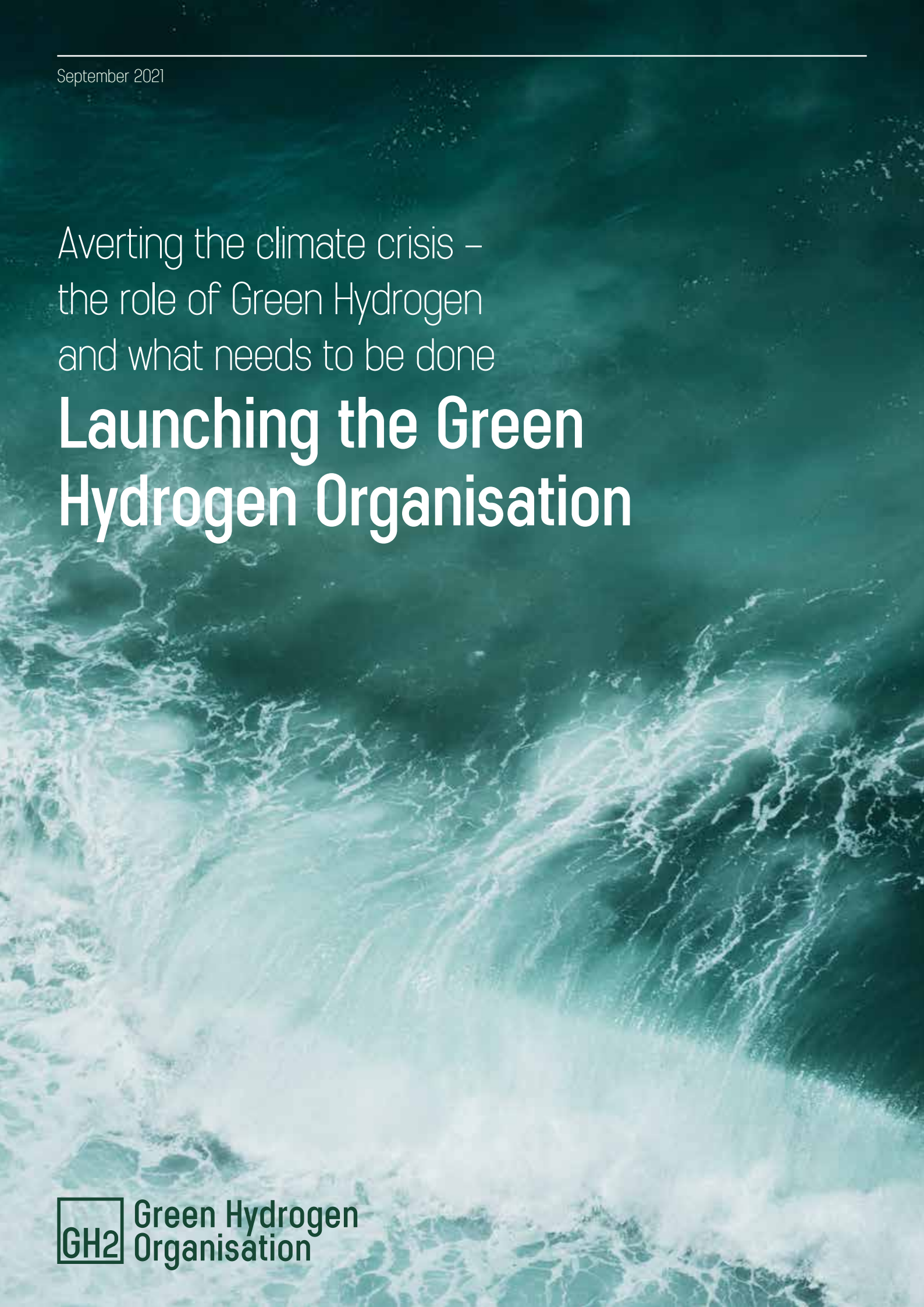
September 2021

Averting the climate crisis –
the role of Green Hydrogen
and what needs to be done

Launching the Green Hydrogen Organisation



GH2 Green Hydrogen Organisation

"Green hydrogen is the key to rapidly decarbonising stubborn but massive processes like materials, trucking, and shipping, where we rely so heavily on dirty fuels. These highly emitting parts of our economy are often invisible for the average consumer, but that doesn't make their effects on our climate any less catastrophic.

Green hydrogen is, in a way, the sleeping giant of the energy transition, and I believe will have a bigger impact on tackling climate change than any other technology. GH2 has been established to tell this story and coordinate a dramatic acceleration of the green hydrogen sector. Every responsible business should be backing this effort. We have the technology at our fingertips. With determination, cooperation, and the leadership of GH2 and its members we can transition away from fossil fuels way faster than most people realise."

Dr Andrew Forrest,
founding chairman of Fortescue Metals Group and the Minderoo Foundation

Averting the climate crisis - the role of Green Hydrogen and what needs to be done

Launching the Green Hydrogen Organisation

Version 1.0.0

September 2021.

Green Hydrogen supplies 25% of the World's Energy by 2050.

Founding goal of the Green Hydrogen Organisation

Six key messages from us

1. Green hydrogen — hydrogen produced through the electrolysis of water with renewable energy — is a **proven technology with vastly underappreciated potential** to decarbonize large sectors of the global economy and help meet our climate change goals.

2. The Green Hydrogen Organisation (GH2) leads **a global effort to promote green hydrogen in collaboration with government, industry and other supporters and stakeholders**. Collaboration at a global level is essential, especially in establishing global markets and cross-border infrastructure.

3. GH2 will **support governments in establishing energy sector policies that enable and stimulate the demand and markets for green hydrogen**. These markets will grow, but their development and growth can be accelerated in cost effective ways. This includes incentivizing and stimulating investments by producers, suppliers, distributors, users and consumers. By underwriting investment, government support can lower costs, and mobilise job creation. Governments should also eliminate unnecessary regulatory barriers and harmonise standards across sectors and borders. Public support for research and development is essential to lower costs and increase efficiency, including for electrolysers, fuel cells and hydrogen-based fuels.

4. A founding principle of the GH2 is that **green hydrogen must be prioritized and differentiated from all forms of fossil fuel and fossil fuel-derived hydrogen, including blue hydrogen**. Global energy markets are distorted by massive direct and indirect subsidies for fossil fuels and under-priced carbon emissions. These have regressive social outcomes and devastating environmental impacts. Energy sector policies that promote non-green hydrogen are reinforcing these distortions. Options based on carbon capture and storage solutions are ineffective in the short term and uneconomic in the long term. Government support should be redirected toward more efficient, equitable and sustainable options. This will stimulate investment and job creation. Hydrogen policy, markets, industry and related infrastructure should be designed to support green hydrogen primarily.

5. In partnership with developing and emerging countries, and their development partners, **GH2 will work to make the production and use of green hydrogen central to the achievement of the United Nations Sustainable Development Goals (SDGs)**. This includes ensuring access to affordable, reliable, sustainable and clean energy, and leveraging green hydrogen investments to promote economic and employment opportunities. We will support the development of
fuel cell technology and the potential to improve transport systems, health care services and water treatment.

6. The Green Hydrogen Organisation supports a just transition. We believe that **the global challenges of sustainable economic development, poverty reduction, social justice and climate change are interconnected**. They demand bold action by government, industry and civil society to open up new pathways for sustainable development. We will support the elaboration of green hydrogen standards that promote best practices in minimizing ESG risks. We support global efforts to protect human rights, advance gender equality, and address conflict and instability. We believe in the principle and practice of accountability by government and industry to all citizens for the stewardship of our natural resources. We will report on our activities and progress, and uphold highest standards of transparency, accountability and good governance.

Foreword

Hydrogen. Everyone is talking about it.

It is the key to decarbonising our economy. When we burn hydrogen, instead of oil, gas or coal, we emit water instead of carbon dioxide.

We cannot keep burning fossil fuels. We cannot keep pumping more and more CO_2 into the atmosphere. Coal, gas, oil all have to be replaced.

And hydrogen is the answer.

But not all hydrogen is the same. The molecule is the same no matter how hydrogen is produced. But if that hydrogen is produced from gas or coal, or with electricity generated by burning gas or coal, then there is nothing clean or green about it.

In fact the CO_2 emissions from fossil fuel hydrogen production are so high that they render the total emissions footprint of a hydrogen fuel cell higher than a traditional internal combustion engine.

Sun, wind, hydro and other sources can deliver zero carbon energy. Much of it can be used through the electricity grid or stored in batteries or pumped storage systems. But there are no batteries large enough for ships that spend months at sea, or for long-haul trucks.

So, yes, hydrogen is the answer. But it is only the answer to global warming if it is produced with renewable energy. Otherwise we are going backwards in terms of emissions.

And we cannot afford to do that.

So that is why we have formed the Green Hydrogen Organisation (GH2). Our mission is to ensure that the only hydrogen accepted as clean and sustainable is that produced without CO_2 emissions.

It is that simple – green hydrogen means hydrogen made by electrolysing water with renewable energy.

That sounds obvious, so why do we need GH2?

Because not everyone understands that all hydrogen is not the same in terms of its impact on our planet. Too many of the national hydrogen policies and hydrogen associations overlook the fact that hydrogen produced from fossil fuels will generally result in more CO_2 emissions, not less.

And of course the fossil fuel sector has a vested interest in persuading us that they can produce “clean” hydrogen by capturing the CO_2 emissions and storing them. Yes, it’s back, like the creature from the crypt, Carbon Capture and Storage (CCS) is having a curtain call in the form of “blue hydrogen.”

It is important to be very clear about this. CCS has received billions of dollars in research and development over many years. There were high hopes for it. I shared them when I was Australia's Environment Minister in 2007. But now we know that it is simply not commercially viable. It has failed, and not for want of trying. Its only value is as a means of delaying the necessary transition away from fossil fuels.

GH2's goal is to see green hydrogen used to decarbonise the huge range of industries that cannot reach net-zero emissions with electrification alone. Steel, cement, long-haul trucks, aircraft, fertilisers – these are all industries that need green hydrogen to reach zero.

We also have another, longer term goal. We believe energy systems can be ethical, decentralised, and fair. Jobs and stable energy resources can be created in all countries through the green hydrogen sector. Globally, almost 800 million people lack access to electricity. Addressing this should be a priority, using renewable energy and green hydrogen, not perpetuating a dependence on fossil fuels.

Green hydrogen is a technology available to any country with a natural endowment of renewable energy. This includes most developing countries in the world, many of which have been held hostage to oil and gas prices for generations.

GH2 has been established to build the energy systems of the future. Green hydrogen is a vastly superior technology to fossil fuels, and it will inevitably replace them. The only question is when, and we are running out of time.

The technology powering green hydrogen – electrolysers, renewable energy, transport, and storage infrastructure – must and will become cheaper and more efficient. Governments must stop subsidising fossil fuels and support this technology of the future.

Producers, consumers and the public must demand that the products they consume, the houses they live in, the planes they fly in, are powered by green hydrogen, not coal, oil or gas.

If you are committed to the clean energy transition, reach out to us here at GH2. We have a planet to save and no time to waste. Green hydrogen is the technology that can enable our transition to a zero emission global economy.

Let's do it!

Malcolm Turnbull
Inaugural Chair of the Green Hydrogen Organisation

Foreword

Welcome to the Green Hydrogen Organisation, GH2!

With this report we explain:

why the world needs enormous amounts of green hydrogen, produced using water and electricity, providing and storing energy beyond batteries,

what green hydrogen is, and what needs to happen with standards and certification to make sure that hydrogen resulting in emissions is not favored over green hydrogen,

how GH2 and its members and supporters will play their roles in making this happen, and who is required at the table and what is expected of them.

Currently, the focus in the run-up to COP26 is on commitments and pledges, on how governments and the private sector promises change. This is welcome, but it needs to be followed by action and implementing capacity. The private sector needs to change what it does and governments need to enable this change.

We intend for the GH2 to join the new breed of international organisations that straddles governments, the private sector and civil society. We hope that GH2 will harness innovative diplomacy, taking entrepreneurship and modern governance to enable a faster shift to producing and using green hydrogen.

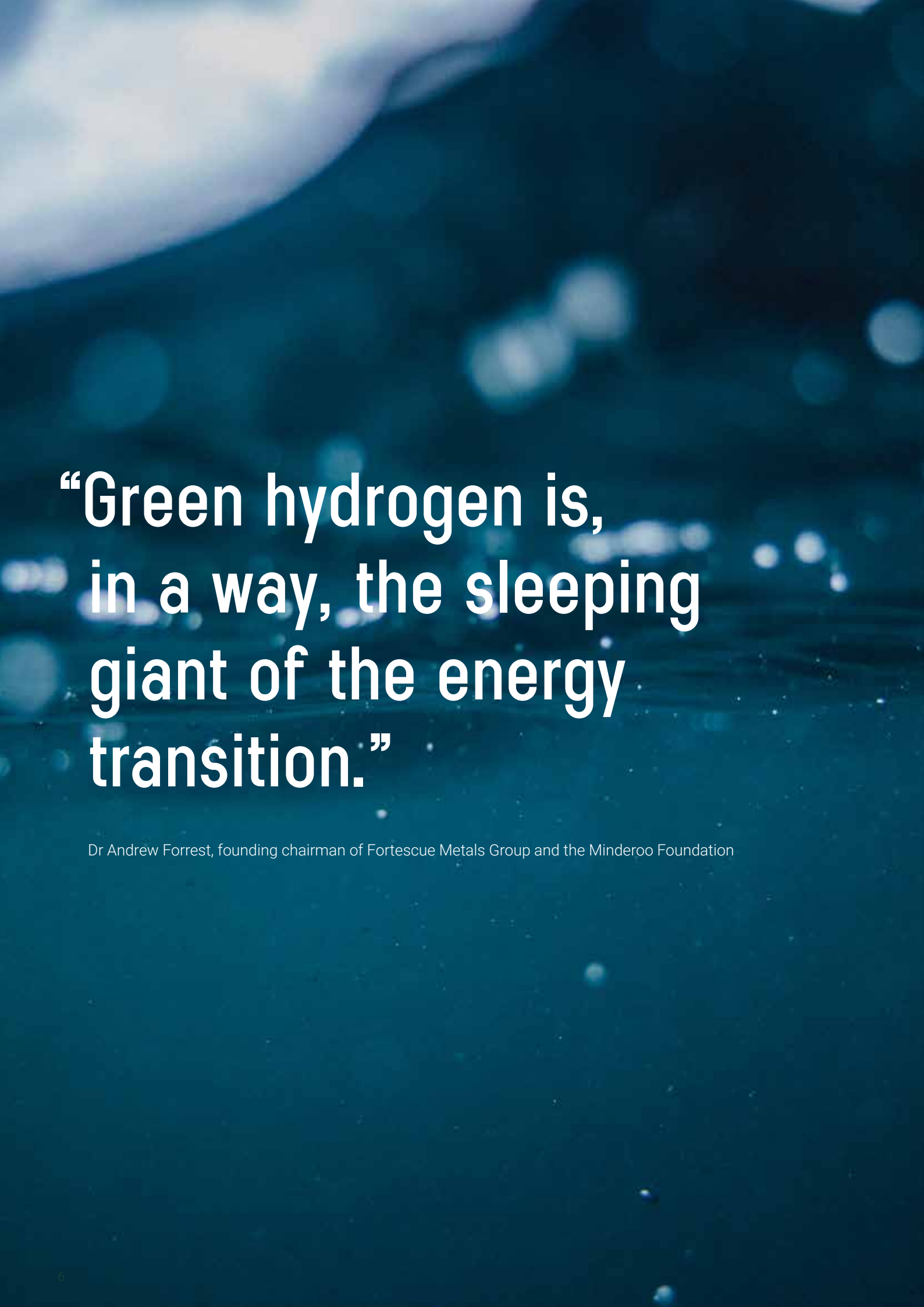
In preparing for this launch we have sometimes been asked whether another organisation is needed. To this I have the following reply: The world is overheating. Despite the commitments to cut greenhouse gas emissions, the emissions continue to grow. Most of the emissions come from the burning of fossil fuels. The use of fossil fuels is hardwired to much of what we do. The world economy and the way we use energy has to urgently change. There are vast interests benefitting from the fossil-fuel economy and from slow transitions. It is not that we have too many organisations that with a razor-sharp focus tries to practically change policy, economic incentives and behavior. The issue is that we don't have enough of them.

Please join us. No journey can be more meaningful. The transition away from fossil fuel-based energy systems cannot be done without the extensive use of green hydrogen. And let's remember, moving away from fossil fuel-based economies is about opportunities: a healthier environment, about a healthy planet, better lives and creating jobs. The transition will not be easy for everyone, but it is overall about using technology to improve life.

Jonas Moberg
CEO
Green Hydrogen Organisation

“We hope that GH2 will harness innovative diplomacy, taking entrepreneurship and modern governance to enable a faster shift to producing and using green hydrogen.”

Jonas Moberg, CEO of the Green Hydrogen Organisation.



“Green hydrogen is, in a way, the sleeping giant of the energy transition.”

Dr Andrew Forrest, founding chairman of Fortescue Metals Group and the Minderoo Foundation

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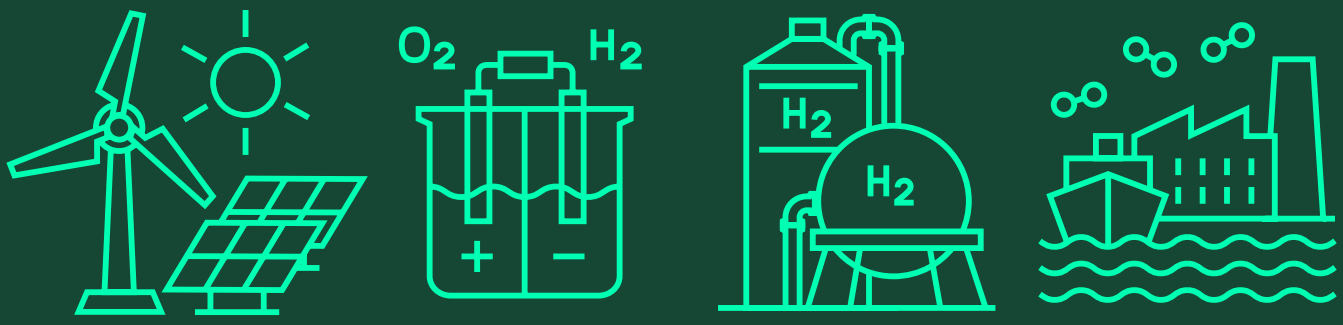
What is Green Hydrogen?

Green hydrogen — hydrogen produced through the electrolysis of water with renewable energy — is a proven technology with vastly underappreciated potential to decarbonize large sectors of the global economy. We have known about electrolysis for over 200 years, and industrial quantities of green hydrogen have been produced by companies like Norsk Hydro in Norway since the 1920s. In 2019, Japan successfully imported its first shipment of green hydrogen from Australia[1]. Since then countries have begun racing to strike accords and innovation partnerships that would facilitate global trade in green hydrogen[2].

Green hydrogen generates zero carbon emissions when it is produced, and zero carbon emissions when it is used. The versatility of hydrogen is one of its key features, and it has the potential to help a range of industrial and long haul transport sectors reduce emissions. Four areas where green hydrogen is likely to be the cheapest and fastest route to net zero emissions - steel (~8%[3]), cement (~8%[4]), shipping (~2%[5]) and trucking (~6%[6]) - alone account for a quarter of global emissions.

Green Hydrogen Value Chain



1. Renewable energy production + water
2. GH2 production
3. GH2 storage & distribution
4. GH2 utilisation

The Green Hydrogen Organisation's goal is that green hydrogen will supply 25% of the World's Energy needs by 2050. This is an ambitious goal, given that green hydrogen currently accounts for 0.1% of global hydrogen production and a tiny fraction of total global energy use. However, after years of slower than expected growth, the declining costs of both renewable electricity (which accounts for ~70% of the cost of producing hydrogen) and electrolysis technology is galvanizing government, industry and community support. Analysts have forecast that the global hydrogen market could provide USD $11 trillion of infrastructure investment opportunities over the next 30 years and direct annual revenues of $2.5 trillion[7]. The challenge and opportunity is to accelerate this transition, reducing our dependence on fossil fuels and harnessing the benefits of green hydrogen as quickly as possible.

Reducing emissions to net zero is essential to limit the increase in average global temperatures to no more than 1.5 degrees Celsius, the threshold seen as critical if the world is to avoid disastrous climate change[8]. Wind and solar power have seen large cost reductions and significant growth in recent years. They are an abundant, renewable source of clean energy that can help decarbonise the 20% of global final energy consumption that comes from electricity. However they are non dispatchable and so need to be supported by either energy storage solutions or other types of power.

Green hydrogen is a carbon-free fuel and feedstock that can decarbonise a sizable fraction of the 80% non-electric final energy consumption, especially in energy-hungry industrial, chemical and transportation sectors, while balancing the variability of renewable energy. The growing interest in green hydrogen is welcome, but the pace of change is far too slow. The governments of Australia, Chile, Germany, Japan and United Kingdom have responded with hydrogen strategies, and several large-scale green hydrogen investments are underway. In some cases, like Chile[9], these strategies set clear, aggressive targets to ramp up green hydrogen production, support the development of export markets, and drive down costs for technology and other enablers. In other cases, the distinction between support for green hydrogen and support for fossil fuel hydrogen is blurred with ill-defined phrases like "clean hydrogen". Unless these strategies unequivocally enable sustainably produced hydrogen and not merely hydrogen produced with fossil fuels but with lower emissions, there is a risk that they will contribute to further delays in making green hydrogen cost competitive.

We will not succeed in unlocking the potential of green hydrogen – and meeting our climate change goals – without properly pricing the carbon released into the atmosphere by coal, oil, and natural gas.

The IMF has calculated that the fossil fuel industry receives a stunning $5.2 trillion in subsidies annually (6.4% of global gross domestic product).[10] This includes conventional, pre-tax subsidies — government funding to reduce the price of fuel – of roughly $500 billion a year. BloombergNEF have calculated that G-20 member countries have given more than $3.3 trillion in subsidies for coal, oil, gas, and fossil-fuel power between 2015-2019, since signing the Paris agreement.[11]

Government support and subsidies for fossil fuels undermines the energy transition. These policies are. are also extraordinarily regressive, reinforcing poverty and inequality, with the richest 20% of households receiving six times more in subsidies than the poorest 20%.[12] It is important to acknowledge the myriad ways in which our economies are geared towards fossil fuels. Access to fossil fuels has shaped geopolitics, catalysing and sustaining conflict both within and between nation states, and undermining the economic progress of many oil rich nations. Long term evidence suggests that oil rich states are cursed with lower growth: for every 10% increase in share of oil exports, a country can expect 7% lower GDP per capita in the long run, as innovation and productivity are sidelined by efforts to reap volatile profits from fossil fuels.[13]

We will not succeed in unlocking the potential of green hydrogen – and meeting our climate change goals – without properly pricing the carbon released into the atmosphere by coal, oil, and natural gas. A recent report by the International Institute for Sustainable Development concluded that reforming fossil fuel subsidies in 32 countries could reduce CO_2 emissions by 5.5bn tonnes by 2030 and also save governments nearly $3 trillion by 2030.[14] Regrettably, several countries are developing hydrogen options to support their fossil fuel sectors, instead of prioritising sustainable alternatives.

Fossil-fuel based Hydrogen: A road to nowhere

Hydrogen is the most abundant element in the universe. Most of the hydrogen on Earth exists in molecular form, such as water and various organic compounds. Hydrogen gas isn't extracted in the same way that we might extract oil, gas or coal, but is instead produced using a range of different technologies and chemical reactions. A primary source of energy is needed to produce hydrogen, but the different approaches imply widely diverging economic, social and environmental impacts. For this reason, it is critical to differentiate green hydrogen from fossil-fuel based alternatives.

All hydrogen molecules are the same - and colourless - no matter how hydrogen is produced. But the way in which hydrogen is produced is crucial. If hydrogen is produced from gas or coal, or with electricity generated by burning gas or coal, it is not clean or sustainable. Here we consider some of the terms and colours used for hydrogen produced using fossil fuels. In addition to green hydrogen, there is also pink hydrogen, referring to when nuclear power is used.

Brown Hydrogen

Brown (or Black) hydrogen is the oldest way of producing hydrogen. This is achieved by transforming coal into gas, with the hydrogen separated from the other elements using absorbers or special membranes. This hydrogen is known as brown or black depending on the type of coal used: brown (lignite) or black (bituminous) coal. It produces large carbon dioxide emissions (see below), and is not a viable long-term solution.

Grey Hydrogen

Grey hydrogen has been produced for many years. It involves using natural gas, which is split into hydrogen and CO_2 either by steam methane reforming (SMR) or auto thermal reforming (ATR) technology. Again, this involves large and unsustainable carbon dioxide emissions.

Blue Hydrogen

So called blue hydrogen involves combining grey hydrogen with carbon capture, utilization and storage (CCUS). Blue hydrogen is often presented as a sustainable option, or as an interim solution on the road to green hydrogen. In practice, CCUS has received billions of dollars in support and subsidies since the first pilot projects began in the mid-1990s, and yet has failed to fulfill its promise to significantly lower emission. In 2018, the International Energy Agency (IEA) calculated that, between 2007 and 2017, governments earmarked USD 28 billion of funding to support CCUS projects.[15] Ultimately, only 15% of this funding was disbursed, because the majority of CCUS proposals and projects failed. Nevertheless, in 2021, the IEA reports that from the start of 2020 to early May 2021, governments and industry pledged more than USD 12 billion to CCUS projects and programmes.[16]
Even if CCUS worked efficiently, there are substantial emissions from the production and transportation of gas before it's converted into hydrogen. In practice, the promise of blue hydrogen is distracting attention from cheaper, cleaner and faster options to drive the energy transition, diluting scarce R&D budgets, and blurring the focus of governments and investors.

Green Hydrogen

Green hydrogen is defined as hydrogen produced by splitting water into hydrogen and oxygen using renewable electricity through a process called electrolysis. This results in very low or zero carbon emissions.

Emerging green hydrogen strategies and policies differ widely on the definition of "renewable energy", the boundaries of the carbon accounting system, the emission thresholds at which hydrogen is considered green, and the feedstocks and production technologies deployed.[17] This lack of standardisation is undermining efforts to accelerate the use of green hydrogen.

Accordingly, a central objective of the Green Hydrogen Organisation (GH2) is to establish global standards for green hydrogen. Clear global standards will support policy and project development, lower costs for producers and consumers, and help build support and confidence in the market for green hydrogen.

The boundaries of the carbon accounting system and the thresholds at which hydrogen is considered "green" are crucial considerations. The emissions associated with project construction need to be considered, together with the upstream emissions (water, energy and electricity production) and downstream transportation and utilization. In taking a holistic approach – from energy source to point of use – an absolute zero emissions threshold is both unrealistic and counterproductive. But care must be taken set meaningful targets, and to avoid lowering the bar in ways that allows fossil fuel-based hydrogen to masquerade as "green".

In developing a standard and to enable the production, trade and use of green hydrogen, GH2 will promote:

- Elimination of GHG emissions – climate disaster has to be avoided at all cost and this can only be done through an urgent attention to ensuring energy supply that is renewable.
- Sustainability - Beyond emissions, the wider sustainability of the green hydrogen industry needs greater attention. GH2O will support the elaboration of green hydrogen standards that promote global best practice in addressing environmental, social and governance issues. We will support global efforts to protect human rights, advance social justice and equality.
- Transparency - We will develop open data standards that promote greater transparency and accountability, and to support harmonization with other related standards and certification efforts (e.g., carbon pricing and certification of green electricity).
- Collaboration - Government and industry need to work together on developing standards that are clear, consistent, fair and fit for purpose.

Hydrogen emissions

A founding principle of the **Green Hydrogen Organisation** is that green hydrogen must be prioritized and differentiated from all forms of fossil fuel, including blue hydrogen. Energy sector policies that promote fossil fuel hydrogen are inhibiting the uptake of more sustainable long-term solutions.

'Clean' hydrogen is a term that has been applied to hydrogen produced using renewable electricity and natural gas via steam methane reforming (blue hydrogen). For example, the CertifHy in the EU includes two different guarantee of origin labels: CertifHy green hydrogen (from renewable sources and having a greenhouse gas balance below a defined threshold), and CertifHy Low Carbon Hydrogen (having a greenhouse gas balance below a defined threshold).[18] However, many reports and government documents discuss gas-based hydrogen as part of decarbonisation efforts without specifying a capture rate needed to ensure that low-emissions are achieved.[19]

Researchers at the Crawford School of Public Policy at the Australian National University have been analysing the emissions and costs of fossil fuel based compared to renewable electricity-based hydrogen. A recent Hydrogen Council report presents a combined renewables and gas scenario that was associated with "a completely decarbonised hydrogen supply from 2040".[20] This is despite a notable share of 'blue' hydrogen (i.e. SMR with CCS). In the report the amount of global hydrogen production is broken down by technology (Figure 1a). This allowed the researchers to use this scenario to calculate global emissions with different CCS technologies and capture rates. This allowed the researchers to use this scenario to calculate global emissions with different CCS technologies and capture rates, including both process and fugitive emissions.[21] These emission intensities are shown in Table 1 (with a comparison to estimates from the Hydrogen Council).

The analysis shows that if moderate capture rates are achieved (56%), emissions would increase to levels much higher than the present day (Figure 1b). If high capture rates are achieved, then emissions could fall with the phase out of SMR without CCS. However, as hydrogen production increases, emissions could increase back to present day levels in the middle of the century (Figure 1c).

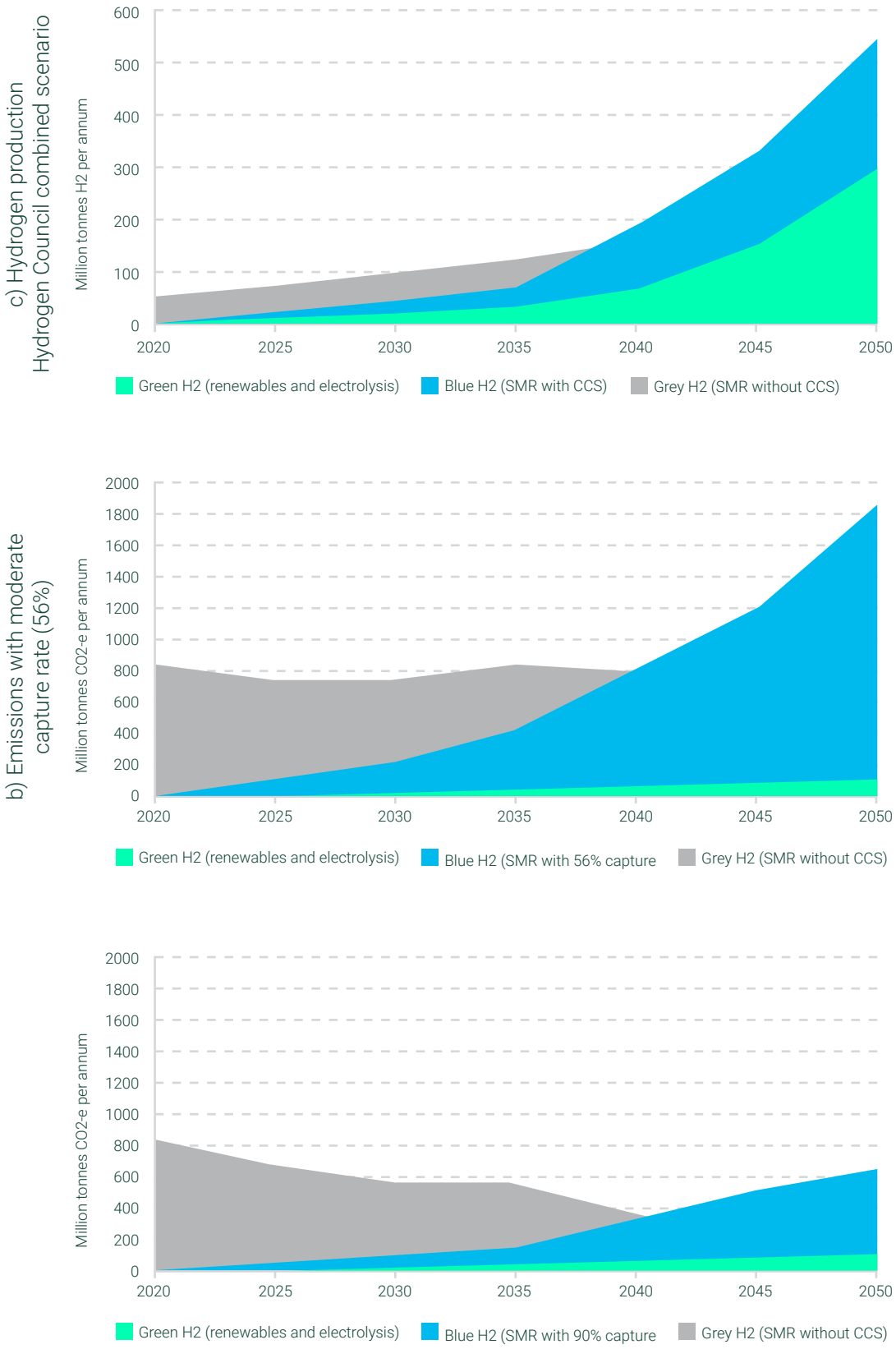
The Hydrogen Council's combined scenario shows that a hydrogen industry that uses natural gas would emit a substantial amount of emissions. Even if SMR without CCS is phased out, it is misleading to refer to a combined scenario as "decarbonised hydrogen supply". This analysis shows that capture rates matter (comparing Figure 1b and 1c). Fugitive emissions are not impacted by CCS and these emissions need to be considered when assessing the emissions associated with gas-based hydrogen.

Table 1 – Emissions intensities for the production of hydrogen ($kgCO_2$ per kgH2)

	Longden et al*	Hydrogen Council	This Analysis
Natural gas without CCS	11.1 – 13.7	9.2 – 11.1	12.4
Natural gas with CCS and a 56% capture rate	5.8 – 8.5		7.2
Natural gas with CCS and a 90% capture rate	1.7 – 4.3	1.2 – 3.9	3.0
Renewable electricity and an electrolyzer		0.3 – 1.0	0.3

*these estimates are CO_2-equivalent as fugitive emissions are included.

Figure 1 – Hydrogen production and emissions with different capture rates
Note: calculations based on Longden et al. (2021) and Hydrogen Council (2011)



Green hydrogen's pivotal role in the energy transition

In this section, we explore the characteristics and applications of green hydrogen which, collectively, provide a sustainable way to meet 25% of the world's energy needs by 2050. In this document, the Green Hydrogen Organisation (GH2) highlights opportunities to dramatically accelerate the production and utilisation of green hydrogen across a range of sectors, including establishing clear standards and strong incentives to encourage the early deployment of green hydrogen solutions and mobilise additional private sector investment.

Heavy industry (cement, steel, chemicals and aluminium) and heavy-duty transport (shipping, trucking and aviation) together account for nearly one-third of global CO_2 emissions - and this share is expected to double under business-as-usual scenarios.[22] Green hydrogen's versatility as a store of renewable energy, a clean burning fuel, and a chemical feedstock for industrial processes provides unmatched potential to address emissions from these sectors and help decarbonize the global economy.

1. **Distributing renewable energy.** Energy supply and demand are not well matched. For centuries, we have developed energy transport and transit systems that carry fossil-fuel based energy (predominantly oil, gas and coal) from resource rich to resource poor regions. Globally, we need to transition from distributing unsustainable fossil-fuel based energy to sustainable, renewable energy. Some countries are not well positioned to generate renewable energy, whereas others have excess capacity and potential. Hydrogen and its compounds have a high energy density and can be easily stored and transported, (re)distributing renewable energy efficiently and flexibly.

2. **Enabling reliable renewable energy.** Electricity from renewables is variable, and residential and industrial demand is often not well matched with supply. Electrolysis can convert excess electricity into hydrogen during times of oversupply and release it when demand peaks. Hydrogen can also be used for long-term, carbon-free energy storage as an energy buffer and strategic reserve. Underground storage of hydrogen is a well-established industry practice. Hydrogen can be stored over long periods of time and scales compatible with seasonal energy storage, making it a leading candidate to enable the seasonal balancing of renewable power sources.[23] It is also cost competitive compared to other options, such as pumped hydro storage.

3. **Decarbonising transport.** In 2019, transport accounted for nearly 30% of global final energy use and 23% of total energy sector direct CO_2 emissions.[24] Reducing oil use and CO_2 emissions in long-distance transport modes – heavy-duty trucking, maritime shipping and aviation – are particularly difficult because of their energy and power density requirements.[25] Battery electric vehicles (BEVs), Hybrid electric vehicles (HEVs) and plug-in hybrid electric vehicles (PHEVs) are already reducing vehicle emissions, particularly in passenger vehicles. However, fully decarbonizing transport will require deployment of hydrogen-powered fuel cell electric vehicles (FCEVs) and battery electric vehicles (BEVs). Green Hydrogen is the leading technology to decarbonise long haul transport, including trucking and shipping. In addition to lowering CO_2 emissions, this will support local air quality improvements and noise reductions. In 2019, air pollution was responsible for 6.67 million deaths worldwide, including the premature death of 500,000 babies, with the worst health outcomes occurring in the developing world.[26]

Green Hydrogen in Shipping

A recent analysis by the Global Maritime Forum mapped the uptake of 106 pilot and demonstration projects to address the transition to zero emission fuels in the maritime industry. They note an increase in large ship projects focussed on hydrogen and ammonia.

Shipping also has a key role to play in transporting green hydrogen between producers and consumers. The first liquid hydrogen powered ships are expected in 2022, and the construction of compressed hydrogen carriers is expected to begin shortly.[27] Green hydrogen can also be transported by converting it to ammonia or another liquid organic hydrogen carrier.

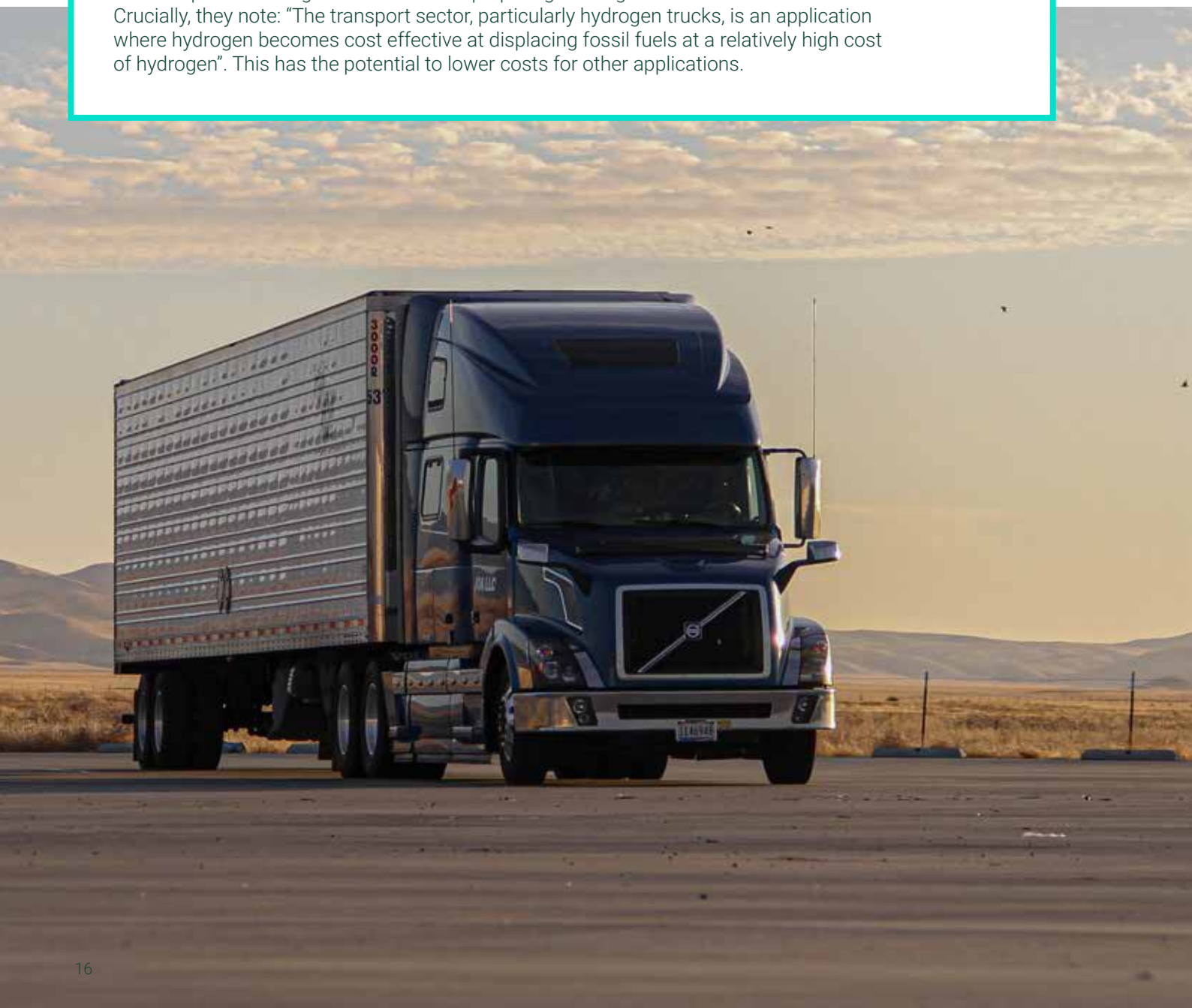
The demand from customers is also playing an important role. Iron ore producer Fortescue Metals Group chief executive Elizabeth Gaines recently said: "in line with Fortescue's strengthened target to achieve carbon neutrality by 2030, the company's focus is on thedevelopment of vessels powered by green ammonia… tenders for LNG-powered bulk carriers will not be pursued."[28]

Green Hydrogen in Trucking

The road freight sector is a key enabler of economic activity, a major source of energy demand, and a large contributor of greenhouse gas emissions. Trucking relies almost exclusively on oil-based fuels. It is the second-largest source of global oil demand (after passenger cars).[29] Globally, more than one-third of transport-related CO_2 emissions, and 7% of total energy-related CO_2, comes from road freight transport. However, the decarbonisation of long-range and heavy-duty trucking is one of the most difficult challenges in reaching net zero carbon emissions.[30] While emissions from passenger car travel are falling, emissions from trucks and buses have risen by around 2.6% annually since 2000.[31]

H2Accelerate, a collaboration between Daimler Truck AG, IVECO, OMV, Shell, TotalEnergies, and Volvo Group, recently published a whitepaper focused on establishing commercially viable hydrogen trucking system. Hydrogen trucks can operate in a similar way to diesel vehicles, with fast refuelling (under 15 minutes) and similar ranges (in excess of 800km even for the heaviest loads, depending on the specific technology used), offering operational simplicity and reduced total cost of ownership compared with battery alternatives with fast charging.

The companies driving H2Accelerate are preparing to bring these solutions to market. Crucially, they note: "The transport sector, particularly hydrogen trucks, is an application where hydrogen becomes cost effective at displacing fossil fuels at a relatively high cost of hydrogen". This has the potential to lower costs for other applications.



4. **Decarbonise industrial energy use.** Some of the strongest use cases for Green Hydrogen are the manufacturing processes that require the physical and chemical properties of molecule fuels. Energy use in industry accounts for 24.2% of global greenhouse gas emissions.[32] The manufacture of iron and steel alone accounts for 8%14. Cement accounts for another 8%. Emissions from the manufacturing of fertilizers, pharmaceuticals, refrigerants and oil and gas extraction are also major contributors. Hydrogen can enable a switch away from fossil fuels in many of these applications.

From Green Hydrogen to Green Steel

Steel is one of the world's most important engineering and construction materials. However, every ton of steel produced emits on average 1.85 tons of carbon dioxide, equating to about 8% of global carbon dioxide emissions.[33] Steelmaking requires stripping oxygen from iron ore to produce pure iron metal. In traditional steelmaking, this is done using coal or natural gas in a process that releases CO. In green steel production, green hydrogen replaces coal and natural gas.[34]

McKinsey & Company (2020) outline two key approaches. First, using green hydrogen as an alternative to pulverized coal injection to improve the performance of conventional blast furnaces. Globally, about 70% of steel is produced using the blast furnace method.[35] Utilisation of green hydrogen can reduce carbon emissions by up to 20 %, but still requires the use of coking coal. The second option is to use green hydrogen to produce direct reduced iron (DRI) that can be further processed into steel using an electric arc furnace (EAF). This approach enables nearly carbon-neutral steel production. The method currently accounts for less than 5% of global production but offers the greatest opportunity for using green hydrogen.[36]

McKinsey conclude: "[green] hydrogen-based steel production using an EAF is technically feasible and already considered to be part of a potential long-term solution for decarbonizing the steel industry on a large scale. The question is not whether but when and to what extent this transformation will happen".[37]

Green Hydrogen in the cement industry

Concrete is the most widely used man-made material in existence and second only to water as the most-consumed resource on the planet.[38] It is also a major contributor to climate change. Each year, more than 4 billion tonnes of cement are produced, accounting for around 8 per cent of global CO_2 emissions.[39] Demand is expected to grow, especially in emerging economies, to over 5 billion tonnes a year over the next 30 years.[40] The thermal combustion and chemical processes involved are a large source of greenhouse gas emissions. Around half the emissions are due to the chemical process called calcination, whereby limestone is heated and broken down into calcium oxide and CO_2. Around 40% of the emissions result from combustion processes needed to yield the thermal energy required for this reaction (1450°C).[41] Several companies are considering the potential to replace and/or supplement fossil fuels with green hydrogen to reduce emissions from the combustion processes. Others are exploring the potential to combine carbon dioxide from the chemical process with green hydrogen to produce e-methane.[41]

Green Hydrogen in Fertilisers

Some of the most obvious applications for green hydrogen are the sectors where hydrogen is already widely used today. Currently, hydrogen is used mostly in oil refining and for the production of fertilisers. Demand for hydrogen, which has grown more than threefold since 1975, continues to rise – almost entirely supplied from fossil fuels, with 6% of global natural gas and 2% of global coal going to hydrogen production.[43] Consequently, despite being a niche market, hydrogen accounts for 830 million tons of CO_2, equivalent to almost 3% of global emissions in 2019.[44]

Fertilizers have become an essential part of our global food supply chain and are credited with alleviating hunger, malnutrition and poverty worldwide. However, rising agricultural nitrogen emissions are a major source of green gas emissions. Nitrogen is a crucial nutrient for plant growth, hence it's use in synthetic fertilizers. However - especially when it is excessively applied - nitrogen leads to microbial reactions that generate nitrous oxide (N2O). At 300 times the potency of carbon dioxide, and persisting for 100 years in the atmosphere, this gas has a profound impact on climate change.[45] One important way to address this issue is to reduce the overapplication of fertilizer. Precision agriculture involves applying exact amounts fertilizer, ensuring that plants use it all up instead of leaving large quantities behind in the soil to be broken down by microbes and released as N2O.[46]

Fertilizer production itself can also be made more sustainable by utilising green hydrogen. Hydrogen is the key component in Ammonia, which in turn is the key ingredient in most fertilizers. Ammonia producers conventionally use natural gas, in an extremely carbon dioxide (CO_2) intensive process.[47] The utilisation of green hydrogen provides an opportunity to dramatically reduce emissions. However, at current rates, only about 10% of Europe's ammonia will come from renewable hydrogen by 2030. European fertilizer producers are likely to be at the forefront of green ammonia initiatives, given policy momentum and incentives under the European Green Deal. Ratings agency S&P conclude: "In the long term, we foresee a pronounced impact on the fertilizer industry from green hydrogen development, with new entrants, and partnerships in regions with access to cheap renewable energy sources … Fertilizer companies with capital to invest in hydrogen projects advantageously located near green ammonia consumers, or those that partner with overseas players with access to cheap renewables, will have an edge over companies without access to such capital or locations".[48]

Picking winners? Creating an enabling environment for green hydrogen

Cheaper electricity from renewables, hydrogen's high energy to mass ratio and low losses during storage and transportation are set to transform heavy industry and heavy-duty transportation. At least 20 countries, collectively representing around 70% of global GDP, are proposing hydrogen strategies or roadmaps as key elements of their decarbonisation plans.[49] These strategies differ widely in the scope, specificity and scale of support. In some cases, hydrogen strategies single out specific projects, companies and sectors. In other cases, the focus is the wider enabling environment.

Despite green hydrogen's enormous potential to stimulate development while reducing carbon emissions, there is no standard or certification to trade green hydrogen, no coordinated international effort to support the industry, and green hydrogen is a low priority amongst development finance institutions.

"In order to expedite the use of green hydrogen, it is essential to make greater efforts to create hydrogen demand through FCEV and hydrogen fuel cell power generation, secure price competitiveness of green hydrogen through technological innovation, and extended support of green hydrogen trade through government policy"

President Chi Young-jo, President & Chief Innovation Officer, Hyundai Motor Group.

A just transition

To limit global temperature rise to 1.5°C, we need to cut emissions in half by 2030 and reach net-zero by 2050. The transition required is extraordinary - creating new opportunities for development and job creation in some countries and communities, but also disruption and challenges in countries and communities that depend on the exploitation of fossil fuels. Accordingly, the 2015 Paris Agreement highlighted the importance of "a just transition": the creation of decent work and quality jobs in accordance with nationally defined development priorities".[50]

Each signatory country to the agreement determines what commitments they should make - nationally determined contributions (NDCs) - communicating their plans for reducing greenhouse gas (GHG) emissions (Article 4), and pledges on adaptation, finance, technology transfer, capacity building and transparency (Article 3).[51] Overall, the commitments made by governments are far from sufficient. As of June 2021, the World Resources Institute (WRI) reports that 59 countries, representing 54% of global greenhouse gas emissions have communicated net-zero emissions targets, including the world's two largest emitters – China and the United States.[52]

Several countries have set ambitious targets. In Germany for example, the energy transformation (widely known as the "Energiewende") addresses the country's planned transition to a low-carbon, nuclear-free economy, including phasing out coal production and financial incentives for wind and solar power.[53] Through the "European Green Deal", the European Commission has pledged to mobilise at least €1 trillion in sustainable investments over the next decade.[54] The plan includes a Just Transition Mechanism (JTM): "targeted support to help mobilise at least €65-75 billion over the period 2021-2027 in the most affected regions, to alleviate the socio-economic impact of the transition".[55]

Both examples highlight the focus on investments that create new opportunities for employment and community development. In the case of green hydrogen, this investment is often focused on remote renewable energy resources like solar parks and hydro facilities that can become economic once they are integrated into hydrogen production facilities.[56] The development of green hydrogen markets also allows us to distribute energy more evenly, and to improve energy security in countries that are excessively dependent on revenues from oil and gas, and in countries that are heavily reliant on oil and gas imports. In 2018, almost 60 % of the EU's energy needs (excluding the UK) were met by net imports.[57]

Government, industry, workers and local communities need to work together to maximise the opportunities and explain the adjustments that are needed. Early action and clear communication can minimize the negative impacts and maximize positive opportunities. The Green Hydrogen Organisation supports a Just Transition. We believe that the global challenges of sustainable economic development, poverty reduction, social justice and climate change are interconnected. They demand bold action by government, industry and civil society to open up new pathways for sustainable development.

“We must show solidarity with the most affected regions in Europe, such as coal mining regions and others, to make sure the Green Deal gets everyone’s full support and has a chance to become a reality.”

Frans Timmermans, Executive Vice-President of the European Commission.

Green Hydrogen and the Sustainable Development Goals

The Sustainable Development Goals (SDGs) call for the betterment of global populations, while preserving the environment and guarding against a climate disaster.[58] Many developing countries and emerging economies are already suffering from climate change. And the way in which these economies develop will also have a great impact on the climate. The meeting of the SDGs will fundamentally depend on how successful the fight against climate change is. And the fight against climate change is about bringing the use of fossil fuels to an end.

Green hydrogen is a unique technology and fuel that allows for scalable investment and dramatically decarbonised industry. As a system for energy production, it also promises to deliver greater energy independence to emerging and developing countries without natural endowments of fossil fuels. In order to achieve the Sustainable Development Goals and Paris Agreement targets, the energy transition must become a transformational global effort. An energy revolution is underway, but 759 million people still live without electricity and the development opportunities it provides.[59]

Green hydrogen has enormous but largely underappreciated potential to support the achievement of the United Nations Sustainable Development Goals (SDGs). The most obvious contributions relate to goals 7, 8 and 13. In addition, there are direct and indirect contributions that contribute to almost all of the SDGs.

Developing countries with renewable energy resources could produce green hydrogen, generating economic opportunities and increasing energy security by reducing exposure to oil price volatility and supply disruptions. Developing countries that have depended on revenues from fossil fuels can leverage their existing expertise and infrastructure to develop new, and sustainable opportunities.

The use of renewable energy and green hydrogen will contribute to all SDGs, particularly:

Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all

↑ Major contribution

Green hydrogen development can provide developing countries with zero-carbon energy to support energy sector development, increase energy security and create export opportunities. Fuel cells can be used to provide decentralized solutions for critical services and infrastructure, increasing energy access in remote areas and in emergency situations.

Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

↑ Major contribution

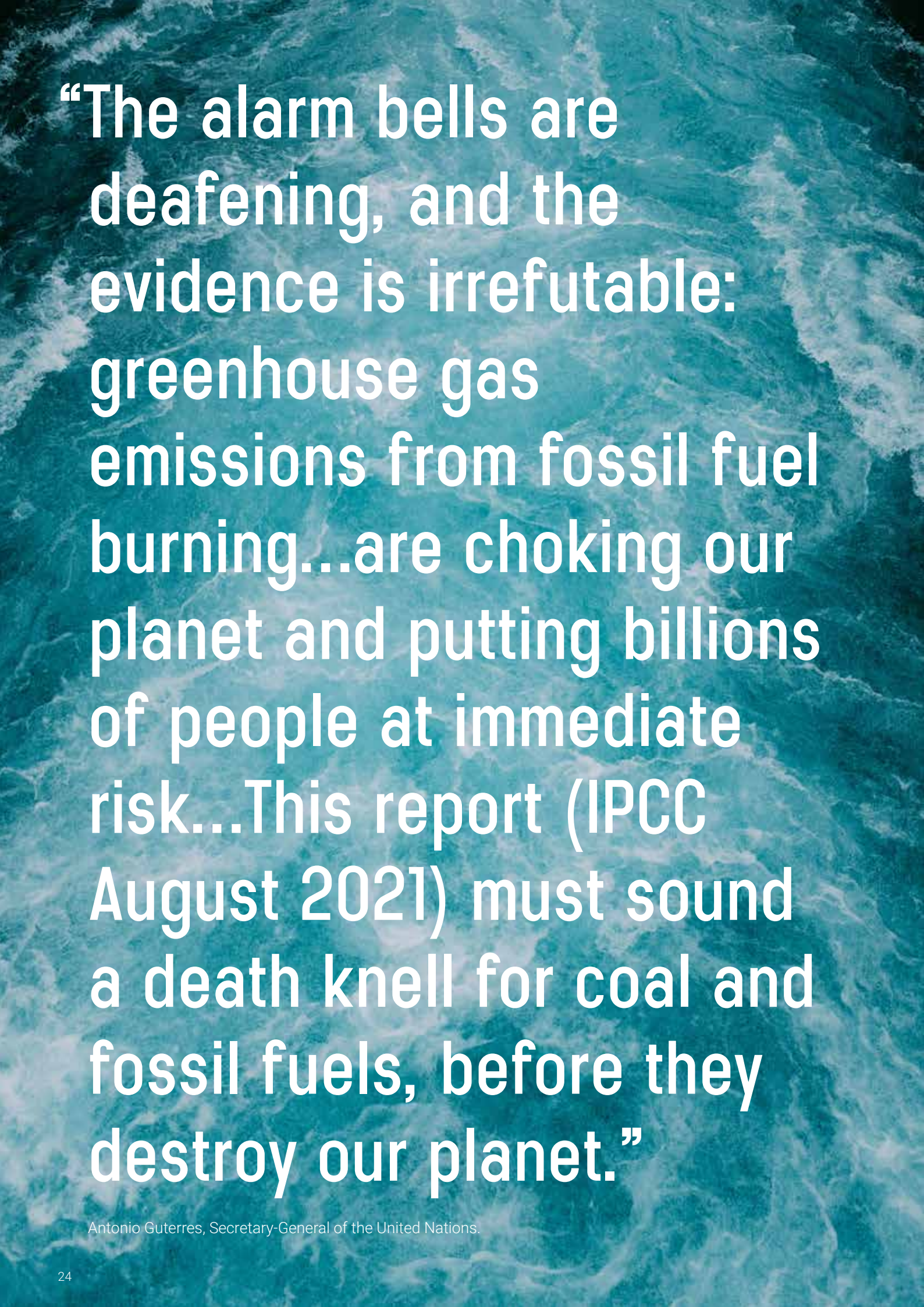
Investments in green hydrogen have the potential to stimulate economic development and job creation. The marketplace for hydrogen production and fuel cell equipment is projected to grow to USD 2-4 trillion annually by 2050.

Goal 13. Take urgent action to combat climate change and its impacts.[60]

↑ Major contribution

Green hydrogen can provide energy systems with a long-term energy storage solution capable of mitigating the variability of renewable resources, thus increasing the pace and penetration of renewable energy.[61] Utilisation of green hydrogen addresses emissions from transport and heating, and is the leading technology to decarbonise heavily polluting industries like steel refining, cement-making and shipping.

Support from development finance institutions (DFIs) will play an important role in realising this potential, both through project finance and in creating the necessary enabling environment.
And yet few DFIs have dedicated green hydrogen strategies. While DFI investment in fossil fuel projects is contracting– it still vastly exceeds investment in green hydrogen. This needs to change, urgently.



“The alarm bells are deafening, and the evidence is irrefutable: greenhouse gas emissions from fossil fuel burning...are choking our planet and putting billions of people at immediate risk...This report (IPCC August 2021) must sound a death knell for coal and fossil fuels, before they destroy our planet.”

Antonio Guterres, Secretary-General of the United Nations.

Accelerating the production and use of Green Hydrogen

The focus in the run-up to COP26 is on commitments and pledges from government and industry in order to achieve net-zero emissions by 2050. This is welcome, but implies an unprecedented transformation of how energy is produced, transported and used globally.[62] Pledges and targets need to be followed up with concrete actions and targeted support for solutions, like green hydrogen, that have transformative potential.

The Green Hydrogen Organisation recommends that:

1. **Governments establish clear policies and targets to support the development of green hydrogen markets**. It is essential that governments set a clear, consistent and stable energy policy framework that enables producers, consumers and communities to plan for the long term. Governments should establish frameworks that support legislative and regulatory frameworks to support green hydrogen production and consumption. Global standards are needed so that green hydrogen can be prioritized and differentiated from all forms of fossil fuel-based hydrogen.

2. **Governments should level the playing field**. A key first step in promoting the emergence of sustainable, green hydrogen is to level the playing field with respect to fossil fuel-based energy systems. The IEA's modeling of a 1.5°C-aligned energy scenario shows there is no need for further investment in oil, gas and coal projects in a net zero pathway.[63] Governments should stop approving new fossil fuel projects (including through state-owned enterprises and the support provided through development, investment and export credit agencies). Moreover, governments must remove the massive direct and in-direct subsidies currently directed toward the fossil fuel sector. They should redirect their support toward sustainable alternatives, including green hydrogen.

3. **Agree a global approach to carbon pricing**. Meaningful and effective carbon pricing is essential. Globally, four-fifths of global emissions are unpriced.[64] There is a growing appreciation that the most effective and efficient way to achieve our climate goals would be to create a global carbon price, anchored on a minimum carbon price floor, similar to the recently agreed global minimum on corporate taxes. The G20 and the IMF, among others, have recently expressed support for this approach. The IMF has argued that the system needs to be flexible to account for the differentiated responsibilities of countries given, among other factors, historical emissions and development levels.[65]

Catalyzing and growing Green Hydrogen markets

In addition to the enabling actions noted above, strong leadership and global coordination is needed from government and industry to catalyse and grow the markets for green hydrogen. While the cost of producing green hydrogen is falling rapidly, a key challenge is to further lower costs and stimulate the demand that will support new markets and economies of scale. A wide range of infrastructure needs to be developed or repurposed. Substantial investments in capacity building and research and development are also needed.

The Green Hydrogen Organisation works with government and industry to:

1. **Establish a leading role for renewable energy and green hydrogen in long-term energy policy**

   Governments play a key role in establishing targets and market expectations, and in creating an enabling environment that will mobilise additional private sector investment. Greater coordination, clear standards and strong incentives are needed to develop the renewable energy and green hydrogen sectors. A wide range of factors need to be considered, including increasing appropriate sites for renewable energy production, lowering renewable energy development and production costs, meaningful carbon pricing, improving transmission and storage infrastructure, and harnessing synergies between applications and consumers in different regions and sectors.

   A key aspect of this work is ensuring that the legislative and regulatory framework is fit for purpose. Project developers face hurdles where regulations and permit requirements are unclear, unfit for new purposes, or inconsistent across sectors and countries. Sharing knowledge and harmonising standards is essential, including for equipment, safety and certifying emissions from different sources.

2. **Reduce green hydrogen production costs**

   Governments should adopt policies to create sustainable markets for renewable energy and green hydrogen to underpin investments by producers, suppliers, distributors and consumers. By scaling up supply chains, these investments can drive cost reductions. The green hydrogen market is small and the costs are typically quite high (compared to grey). However, costs will fall rapidly, especially if more countries reduce subsidies, implement meaningful carbon pricing, and support green hydrogen production at greater scale.

The renewable electricity used to produce green hydrogen accounts for the largest proportion of the cost and is crucial in increasing the competitiveness of green hydrogen. The second-largest cost component is the cost of electrolysers. IRENA have recently explored strategies and policies to cut costs. With larger production facilities, design standardisation and insights from early adopters, the proposed strategies could cut costs by 40% in the short term and up to 80% in the long term. The Green Hydrogen Catapult project is aiming to halve the price of hydrogen to $2 per kilogramme (equivalent to $50 per megawatt hour) by 2026. The Biden administration has targeted a price of $1/kg by 2030.

> “Green hydrogen is the technology that can enable our transition to a zero emission global economy.”
>
> Malcolm Turnbull, Chair of the Green Hydrogen Organisation.

3. Stimulate demand for green hydrogen and address the investment risks of first-movers

In addition to setting targets, government and industry both play a key role in stimulating demand for green hydrogen. Targeted investment, time-limited loans, investment guarantees and other tools are crucial in encouraging the private sector to invest, learn and share risks and rewards. Priorities include:

- Establishing the first shipping routes to kick-start the international green hydrogen trade, including opportunities to leverage existing industrial ports as hubs for green hydrogen.
- Supporting transport fleets, freight and corridors to make hydrogen-based and fuel-cell vehicles more competitive.
- Utilising existing gas infrastructure to supply green hydrogen consumers. Up to 20% of hydrogen by volume can be blended with natural gas and shipped through current gas pipeline infrastructure without major modification.

4. Develop expertise and support research and development

While the rise of green hydrogen will create thousands of new job opportunities, many countries lack the necessary training and skills to support the green hydrogen economy. As the industry grows, a shortage of specialized workers could hinder progress and increase costs. Further research and development is also crucial to lower costs and improve efficiency. Government support and funding is crucial in setting the research agenda, taking risks and attracting private capital for innovation.

5. Engage globally and track progress

Enhanced international co-operation is needed across the board but especially on standards, sharing of good practices and cross-border infrastructure. Hydrogen production and use need to be monitored and reported on a regular basis to keep track of progress towards long-term goals.

The Green Hydrogen Organisation

The mission of the Green Hydrogen Organisation (GH2) is to dramatically accelerate the production and utilisation of green hydrogen across a range of sectors globally. It will push to rapidly decarbonise industries like steel, cement, fertilisers, shipping and aviation that have so far made limited progress reducing their emissions. Currently, there is no standard or certification to trade green hydrogen, no coordinated international effort to support the industry, and green hydrogen is a low priority amongst development finance institutions, despite green hydrogen's enormous potential to stimulate development while reducing carbon emissions. GH2 is set up as a not profit foundation under Swiss law. In addition to its office in Geneva it is present in London, Perth, and Sydney.

The GH2 has three priority areas:

1. **The Global Green Hydrogen Charter**, bringing together governments to share good practices and policies that will support the growth of global green hydrogen markets.
2. **The Green Hydrogen Development Plan**, bringing governments, development finance institutions, and other development actors to rapidly increase support for green hydrogen production and use in developing countries and emerging markets.
3. **The Green Hydrogen CEO Roundtable**, dedicated to the creation of hydrogen markets, green hydrogen accreditation and standards, bringing together the private sector in efforts enabling investment in the green hydrogen supply chain.

The Green Hydrogen Organisation is hosting the **first global Green Hydrogen Trade Fair and Assembly in May 2022**. This summit will bring together leading companies wishing to exhibit alongside the first International Green Hydrogen Summit, at which governments will report on progress with creating the conditions for rapid growth in the production and use of green hydrogen. Together with leaders from the private sector and civil society, they will take action to faster tackle climate change through the use of green hydrogen.

“We do not have time to invest precious attention and resources into false solutions... it will be critical to guard against allowing those with vested interests to draw out a long transition period using fossil fuel hydrocarbons to produce hydrogen.”

Dr Andrew Forrest, founding chairman of Fortescue Metals Group and the Minderoo Foundation

The Green Hydrogen Organisation Charter

The GH2 Charter is bringing together governments with other stakeholders to develop and share good practices and policies in enabling the rapid acceleration of the use of green hydrogen. The GH2 International Secretariat has drafted the following guiding principles to guide and inform this work:

1. We believe that the **global challenges of sustainable economic development, poverty reduction, social justice and climate change are interconnected**. They demand bold action by government, industry and civil society to open up **new pathways for sustainable development.**

2. We will demonstrate that green hydrogen — hydrogen produced with renewable energy — is a **proven technology with vastly underutilized potential to improve energy systems** and decarbonize large sectors of the global economy in a cost-effective fashion.

3. We insist that **green hydrogen is prioritized and differentiated from all forms of fossil fuel**, including non-green hydrogen. Global energy markets are distorted by direct and indirect subsidies, and under-priced carbon emissions. Energy sector policies that promote non-green hydrogen reinforce these distortions are inhibiting the uptake of **more sustainable long-term solutions.**

4. While affirming that the development of natural resources and energy markets is in the domain of sovereign governments to be exercised in the interest of their citizens and national development, we recognize that **overcoming the barriers to building green hydrogen markets requires collaboration that transcends national boundaries.**

5. In seeking solutions, we believe that all stakeholders have important and relevant contributions to make – including government agencies, industry, consumers, financial organisations, investors and non-governmental organisations. We will work to promote a greater public understanding of green hydrogen's potential. We will **contribute to open, public debate, in collaboration with civil society and community representatives in the areas where we operate.**

6. **We call on government and industry to develop dedicated green hydrogen strategies,** including specific commitments to mobilize additional investment along the green hydrogen value chain, and to support the elaboration of Green Hydrogen Standards to promote greater confidence and investment. **Supply and demand need to be supported substantially and simultaneously.** This includes supporting research and development to accelerate innovations that will increase efficiency and lower costs.

7. We will work together to **leverage green hydrogen to meet United Nations Sustainable Development Goals (SDGs)**, including ensuring access to affordable, reliable, sustainable and modern energy, and leveraging our investments to promote economic and employment opportunities. We will focus on the **development of fuel cell technology and potential to improve transport systems, health care services and water treatment.**

8. We believe that shared prosperity is underpinned by open, competitive markets. We recognize that expansion of the **green hydrogen markets must be set in the context of respect for contracts and laws.**

9. We recognize that green hydrogen production and consumption, when not managed properly, can create negative economic, social and environmental impacts. We will **incorporate ESG issues into policy work, investment analysis and decision-making processes.** We will support the elaboration of Green Hydrogen Standards that promote best practices in minimizing ESG risks. **We support global efforts to protect human rights, advance gender equality, and address conflict and instability.**

10. In realizing green hydrogen's potential, we are **committed to safeguard the sustainable management of water resources.** We are committed to recognizing and resolving disputes that result from opposing interests of water users, public or private.

11. We recognize that risks throughout the hydrogen value chain require specific knowledge and capabilities to ensure the safe production, storage, transport, and use of hydrogen. We are committed to **supporting the further elaboration and enforcement of best practice safety standards.**

12. We believe in the principle and practice of accountability by government and industry to all citizens for the stewardship of our natural resources. We will **report on our activities and progress, and uphold highest standards of transparency, accountability and good governance.**

"Let's be clear, we are in a race to save the environment as we know it. A race to net zero. Losing is unthinkable"

Dr Andrew Forrest, founding chairman of Fortescue Metals Group and the Minderoo Foundation

"The oil and gas sector is preying on public hope, and the political opportunism this allows – by allowing the colours of the rainbow and calling it clean hydrogen, which of course, being made from fossil fuels, it is anything but [...] Blue, grey, pink, yellow hydrogen is not renewable green hydrogen.
And don't get me started on the smokescreen of sequestration. [...]
The most recent argument that hydrogen made from fossil fuel whose carbon emissions have attempted to be sequestered – buried in the ground – is "the new green", is false. Regardless of the success of sequestration – it normally fails, there are huge carbon emissions emitted in its process."

Dr Andrew Forrest, founding chairman of Fortescue Metals Group and the Minderoo Foundation

The Green Hydrogen Development Plan

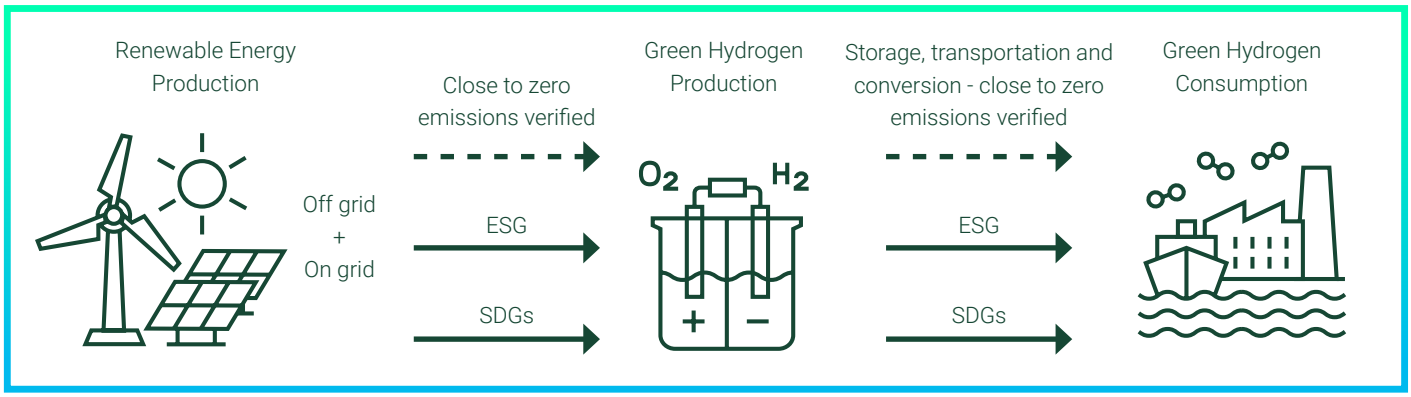
The G7 leaders concluded in June 2021 that climate change is an existential threat. Energy systems will have to change everywhere. There is an urgent need for developing countries and emerging markets to shift their energy use towards renewable sources. Many developing countries are already experiencing an energy crisis and energy poverty, significantly undermining their development. Demand in many countries outpacing the power available and grid capacity. In addition, many developing countries are dependent on expensive fossil fuel imports. Other developing countries are dependent on the export of oil and gas and coal. The growth of renewable energy, together with green hydrogen, can have a transformative impact.

The Green Hydrogen Development Plan is an initiative by the Green Hydrogen Organisation to provide a forum for the governments of developing and emerging economies, development finance institutions and other stakeholders to accelerate efforts to decarbonise the energy supply chain and accelerate the shift to renewable energy and green hydrogen.
The Compact is likely to develop into a set of policies, good practices by governments and their development partners in support for a significantly faster shift away from fossil fuels.

Facilitated by Erik Solheim and supported by the Secretariat of the Green Hydrogen Organisation, the aim is to develop concrete government policies, share good practices and green hydrogen strategies. Following the launch of the Green Hydrogen Organisation in August 2020, report on progress will be made at COP 26. During the International Green Hydrogen Summit and Assembly in the late spring 2022, governments part of The Green Hydrogen Development Plan will be invited to present updates on implementing their national action plans.

The GH2 Green Hydrogen Standard

The GH2 has established a global definition of green hydrogen. It requires that there be close to zero greenhouse gas emissions from green hydrogen production. It requires that the environmental, social and governance consequences are tracked, including the impact on local communities and human rights. In developing economies, the development opportunities and impacts of green hydrogen production and use are fully considered.



Agreed standards and definitions are critically important in determining how quickly green hydrogen becomes accepted and competitive. GH2's Green Hydrogen Standard has three criteria:

1. Rigorous accreditation of greenhouse gas emissions – guaranteeing close to zero emissions

The GH2 Standard addresses total greenhouse gas emissions, guaranteeing that green hydrogen is based on renewable sources with close to zero emissions. The GH2 Standard is rigorous, yet practical, with carbon accounting procedures and thresholds that can be applied consistently to grid and off grid production.

Globally, hydrogen strategies and policies differ widely on the definition of renewable energy, the boundaries of the carbon accounting system, the emission thresholds at which hydrogen is considered green, and the feedstocks and production technologies deployed.[66] While there have been several efforts to promote standardisation and consistency[67], there is more work to be done to establish a globally agreed standard and certification scheme to support the trade in green hydrogen.

The boundaries of the carbon accounting system and the thresholds at which hydrogen is considered "green" need to be clearly defined and trusted as credible by all stakeholders. The emissions associated with project construction need to be considered, together with the upstream emissions associated with water, energy and electricity production and the downstream emissions associated with hydrogen transportation and use.

Advocates of fossil fuel-based hydrogen often favour a narrow approach to carbon accounting which excludes either the upstream emissions associated with oil and gas production and/or the downstream emissions associated with (largely unproven) carbon capture, utilisation and storage (CCUS). These emissions are substantial and, in many cases, may exceed the emissions associated with the conventional utilisation of oil and gas.[68, 69] Care must be taken to set meaningful targets, and to avoid lowering the bar in ways that allows fossil fuel-based

hydrogen to masquerade as "low carbon". The GH2 will accredit green hydrogen production facilities that have robust systems to accurately and comprehensively measure the greenhouse gas emissions.

2. Environmental, social and governance performance

In addition to the greenhouse gas emissions, the GH2 Standard tracks the overall social, environmental and governance impact of GH2 certified hydrogen.

Accelerating the production and utilisation of green hydrogen requires a large increase in the production and utilisation of renewable energy, particularly wind, solar and hydroelectricity. These projects need to be developed and operated responsibly and sustainably. The GH2 is collaborating with the International Hydropower Association (IHA) and takes the *Hydropower Sustainability Guidelines on Good International Industry Practice*[70] as the foundation for ensuring that green hydrogen is sourced from renewable energy sources that meet best practice sustainability performance standards. Key questions include: Are the social and environmental impacts of new projects fully considered? Can free, prior and informed consent be verified? Are human rights respected and promoted where the energy is produced?

Green hydrogen production facilities also need to be developed and operated responsibly and sustainably. GH2 is working to incorporate best practice sustainability assessments into policy work, investment analysis and project decision-making processes. The GH2 Standard addresses the impact on affected communities, labour and working conditions, and the prohibition of all forms of slavery, child and forced labour.

The use and management of water resources requires close attention, ensuring that water is sourced responsibly from renewable sources without compromising the needs of the future. The GH2 Standard also addresses adherence to best practice health and safety standards in green hydrogen production, storage and transportation.

3. The development impact – SDG performance

The GH2 Standard requires that the development impact of any GH2 Standard certified green hydrogen is assessed, from power generation to use of the hydrogen. The extent to which projects, transportation and use has an impact on the Sustainable Development Goals (SDGs) is addressed. Green hydrogen development can provide developing countries with zero-carbon energy to support energy sector development, increase energy security and create export opportunities. Fuel cells can be used to provide decentralized solutions for critical services and infrastructure, increasing energy access in remote areas and in emergency situations. The GH2 Standard supports just transition strategies that allow us to phase out the industries that are harming workers, community health and the environment, while providing just pathways for workers to transition to new employment.

Emerging and developing economies are forecast to account for the majority of future greenhouse gas emissions.[71] It is clear that a rapid acceleration of renewable energy production is needed to achieve our development goals. It follows that government, industry and civil society in emerging and developing economies must play a leading role in developing green hydrogen markets. However, despite green hydrogen's enormous potential to stimulate development while reducing carbon emissions, green hydrogen is not given sufficient priority within many development finance institutions. This is undermining efforts to accelerate the production and use of green hydrogen and meet our climate change goals.

The objective of the GH2 Green Hydrogen Standard is to establish a global standard for the production and use of green hydrogen. The emissions associated with hydrogen production are an important consideration. The GH2 takes a holistic approach – from production to final use - which considers the sustainability of the industry and its contribution to achieving the UN's sustainable development goals (SDGs).

By addressing emissions, impacts and development opportunities holistically, the GH2 Standard will promote greater confidence, leverage investment, and unlock green hydrogen's vast potential. GH2 is inviting stakeholders to join in the effort to further develop the GH2 Green Hydrogen Standard.

Green Hydrogen Data Standards

GH2 supports open data and will develop and promote green hydrogen data standards. The development of green hydrogen markets requires timely, comprehensive and reliable data that can inform evidence-based dialogue between governments, companies, communities and civil society. Access to high quality information empowers individuals, the media, civil society, and business to make better informed choices about the services they receive and the standards they should expect. It is crucial for governments in improving policy making and sector management. Free access to, and subsequent re-use of, open data are of significant value to society and the economy.

As part of its commitment to establishing and promoting global green hydrogen markets, the GH2 is collaborating with partners to provide publicly accessible, up-to-date data on green hydrogen project development, operational capacity and production:

- Green hydrogen projects announced year to date (measured as amount of tons of hydrogen capacity addition)
- Green hydrogen projects announced year to date (measured as number of projects)
- Investments in green hydrogen announced year to date (both government funding and private capital being announced in the projects).
- Current global green hydrogen generation operational capacity

In addition, GH2 is collaborating with partners organisations to model green hydrogen's potential contribution to global energy markets, including:

- Demand for green hydrogen by industry segments
- Forecasting green hydrogen's share of global energy demand by 2050

The data is available via **gh2.org**

GH2

GH2 is being founded by Dr Andrew Forrest and its inaugural chairman is Malcolm Turnbull and Hyundai and nnn are also represented on the Board. We intend for the GH2 to join the new breed of international organisations that brings together governments, international institutions, the private sector and civil society. We hope that GH2 will harness innovative diplomacy, taking entrepreneurship and modern governance to enable a faster shift to producing and using green hydrogen. GH2 is set up as a not profit foundation under Swiss law, with the mission being to promote the production and use of green hydrogen and its derivatives.

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