by 2050.

It is with this in mind that we stand behind five guiding principles on hydrogen's role in the energy transition:

1. Zero emission hydrogen is an opportunity for governments to advance the energy transition. However the only near zero emission hydrogen is that made from renewable electricity.

Governments must prioritise support for near zero emission hydrogen in order to align with our climate goals. The only hydrogen that meets this standard today is renewable hydrogen - also known as green hydrogen - which is made from additional renewable energy such as wind and solar power.

Hydrogen won't have the impact on climate we need if it is a fig leaf for continuing to burn fossil fuels which drive up emissions. Fossil hydrogen with CCS, also called blue hydrogen, which is produced by burning natural gas and attempting to capture carbon emissions with CCS, should be approached with caution. That's because CCS is always partial, fugitive methane emissions during production and transportation are significant, and the risk of lock-in to fossil fuels is very real.

A variety of emerging studies are highlighting the lack of understanding of the climate impacts of blue hydrogen. In the worst case scenario its emissions could be even worse than simply burning fossil fuels outright, and at best it is a very expensive way to limit GHG emissions from necessary hydrogen production.

Therefore we cannot assume hydrogen made from fossil fuels and CCS will by default be low emissions. Assessing and mitigating the lifecycle emissions of fossil hydrogen with CCS is a complex issue that could take many years, when we know we need to invest in decarbonisation solutions today.

There is also discussion around hydrogen made from plastics as a viable near zero emissions solution. We believe this is false. Plastics are nearly all of fossil origin, meaning there are by default CO_2 life cycle emissions.

2. Deploy renewable hydrogen for hard to decarbonise sectors, starting with where fossil hydrogen is used today.

Hydrogen presents an opportunity to decarbonise sectors of the global economy that do not have existing electrification solutions, creating jobs and a long term deep decarbonisation pathway.

The first sector to be targeted must be where fossil hydrogen is used today. Fossil hydrogen has been produced from natural gas and coal for decades, but unlike fossil hydrogen with CCS, the CO2 emissions aren't captured. The fossil hydrogen currently used for chemical feedstocks and fertiliser globally accounts for roughly 3% of the world's greenhouse gas emissions – not dissimilar to the amount generated by aviation globally.

Hydrogen (in the form of synthesis gas) is already used to reduce iron ore to iron metal. The first production of fossil free steel in Sweden has already taken place, made from renewable hydrogen. Scaling up renewable hydrogen to produce steel could be the beginning of developing a more competitive and sustainable steel sector.

It's worth noting that hydrogen is also a possible vector for energy storage, but it's only one of many. While the cost of storing the hydrogen can be low and technically feasible, the losses from energy transformations and the high cost arising from intermittent use of equipment makes hydrogen energy storage an expensive solution compared to alternatives. Hydrogen for storage should only be used as a last case resort where no alternative exists, and after the decarbonisation of existing fossil hydrogen production.

3. Hydrogen shouldn't be used to delay deploying electrification and energy efficiency solutions today, such as in heating and transport.

Hydrogen isn't the best solution if it's more risky, expensive or emissions intensive than already available alternatives like electrification or energy efficiency solutions in sectors like heating and land transport.

Research shows that this is the case when considering hydrogen to heat buildings or to power land transport. Producing hydrogen uses vast amounts of energy, making it extremely inefficient, which is a fundamental flaw when comparing it with other electrification alternatives.

Heating buildings with boilers using renewable hydrogen takes about six times more electricity than using electric heat pumps. Similarly, it takes about three times more electricity to power a hydrogen fuel cell lorry or bus than one running on a battery.

If affordable hydrogen solutions are ultimately developed for these areas, it shouldn't be at the expense of rolling out what we know works now.

Hydrogen is also considered as a solution to produce e-fuels. However converting hydrogen into e-fuels only reduces efficiency, and raises the cost per unit of energy even further. E-fuels are a way of trying to cope with the difficult practicalities of using hydrogen due to its low density, however they should only be used when there are no other efficient solutions, such as the electrification of short haul aviation.

Focusing on the wrong demand sectors for hydrogen would be an expensive mistake that can be avoided with other cheaper and available alternatives. Prioritising electrification, energy efficiency and a focus on renewable hydrogen for heavy industries will bring jobs to transitioning economies.

4. Given how valuable renewable hydrogen is, blending it into the existing natural gas grid does not make sense due to its limited impact on emissions savings.

It is widely understood that current natural gas transmission infrastructure can carry a maximum of a 20% mix of hydrogen before needing expensive upgrades. Most natural gas transmission pipelines cannot accept pure hydrogen, and all end user devices such as gas boilers or gas cookers would need to be replaced to run on pure hydrogen.

Studies also show that blending 20% of renewable hydrogen into existing natural gas pipelines will only save around 7% of carbon emissions, while also increasing consumer costs. Blending hydrogen with natural gas reduces the energy content, meaning more of the mix is needed to deliver the same amount of energy to the end consumer.

Furthermore, the safety of hydrogen in domestic environments is questionable where hydrogen is burned in a gas cooker or gas boiler. Recent research suggests blending hydrogen into the gas grid increases polluting NOx emissions, which are associated with a higher risk of respiratory illnesses, than compared to just burning natural gas outright.

Before blending our valuable renewable hydrogen into the natural gas grid, the priority needs to be areas where we can have significant and immediate emissions reductions, such as replacing polluting fossil hydrogen as outlined in our second principle.

5. Prioritise the production and consumption of locally produced hydrogen, to avoid wasting precious renewable energy.

We advise to prioritise direct electrification, energy efficiency and - if necessary - locally produced hydrogen before relying on hydrogen imports to advance the energy transition. Products produced locally with hydrogen, and then exported - such as steel made from renewable hydrogen - are also a better option than directly exporting hydrogen or hydrogen derivatives. Countries should look to decarbonise their own existing fossil hydrogen industries before considering hydrogen exports.

Large scale transport of hydrogen is yet to be a reality, and science tells us that moving hydrogen across large distances will not only be costly, but it is extremely inefficient and will mean big energy losses along the entire supply chain. Simply liquifying hydrogen for transport consumes 30% of the energy in the hydrogen. Transporting hydrogen incurs daily losses for boil off, and if this hydrogen is then used to make electricity at its end destination, we are left with, at best, just 23% of the original energy at the end of the process.

Other hydrogen export options also have challenges. For example, replacing all fossil fuels exported by ship (oil, gas, coal) with large-scale shipping of renewable ammonia (produced from renewable hydrogen) would significantly increase the risk of ammonia leaks into the environment. Because ammonia is highly toxic, this weakens the case for it as a way to export hydrogen. We must prioritise safer solutions that exist locally. Please note we do not have a position on ammonia as a fuel for powering ships, given the complexity of shipping decarbonisation options. More research is needed on this topic.

Lastly, hydrogen is a smaller molecule than the likes of natural gas, meaning it is even more prone to leakage from pipelines. Recent research has shown that when hydrogen is vented or leaks into the atmosphere, its short-term global warming potential is significantly higher than previously thought. The climate impacts of hydrogen leakage from pipelines and transport vehicles must be understood before there is large-scale commitment to transporting hydrogen in this way.

In conclusion, we encourage governments to consult independent experts, alongside the energy industry who stand to benefit from these policies, on the development of a hydrogen sector.

A successful climate action plan is no longer just about the rapid build out of wind turbines and the phasing out of coal plants. It is about deploying all the solutions we have within the right sectors, ensuring that we tap into all expertise available to guide these decisions.

A well thought through strategy on hydrogen is a key part of that climate action plan.

For more information, visit our website www.h2sciencecoalition.com.