Green hydrogen: Key success criteria for sustainable trade & production

A SYNTHESIS BASED ON CONSULTATIONS IN AFRICA & LATIN AMERICA

Brot für die Welt

HEINRICH BÖLL STIFTUNG

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Please see the main dossier with all publications and activities on hydrogen of the Heinrich Böll Foundation and Bread for the World:
https://www.boell.de/en/green-hydrogen
https://www.brot-fuer-die-welt.de/themen/gruener-wasserstoff/

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Heinrich-Böll-Stiftung (Heinrich Böll Foundation) is a catalyst for green visions and projects, a think tank for policy reform, and an international network encompassing well over 100 partner projects in approximately 60 countries. It is closely affiliated to the German Green Party. The primary objectives guiding the political work of the foundation are establishing democracy and human rights, fighting against environmental degradation, safeguarding everyone's rights of social participation, supporting non-violent conflict resolution and defending the rights of individuals.

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Foreword

by Imme Scholz, Director of the Heinrich Böll Foundation and **Dagmar Pruin,** President of Bread for the World

Climate change is already causing widespread damage across the planet, exacerbating existing socio-economic crises, particularly in countries of the Global South. Energy consumption from fossil fuels accounts for the majority of global GHG emissions. The Russian invasion of Ukraine also clearly demonstrates the role that fossil fuels play in conflict. Therefore, countries and communities around the world must very rapidly transition away from fossil fuels to bring humanity onto a safer path towards a sustainable future, protect livelihoods and ecosystems, and to stay within the Paris Agreement's 1.5°C limit.

Green hydrogen and its derivatives, produced from renewable energy, will likely play an important role in this transition. While it is vastly preferable to fossil fuels, it still needs resources: different natural materials, land, and water. It is therefore not the silver-bullet, as some voices are advocating it. The main uses of green hydrogen and its derivatives will need to be targeted at specific applications where electrification is not possible in the longer term, such as long-distance air and maritime transport, some heavy industries, and as the flexible backup for renewables-based power systems.

The production of green hydrogen requires renewable energy generation on such a large scale that the Global South, with its excellent renewables potential, is likely to become a major player in this transition. Furthermore, since production costs will be driven mainly by renewable energy production costs, there is significant potential for international trade in green hydrogen or derived products, exported from countries with abundant and scalable renewable potential.

Green hydrogen could provide benefits and opportunities for countries' socio-economic development and help them to "leapfrog" towards renewable energy infrastructure and associated technologies. However, there are also risks for local communities and the envisaged exporting countries located in the Global South.

Developing infrastructure for a green hydrogen market is a priority, especially for many wealthy nations' governments, but the emerging green hydrogen market must be shaped in a way that takes account of the interests and rights of all parties involved, in a situation that is marked by steep power imbalances. We, the Heinrich Böll Foundation and Brot für die Welt, believe that appropriate policy intervention is needed to steer the expansion of international investment and trade in green hydrogen and its derivatives in a sustainable direction. Such sustainability would ultimately benefit the long-term development of the sector. Therefore, it should be in the self-interest of policy-makers, investors, and affected communities alike to shape rules that all players abide by.

We have spent substantial time engaging with civil society organisations and other key stakeholders in potential exporting nations of the Global South in a "bottom-up" process of consultations. These dialogues focused on the key role that trade in green hydrogen could play in their economies, and particularly on identifying and formulating a set of proposals for standards, legal instruments, and political processes, thereby ensuring sustainable investments and fair trade in green hydrogen.

We need to seize the opportunity and shape the emerging green hydrogen trade now, in its infancy. This document provides guidance for decision-makers and investors to ensure a sustainable hydrogen trade that contributes to a fair and just energy transition and energy security, while helping to mitigate climate change.

Acronyms and abbreviations

CO_2	carbon dioxide
ESG	environmental, social, and governance
EU	European Union
FPIC	free, prior, and informed consent
GDP	gross domestic product
GHG	greenhouse gas
GW	gigawatt
IEA	International Energy Agency
ILO	International Labour Organization
IRENA	International Renewable Energy Agency
kWh	kilowatt hour
m3	cubic metre
Mt	million tonnes
PtX	Power-to-X
R&D	research and development

Executive summary

Green hydrogen – hydrogen produced from electrolysis powered by renewable electricity – will likely play an important role in the global energy transition to a fossil-free, climate-, and environment-compatible future. As its cost of production will be mainly determined by the availability of abundant and cheap renewable energy, countries with this potential are likely to become exporters of hydrogen or its derivatives (such as green methanol, green ammonia, Power-to-X products). Many of these countries are in the Global South, leading some green hydrogen advocates to hail the projected enormous benefits of trading green hydrogen globally.

Historical experiences with North-South trade and investment have not always been positive, to put it mildly. Power imbalances have led to a bloody history of exploitation and environmental injustice, from the early days of the Dutch East India company's genocide on the Banda islands to today's cobalt mining in the Democratic Republic of Congo. This has led some voices to denounce the nascent global green hydrogen trade from the very start as a neocolonial, extractive undertaking. We dare to disagree. Cognisant of the risks inherent in trade relations between unequal partners, we still fundamentally believe that the future is something to be shaped, especially when lessons learnt from the past are applied to the present. The potential opportunities for economic development and wellbeing in both consumer and producer countries are too big to set aside, especially given the urgent global need to decarbonise. What might become a multibillion-dollar business is still in its infancy. Therefore, our starting questions are: How can the new emerging investment and trading relationship avoid the mistakes of the past? How can it be shaped from the start to become fair, equitable, and sustainable?

With this question in mind, the Heinrich Böll Foundation and Brot für die Welt organised a series of workshops with national and global stakeholders and commissioned a policy options paper. This process has yielded criteria and measures that would enable green hydrogen production and trade to start on a better footing, ensuring benefits for local people, communities, and exporting nations as well as importing countries, while maintaining environmental integrity, social justice, and human rights. In summary, the following criteria and policies emerged:

- **As an overarching principle, green hydrogen** policies need to be shaped in such a way that producer countries do not just remain exporters of raw hydrogen, but benefit from value creation along the full value chain of production and trade. Exporting countries should therefore consider how to leverage external demand and the corresponding revenue and investment to "bootstrap" renewable energy and hydrogen production for domestic purposes. Consumer countries, for their part, must consider what trade and investment arrangements would support this principle. This is not only a social justice imperative, but one that is logistically preferable, given that green hydrogen derivatives are easier to transport than raw green hydrogen products. **Green hydrogen roadmaps as part of national energy strategies** – embedded in national sustainable development plans and nationally determined contributions (NDCs) – can provide a long-term vision for hydrogen for domestic use as well as export. These plans must be coordinated by the respective governments with the various stakeholders, including local communities. Such plans must ensure that exporting nations are not just providers of raw materials, but can also benefit domestically by using their green hydrogen production and trade to yield economic progress, energy access, livelihoods, and industrialisation.
- Green hydrogen production must be based on **strong social and sustainability standards and criteria**, including respect for human rights and a "do no harm" principle regarding the environment and local communities.
  - To ensure **environmental benefits**, hydrogen leakage must be prevented, water use minimised, and potential desalination carried out cleanly; careful spatial planning for installations is key, with solid strategic and specific impact (socio-economic and environmental) assessments and coordination with local communities. In particular, biodiversity hotspots must be avoided as sites for green hydrogen facilities. Resource use needs to be minimised and recycling, in particular of rare materials, promoted.

    - To **ensure social justice**, skills training for the local communities needs to be provided so that they also can obtain the new jobs created. These jobs need to be fairly paid and safe, without any expropriation or delocalisation/removal of local communities. The principle of **free, prior, and informed consent** (FPIC, as provided for in International Labour Organization (ILO) Convention 169) needs to be respected not only for marginal and minority communities, but also all affected populations. The impacted people need to be consulted and fairly compensated, from planning through to monitoring once the installation is up and running.
- Well-designed **incentive policies can generate the initial scale-up needed for green hydrogen** to become more economically attractive. To **ensure that only green hydrogen is produced and traded**, appropriate policies – in particular those intended to reduce the price gap to fossil hydrogen – need to be implemented. Under the current high prices for fossil fuels, that initial price gap has come down considerably, enabling an easier leapfrogging directly to green hydrogen. Removing fossil subsidies, installing carbon prices, targeted payments, as well as furthering green hydrogen and its derived products, such as green steel, through public procurement are elements that can contribute to this goal. Other possible measures are quotas and obligations, blending requirements for the use of green hydrogen to guarantee a fixed demand. Aligning national policies and strategies with well-founded roadmaps and solid regulation that provides certainty to companies and investors can generate the initial scale-up needed to make hydrogen economically attractive. International cooperation and regulatory improvement can ensure a larger market for green hydrogen.
- There are **governance issues** to be addressed: What gives green hydrogen its commercial value is its green property, which needs to be monitored and verified in a transparent and reliable way, in accordance with internationally agreed criteria, which need regulation and oversight. **To ensure the green hydrogen trade runs smoothly**, a certification, tracking, and accounting system is needed, as well as a harmonised definition of green hydrogen so that "green" indeed means 100 per cent renewable, in addition to the need for standards for sustainable hydrogen. Arrangements for the actual trading (which commodities, platforms, conditions, financial products, trading procedures) need to be agreed as well as assurances/guarantees to investors regarding the conditions under which they can market the hydrogen produced as green hydrogen in projected investment projects.
    - **Policies for green and sustainable hydrogen production and trade can be developed at the national, bilateral, multilateral, and international levels.** Each of these options has advantages and drawbacks, with options ranging from bilateral contracts to an international green hydrogen treaty. To start the market up relatively quickly under ambitious standards and criteria, could a **"green hydrogen club"** – encompassing a set of environmentally and socially motivated countries agreeing on criteria, policies, and trading mechanisms – be the best option?

The project did not investigate fossil or nuclear-based hydrogen. **We reject the use of non-renewable hydrogen due to its continuation of harmful fossil extraction, associated greenhouse gas (GHG) emissions,[1] and risky nuclear practices.[2]** Obviously, in case of governments and companies persisting with non-renewable hydrogen, all the criteria mentioned in this report apply, while a wide set of further criteria would need to be established to reduce additional problems created through fossil and nuclear technologies. The project also did not assess green hydrogen trade in the broader framework of commodity trade – the benefits, injustices, and drawbacks of commodity trade between North and South have been discussed extensively elsewhere. Suffice to say, we call for all climate-related trade policies, including those related to green hydrogen and its derivates, to be framed within the just transition with people and planet in mind.[3]

The international green hydrogen market is still in its infancy. Policy-makers must seize the opportunity to create a model for how a human-rights based, equitable, just, and environmentally sound trade should work. The proposals from this paper should be used as a template to make green hydrogen trade a positive reality for both people and the planet.

1. Given the upstream methane leakage, "blue" and "turquoise" hydrogen made from fossil gas is not compatible with a 1.5°C future and should therefore be excluded by policies fostering hydrogen production and use. Under the current challenges that result from the dependency on fossil gas imports, these technologies make less and less sense.
2. Equally, hydrogen from bioenergy does not reduce greenhouse gas emissions and has a very high impact on land use, and therefore bioenergy is not an adequate source for hydrogen, https://www.biofuelwatch.org.uk/2022/hydrogen-biomass-briefing/.
3. The Alternative Trade Mandate Alliance (n.d.), Trade: Time for a New Vision, https://www.tni.org/files/download/trade-time_for_a_new_vision.pdf.

Solar Energy Photovoltaic Power Plant in the Atacama desert sands, Chile.
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Introduction

A changing climate is already causing widespread damage across the planet, exacerbating existing socio-economic crises, particularly in countries of the Global South. Fossil fuels account for more than three-quarters of global greenhouse gas (GHG) emissions.[4] In light of the increasing droughts, floods, fires, and related extreme weather events, countries and communities around the world must very rapidly transition away from fossil fuels to address climate impacts and protect livelihoods and ecosystems, and to stay below the 1.5°C global heating limit adopted globally in the Paris Agreement.

Within the just energy transition,[5] green hydrogen and its derivatives, produced from renewable energy, could play an important role for both industrialised and industrialising nations. It could replace fossil fuels due to its easy, long-term storability and bridge temporary supply gaps in renewable power provision in a growingly electrified economy. It has a wide field of applications, specifically for hard-to-decarbonise and difficult-to-electrify industries such as steel, cement, glass and ceramics, chemicals and fertilisers, and long-distance maritime and air transport.[6] According to International Renewable Energy Agency's (IRENA) 1.5°C pathway, described in the World Energy Transition Outlook,[7] green hydrogen and its derivatives will account for 12 per cent of final energy use by 2050.

However, today, 98 per cent of the hydrogen produced globally comes from fossil fuels, and less than 1 per cent from renewable energy.[8] Since production costs for green hydrogen will be driven largely by renewable potential (including cost), significant international trade in hydrogen or derived products, such as ammonia, is likely to emerge. Green hydrogen will be exported from countries with abundant and scalable renewable potential – for example wind, sun, and geothermal. Projections suggest that around a quarter of globally produced hydrogen will be traded across borders in 2050.[9]

Introduction continued

Achieving the agreed climate goals will require a rapid scaling-up of green hydrogen production. The International Energy Agency (IEA) states that global annual production of renewable-based hydrogen will need to increase to at least 500 million tonnes (Mt) to be consistent with climate neutrality scenarios.[10] Although the majority of hydrogen is likely to be used locally or nationally,[11] international trade in green hydrogen and its derivatives will still play a very important role.

Additionally, in the newly emerging political reality of Europe and other geographies weaning themselves off Russian fossil fuels, the push for alternative imports is increasing. The "RepowerEU" plan, released on 18 May 2022, has doubled the EU's ambitions for green hydrogen imports by 2030, to a projected 10 Mt per year.

Green hydrogen could provide benefits and opportunities for countries' just, sustainable, rights-based socio-economic development and help them to "leapfrog"[17] towards renewable energy infrastructure and associated technologies. But it could also continue well-trodden trajectories in which resources in the Global South are extracted to create wealth in the Global North, with little consideration for human rights or the imperative of advancing equity, both within and between countries. So, what risks will trade in green hydrogen entail for the envisaged exporting countries located in the Global South? What international and national policy and regulatory frameworks are needed to ensure that investments and trade in green hydrogen develop from the start within a framework of just sustainable development, equity, and human rights?

For developing economies, it is imperative to increase clean energy supply to achieve the United Nation's Sustainable Development Goal 7 on universal clean energy access, as well as attaining the other Sustainable Development Goals. These objectives mean – for developed and developing areas alike – that a dramatic expansion of renewable energy is necessary, accompanied by the reduction of unnecessary energy consumption and steep improvements in energy efficiency. Only this will enable a 100 per cent clean, renewable energy future and meet the clean energy needs of people, economies, and their environments.

In countries with significant potentials for renewable energy resources, the option of producing green hydrogen is gaining traction quickly, including for export purposes. As of November 2021, 522 large-scale clean hydrogen projects were planned or commissioned globally,[18] and this number is growing due to geopolitical concerns. Prices for renewable energy production and electrolysers are falling – even Shell admits to green becoming cheaper than so-called blue hydrogen made from fossil gas.[19]

As the market is emerging, its shape and structure are still unclear – currently, it is primarily structured around bilateral agreements between future suppliers and importers. However, it is clear that any international market for green hydrogen will be a hybrid – with elements of a commodity market (akin to existing markets for hydrocarbons), but also strongly influenced by political design choices (in particular regarding the green nature of hydrogen). It is essential that any trade agreements – bi-, pluri-, or multilateral – ensure that the trade is fair, equitable, and sustainable, and that it benefits both exporting and importing countries. Without appropriate policy frameworks, the expansion of international investment and trade in green hydrogen and its derivatives could happen in an unsustainable and exploitative manner. Opportunities to develop domestic industries and associated jobs could be missed. Cut-throat international competition for least-cost production could lead to damaging practices similar to those observed in the context of fossil fuel extraction.[20] Not only could this end up harming precious natural environments and local communities; the associated environmental, social, and governance (ESG) risks could ultimately also undermine the long-term just development of the sector.

These risks are more likely for exporting nations based in the Global South, due to frequently weak governance and unequal power relations. According to a recent analysis, the Global South is experiencing a large net appropriation of resources by the Global North, via trade and illicit financial flows, worth more than $10 trillion per year.[21] Most countries in the Global South are currently reliant on fossil fuels for their energy. Therefore, it is important to ensure that the framework for the development of a green hydrogen trade is embedded in a broader, just, and sustainable energy transition strategy, allowing the benefits from (new) renewable energy structures and green hydrogen production to serve local populations and industries, creating new technologies, skills, jobs, and clean energy access while not harming the environment. The overall development of green hydrogen and related trade policies must respect the tenets of a just transition to a clean energy future. It should thus be in the self-interest of investors, host countries, and affected communities alike to shape a just and "sustainable" green hydrogen trade that is defined by rules that ideally all players abide by, enabling investments in Global South countries that help them leapfrog towards renewable and sustainable energy infrastructure and alternatives.[22]

Although hydrogen trade is still in its infancy, the appropriate standards, policies, and certification for green hydrogen production and trade need to be established and put in place that benefit all. It is crucial to get it right from the start and ensure that green hydrogen is promoted, not fossil- or nuclear-based hydrogen.

Box 1

A climate justice perspective on the development of green hydrogen

The global climate crisis, exacerbated by the impacts of the COVID-19 pandemic, is having a devastating effect on households, communities, and ecosystems across the world. In 2022 alone there were record-breaking heat waves in Europe, monsoon flooding in Pakistan,[12] a 40 year drought across the Horn of Africa,[13] while extreme weather events exposed millions of people to food and other insecurities in South America. As communities increasingly face the need to prepare for and respond to climate emergencies, it is women and girls who disproportionately bear the brunt. To avoid mounting loss of life, biodiversity, and infrastructure, the Intergovernmental Panel on Climate Change has called for "ambitious, accelerated action [...] involving everyone in planning, attention to equity and justice and drawing on Indigenous and local knowledge".[14]

To do this, a climate justice perspective is essential. Those who are historically marginalised or are already vulnerable are the ones who suffer first and more severely, even though they are least responsible for the climate crisis. Simply put, climate justice requires preventing harm, making up for harms already done as far as possible – especially in the Global South – and this takes mitigation, adaptation, and compensation for loss and damage. Recognising this is a first step in the debates on a just and equitable global energy transition and green hydrogen's role in it. To be considered climate just, green hydrogen policies and programmes must include the following principles and recommendations:

1. **Ensuring a voice for climate-vulnerable populations and communities and the victims of continued fossil fuel extraction.** The rapid development of a green hydrogen economy is a decisive element of the global phase-out of fossil fuels, and therefore in the immediate interest of the most vulnerable populations. Climate justice requires minimising the potential negative impacts of the transition on the most vulnerable, while maximising the opportunities for them. Local communities in green hydrogen project areas have to be consulted, taking special care to include women and respecting the principle of free, prior, and informed consent (FPIC) before implementing any projects or policies that might impact them. The commitment of governments to these consultations and to only act if consent is given (as stated in ILO Convention 169) is a pre-condition for a successful green and just energy transition process. FPIC will also allow communities to negotiate with eventual developers of green hydrogen projects, including in terms of benefits to local communities (jobs, electricity, water from desalination, etc.). It may also lead to a redesign of projects, for example towards agro-photovoltaic systems. Agreements on green hydrogen should therefore include instruments to evaluate the social and environmental impacts of projects and instruments, ensuring these impacts are positive. These agreements can also **avoid environmental racism** by committing to clauses that prevent the development of policies and undertakings that promote environmental racism, that is, that ensure that no particular group of people, whether ethnic, racial, or class groups, bears a disproportionate share of the negative environmental consequences of economic operations and policies.

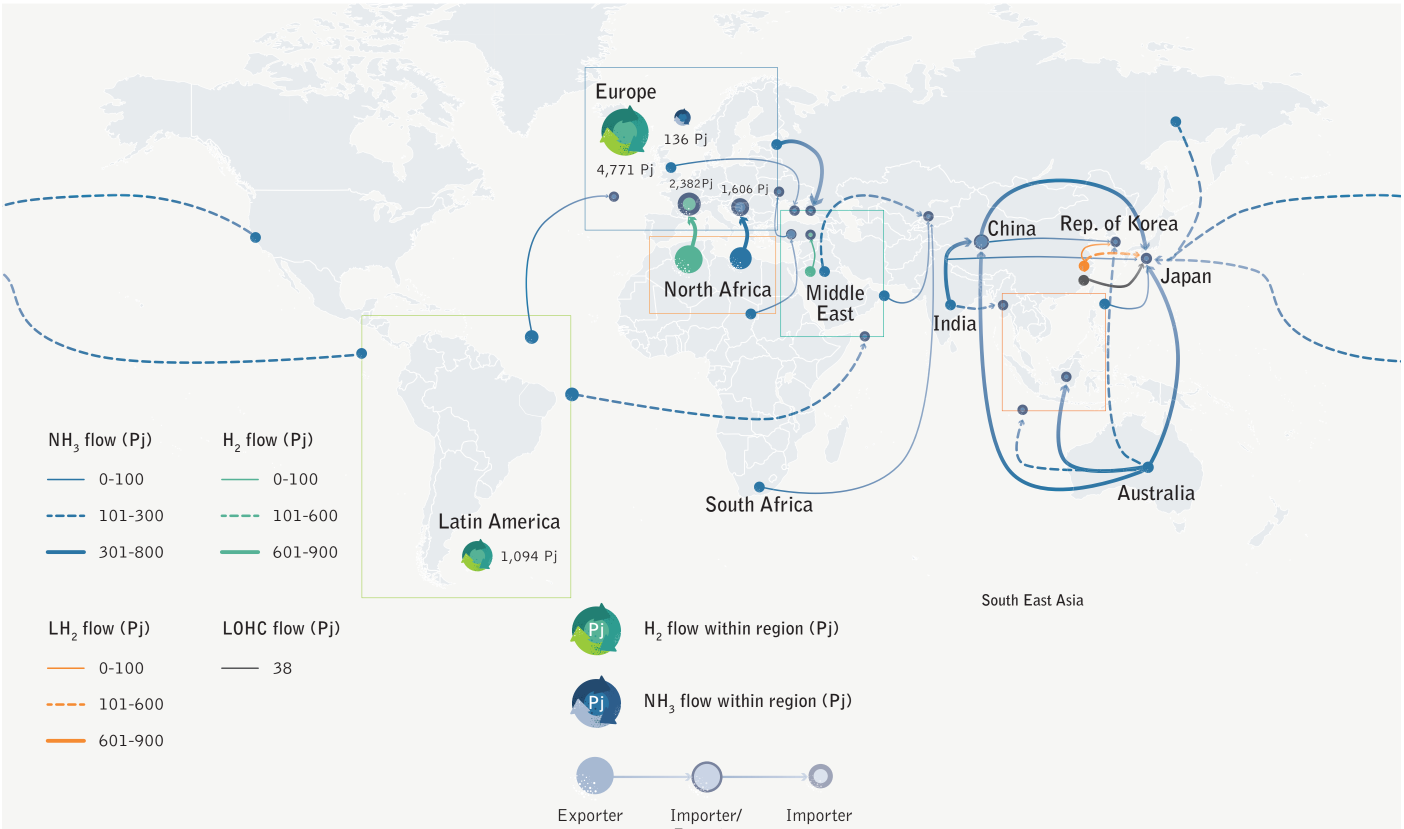
2. **Addressing inequality between the Global North and Global South.** Many poor countries in the Global South emit low per capita GHG emissions.[15] Yet, they see their development opportunities being threatened by climate impacts, the need for costly adaptation measures, as well as higher initial climate mitigation investments. At the same time, in 2018, an estimated 789 million people lacked access to modern electricity infrastructure.[16] Climate justice requires that these countries get support to transform and develop their energy systems, while at the same time addressing energy inequity and poverty. Green hydrogen could entail the opening up of new forms of export revenues to replace fossil fuel exports, for example via green hydrogen and derivatives exports, as well as contribute towards addressing energy poverty. Countries deserve access to the relevant know-how, capacity-building and technologies, as well as the upstream and downstream opportunities for value creation beyond raw materials that a new, renewables-based international energy system and hydrogen trade will create. The risks inherent in the investment into new technologies need to be mitigated by long-term partnerships with importing countries.

Introduction continued

The Heinrich Böll Foundation and Brot für die Welt decided in Autumn of 2021 to launch a project to develop such criteria and policies from the "bottom up". The project involved civil society and other stakeholders in key potential exporting nations of the Global South: Argentina, Brazil, Chile, Colombia, Morocco, South Africa, and Tunisia. In a process of decentralised multi-stakeholder dialogues, interviews, and research, the **standards, legal instruments, and political processes leading to sustainable investments and fair trade in green hydrogen** were explored. In addition to the national consultations, two international consultation workshops were carried out. The project produced a wide range of publications that also contributed to this synthesis, for example a paper on policy options for a green hydrogen trade,[23] a study[24] on pastoralism, and the development of large renewable energy facilities, a hydrogen background paper,[25] and popular education materials.[26]

This paper constitutes the summary of the national consultations, the policies process, and input received from a variety of stakeholders. It aims at informing decision-makers and investors on how to ensure that any hydrogen trading contributes to a fair and just energy transition and energy security, as well as the prevention of climate change. The proposals would also ensure the respect for environmental constraints and an increase in the support for local communities. If implemented, the recommendations from this paper can promote a better future for people and the environment.

Figure 1: Projected trade map and volumes in green hydrogen in 2050



Source: Collins (2022).[27]

„It is essential to provide policy makers with a set of generally agreed recommendations that can ensure a sustainable, beneficial-for-all, green hydrogen production and trade. In parallel, in the countries planning to export green hydrogen, civil society needs to be aware of the opportunities and risks associated with the emerging hydrogen trade, allowing them to interact in an informed manner with their own national policy-makers and industrial actors. This synthesis aims to achieve both."

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6. For more information about the potential uses of green hydrogen, see Heinrich Böll Foundation and Brot für die Welt (2022), Green Hydrogen – Hype or Beacon of Hope? https://www.boell.de/sites/default/files/2022-08/green_hydrogen_-_hype_or_beacon_of_hope.pdf. https://www.brot-fuer-die-welt.de/themen/gruener-wasserstoff/

7. IRENA (2021), World Energy Transition Outlook, 1.5°C Pathway, https://www.irena.org/publications/2021/Jun/World-Energy-Transitions-Outlook.

8. IRENA (2022), Green Hydrogen Certification, https://irena.org/-/media/Files/IRENA/Agency/Publication/2022/Mar/IRENA_Green_Hydrogen_Certification_Brief_2022.pdf.

9. IRENA (2022), Global Hydrogen Trade Outlook https://www.irena.org/publications/2022/Jul/Global-Hydrogen-Trade-Outlook.

10. The IEA includes blue hydrogen in its scenarios, which we do not consider a sustainable option. Today's hydrogen production is around 70 Mt, less than 1 per cent of which is based on renewable energy, see IEA (n.d.), The Future of Hydrogen, https://www.iea.org/reports/the-future-of-hydrogen.

11. IRENA assumes that 75 per cent of hydrogen demand in 2050 will be produced and used locally/regionally, see IRENA (2022), A Quarter of Global Hydrogen Set for Trading by 2050 Tweet, https://www.irena.org/newsroom/pressreleases/2022/Jul/A-Quarter-of-Global-Hydrogen-Set--for-Trading-by-2050. However, recent research by McKinsey estimates a much higher amount of traded hydrogen (all hydrogen, not green) by 2050, which would make the proposals of this paper even more urgent, see McKinsey & Company Hydrogen Council (2022), Global Hydrogen Flows: Hydrogen Trade As a Key Enabler for Efficient Decarbonization, https://hydrogencouncil.com/wp-content/uploads/2022/10/Global-Hydrogen-Flows.pdf.

12. Kevin Trenberth (2022), 2022's Supercharged Summer of Climate Extremes: How Global Warming and La Niña Fueled Disasters on Top of Disasters, The Conversation, September 15, https://theconversation.com/2022s-supercharged-summer-of-climate-extremes-how-global-warming-and-la-nina-fueled-disasters-on-top-of-disasters-190546#:~:text=The%20Northern%20Hemisphere's%20extreme%20summer,an%20estimated%2033%20million%20people.

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16. Ibid.

17. For example, the rapid ongoing transformations and acceleration in digitisation. Countries in the Global South were able to "leapfrog" to new technologies. An example is the introduction of smartphone use and the public and private investment in infrastructure, introduction of a regulatory and trade environment for these new markets, and business models. The question is whether leapfrogging in the energy sector is possible and if it will be accompanied by the same amount of public–private investment in utilities, regulations, and finance.

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22. In the EU some attempts to address energy overconsumption are underway that could be further ramped up through improvements in energy efficiency and accelerating the circular economy. See for instance European Parliament (2022), Why Is the EU's Right to Repair Legislation Important?, https://www.europarl.europa.eu/news/en/headlines/society/20220331STO26410/why-is-the-eu-s-right-to-repair-legislation-important#:~:text=The%20European%20Parliament%20has%20been,%2C%20cost%2Defficient%20and%20attractive.

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LAKE TURKANA

Marsabit County, Kenya: The permanent structures of Lake Turkana Wind Power (LTWP) include 365 wind turbines, a substation and workers' accommodation. The turbines were installed one per day over a year. Each has a capacity of 850 kilowatts. They provide 310 MW of energy to the Kenya national network. © Maurizio Di Pietro / Climate Visuals Countdown

02

Process summary

The aim of the process was to integrate a broad set of stakeholders – from local communities likely to be affected by the development of hydrogen facilities, to international experts active in the climate and energy fields – and kickstart the discussion on how to achieve a green and sustainable hydrogen trade. The aim was not only to obtain a generally agreed global synthesis for policy-makers to understand what the key aspects of a beneficial future hydrogen trade are, but also to create broad civil society awareness of the opportunities and risks associated with the emerging hydrogen trade, allowing them to interact in an informed manner with their own national policy-makers and industrial actors.

Process summary continued

Each of the countries participating in the project established a slightly different method to obtain stakeholders' inputs and elaborate their own conclusions. In general, the following steps were followed:

- Finding the appropriate stakeholders from a broad section of civil society, ranging from environmental non-governmental organisations, local community and indigenous peoples' representatives, trade unions, energy and climate experts, think tanks, and social activists to government representatives.
- Ensuring the basic understanding of participants as to what green hydrogen is and how it is produced and exchanged within and between countries (for this purpose, educational materials were produced and distributed).[28]
- Organising questionnaires and workshops – in some cases multiple workshops per country – to evaluate the key issues around hydrogen production and trade.
- Synthesising the results of the national workshops and questionnaires into a Country Outcome Document.
- The Country Outcome Documents were then synthesised into one Global Synthesis Document.
- The Global Synthesis draft document was discussed by workshop participants, and their feedback was integrated into the final synthesis document (which you are presently reading).

In parallel, on behalf of the Heinrich Böll Foundation and Brot für die Welt, the Ecologic Institute[29] developed a policies paper[30] investigating bi-, pluri-, and multilateral policy options to incentivise and ensure a sustainable and fair green hydrogen trade. The paper was discussed with a broad group of international experts, whose comments were integrated into the final version. The key policies validated by the international experts were also included in the Global Synthesis Document, as were the mostly national policies developed by national consultations participants.

Sheep grazing in a solar park in the Ukraine. © Roman Mikhailiuk / Shutterstock

28. Ibid.

29. See https://www.ecologic.eu/.

30. Benjamin Görlach, Michael Jakob, and Ramiro de la Vega (2022), Pathways Towards a Global Market for Green and Sustainable Hydrogen: Need for Action and Policy Options, https://www.boell.de/en/green-hydrogen and https://www.brot-fuer-die-welt.de/themen/gruener-wasserstoff/.

31. Heinrich Böll Foundation and Brot für die Welt (2022), Green Hydrogen – Hype or Beacon of Hope? https://www.boell.de/sites/default/files/2022-08/green_hydrogen_-_hype_or_beacon_of_hope.pdf. https://www.brot-fuer-die-welt.de/themen/gruener-wasserstoff/

Box 2

Why do we need green hydrogen?[31]

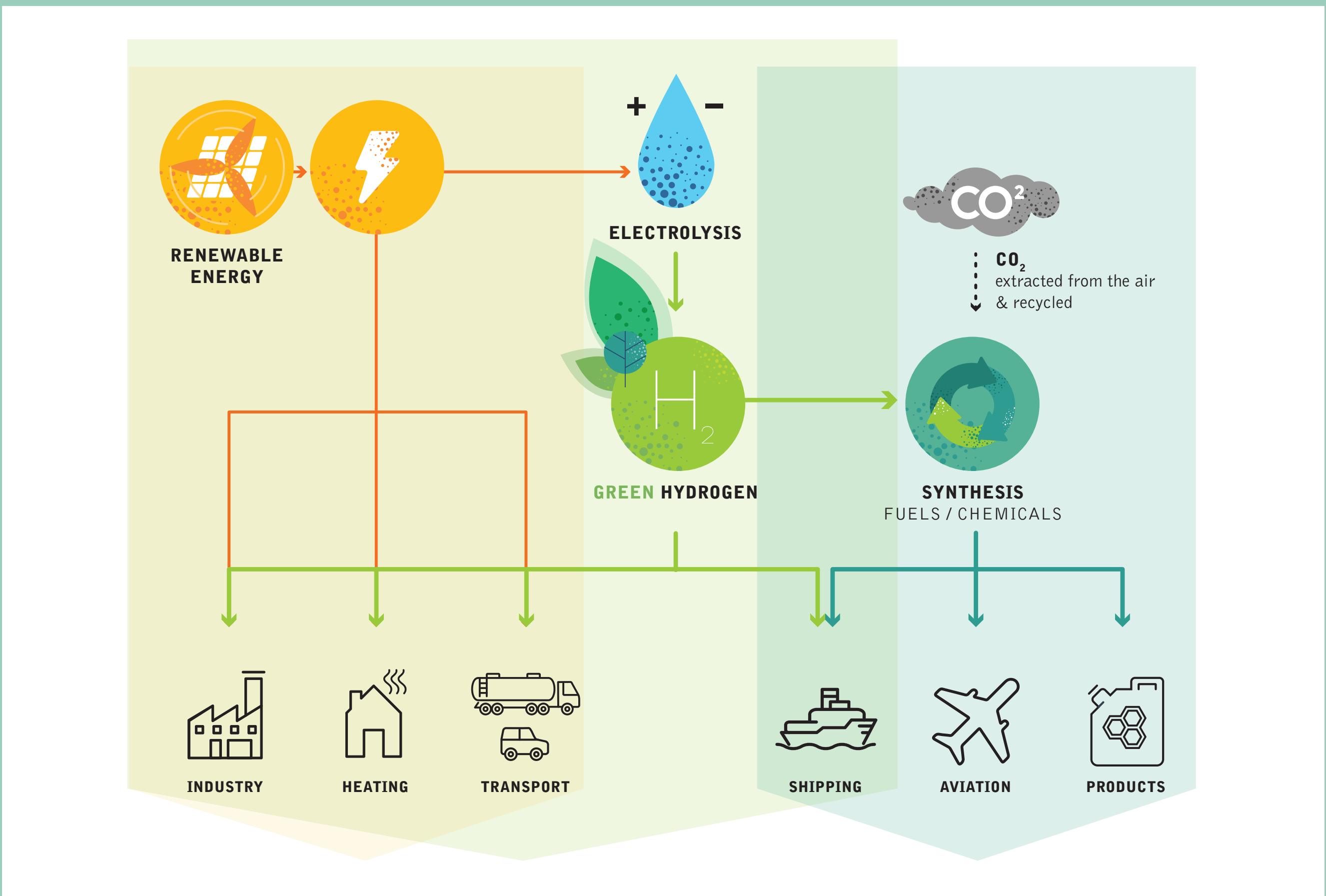
Green hydrogen is considered an essential building block on the road to a zero-emission fossil-free future. Besides the established industrial application, green hydrogen can be deployed in energy-intensive and hard-to-decarbonise sectors. It can be stored and transported relatively easily – the latter for instance in pipelines – and it can be used in liquid form as a fuel, for example for aviation and shipping.

Bringing the energy-intensive production of steel, aluminium, cement, or chemical products into line with the Paris Agreement climate goal is very difficult without using green hydrogen. In contrast, green hydrogen is unlikely to play a role in the foreseeable future as a fuel for passenger cars, since cars with electric drives are significantly cheaper and more efficient.

While much attention is paid to the opportunities of green hydrogen in reducing carbon emissions, much less attention is directed towards reducing energy use and energy waste. In order to avoid green hydrogen becoming yet another "false solution" technology, it is important that it is considered a part of a broader strategy to reduce the overall consumption of energy.

Hydrogen and Power-to-X (PtX): The common term "PtX" – the "P" for "power" – refers to electricity and the energy input for production. The "X" stands for different end products, for example "power-to-gas" as a gaseous energy carrier or "power-to-liquid" as a liquid fuel. Hydrogen can be a "PtG" or a "PtL", depending on the aggregate state of storage. PtX technologies can "indirectly electrify" previously fossil-based sectors. That is, electricity generated from renewable energy is used to produce PtX products that replace fossil fuels and decarbonise sectors such as industry, transport, and others.

Figure 2: Hydrogen uses



Young Maasai shepherd with his livestock near Natron Lake, Rift Valley, Tanzania © Gideon Ikigai / Shutterstock

03

Why we need strong socio-ecological criteria & policies for Green hydrogen investment & trade

The national workshops identified a series of opportunities, but also threats relating to green hydrogen production and trade. The former need to be incentivised by appropriate measures, the latter prevented. The policies and criteria proposed in this paper aim to achieve both.

Why we need strong socio-ecological criteria & policies for Green hydrogen investment & trade continued

3.1 Main Opportunities

- A renewable hydrogen-supported, electrified economy can contribute to development and prosperity in producing countries, for example by promoting local value creation throughout the value chain, building new skills through the transfer of technology know-how, and strengthening local economic actors. It can increase and create new green jobs/livelihoods for local communities, particularly in developing countries with a young population in search of well-paid jobs. It can create economic opportunities in currently economically disfavoured regions.
- Green hydrogen can act as a catalyst for accelerating clean energy investment, market development, energy access, cost degression and leapfrogging towards 100 per cent renewable energy globally.
- With its climate-neutral production, green hydrogen can contribute to achieving global climate targets.
- It can reduce air pollution and increase citizens' health by decreasing exposure to air pollution from fossil fuels or radiation emissions.
- It can develop profitable, long-term partnerships between potential exporting and importing countries.
- Exporting nations can earn needed foreign revenues from exports of green hydrogen, and in particular derived products with higher value added.
- Trade can also incentivise production to satisfy local hydrogen demands; create or decarbonise local industries – such as in the production of fertiliser[32] using green ammonia – and transport; and develop a green infrastructure for energy production, as well as for transport and storage.[33]
- Increased renewables and hydrogen production can diversify energy production away from few current fossil fuel providers, decreasing costs and increasing security of supply.
- When done right, green hydrogen production can strengthen biodiversity and environmental health by avoiding extractive coal, other fossil fuels, or nuclear production and pollution.

3.2 Main Concerns

- There are risks relating to land-use conflicts, forced resettlement, and expropriation for large-scale renewable energy installations, as well as human rights violations.
- Fragile ecosystems could be damaged or destroyed by badly chosen installation locations, including disturbing endangered birds' migratory routes and potential pipeline leakage, which might increase GHG emissions.
- The other risk associated with hydrogen leaks is the high flammability of this gas, which has already led to accidents at hydrogen distribution stations.
- As electrolysis requires freshwater, its use for hydrogen production could increase water scarcity, which could lead to conflicts between different users of water, particularly in dry regions.
- If additional freshwater is produced for hydrogen production through desalination, marine life could suffer if brine from desalination is not treated appropriately.
- If hydrogen is prioritised for exports over the longer term, this could forego the potential that the renewable energy capacity and hydrogen also benefit the domestic energy supply and energy transition, for example when hydrogen-importing countries offer prices that outcompete users in exporting nations. This could even perpetuate a lock-in of fossil fuel energy generation if renewable energy installations are only used for producing hydrogen for exports.
- The Global North and more industrialised importing countries could continue to power industries maintaining (or increasing) current levels of consumption. This could divert green hydrogen from essential uses in hard/impossible-to-electrify sectors towards less efficient purposes.
- Jobs could bypass locals if no skills-creation programmes exist.
- Current power balance issues could continue if importing nations try to impose unfair trade practices, or if bad governance on the part of importing and/or exporting countries or both leads to profits for the few, to the detriment of the many and the planet.

Box 3

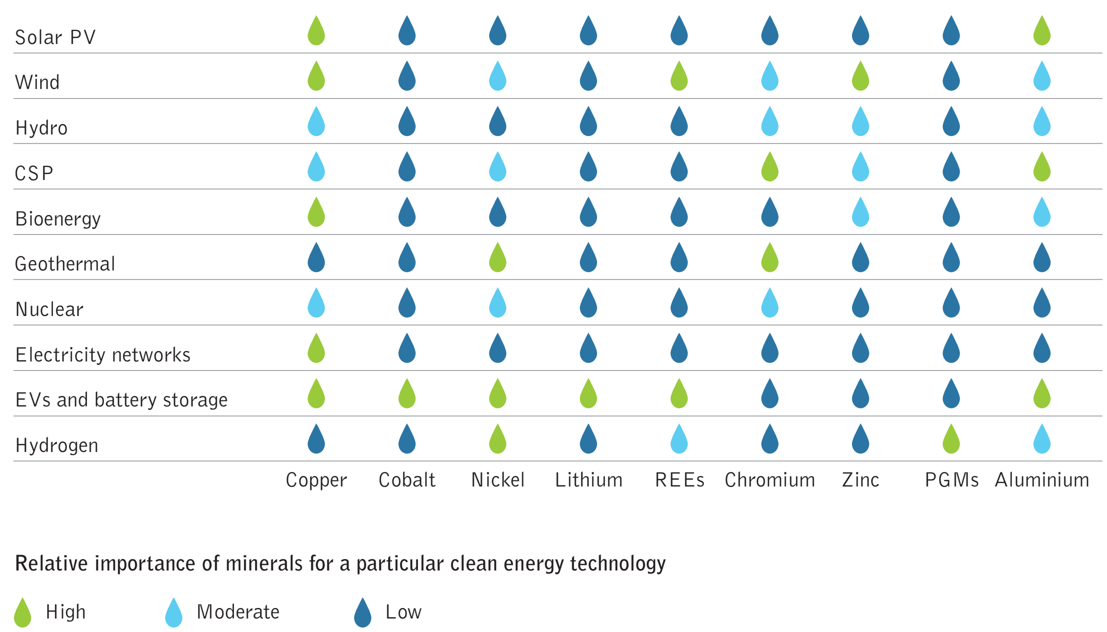
Risks of leakage and other potential risks relating to green hydrogen

Several issues require more research on hydrogen production, transport, and use, for instance:

Hydrogen leakage: A recently published study[34] by the UK Department for Business, Energy and Industrial Strategy found that hydrogen might be twice as potent a GHG as previously thought, about 11 times more than carbon dioxide (CO_2) per tonne of emissions. When reacting with other GHGs in the atmosphere, such as methane or ozone, the hydrogen molecule would increase their global warming potential. Thus, "any leakage of hydrogen will indirectly lead to an increase in global warming", the report warns. The hydrogen molecule – the smallest of the gaseous molecules – is very volatile and could therefore easily escape from pipelines and conduits. It is challenging to make tanks and pipes containing hydrogen completely leakproof, especially when it is compressed at very high levels of pressure. Yet, many chemical companies have shown that managing hydrogen – a rather expensive raw material and so far produced from fossil fuels and the cracking process – is possible without any leakages. Clearly, this is an issue requiring more research to ensure that no leakage occurs.

Ammonia and nitrous oxide:[35] A further issue appearing in recent science pertains to ammonia (NH3), a hydrogen derivative. Although ammonia could solve the CO_2 problem in shipping, it could create a nitrous oxide (N2O) issue, potentially reducing ammonia's climate benefit. Nitrous oxide is a GHG that is 273 times more potent than CO_2. Ammonia has been proposed as a shipping fuel, yet potential adverse side effects are poorly understood. If nitrogen (N2) releases from ammonia are not tightly controlled, the scale of the demands of maritime transport are such that the global nitrogen cycle could be substantially altered. For example, if there were a 0.4 per cent leakage leading to nitrous oxide emissions, it would wipe out the decarbonisation benefit from eliminating carbon from shipping fuels. That said, ammonia is chemically a very stable molecule and the risk of leakage is small. An alternative to ammonia combustion could be cracking of ammonia into hydrogen and nitrogen with subsequent use of hydrogen in a proton–exchange membrane fuel cell (or other fuel cell technologies).

Figure 3: Mineral needs across clean energy technologies



Source: IEA 2021.[36]

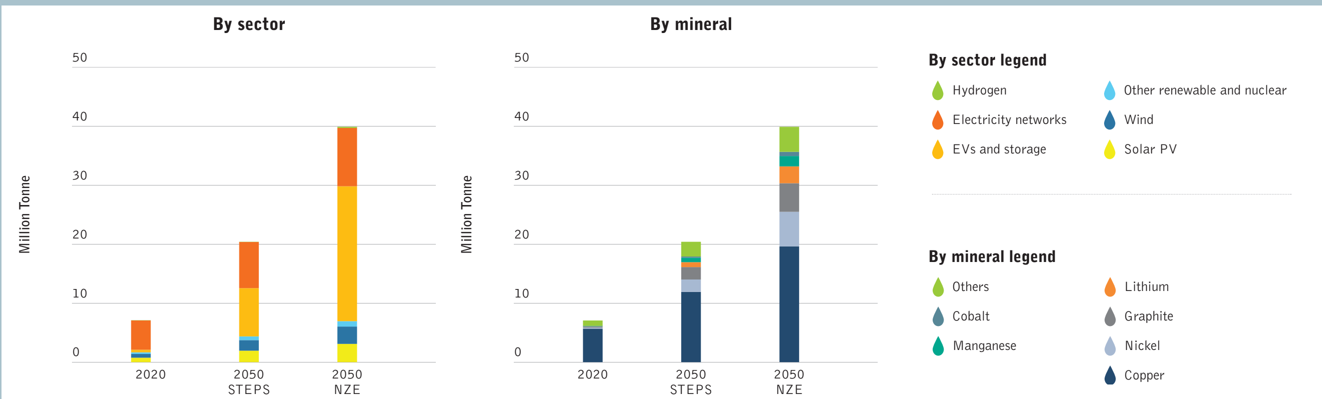
Why we need strong socio-ecological criteria & policies for Green hydrogen investment & trade continued

Box 3 - continued

Risks of leakage and other potential risks relating to green hydrogen

Materials use:[37] Green hydrogen, like any other energy production, also needs materials for its production. However, one of hydrogen's advantages is that it can be stored for a long time, particularly in the power sector when there is no wind and no sun, therefore obviating some battery needs – and many batteries are used for electricity storage. This is important because lithium-ion batteries have grown in popularity over the last decade. Their popularity is putting pressure on the supply of lithium, nickel, and cobalt, the latter being mined particularly in the Democratic Republic of the Congo, under often extremely bad circumstances for the local population and environment, while lithium mining requires super-large quantities of freshwater and has a high eco-toxicity. However, the renewable energy needed to produce hydrogen will also need materials. In this context, it is therefore important for most of that energy to be used in direct applications and electrification, with hydrogen only for selected, hard-to-electrify sectors. Minerals use varies for different renewable energy technologies. However, compared to the mining, transport, and emissions of fossil fuels or the toxic waste of nuclear power, the renewable deployment is cleaner, particularly when the **recycling of the minerals and materials** used is increased, human rights violations are avoided, freshwater consumption is reduced, new materials are developed in research and development (R&D) schemes, creating a precondition for longer-term sustainable and reliable growth of renewable technologies. In parallel, the **mainstreaming of higher ESG standards is necessary, such as the the IRMA[38] standards suggested by non-governmental organisations**. Hydrogen production necessitates some specific minerals – some types of electrolysers need platinum metals, and nickel is also needed at a relatively high level. A German study[39] reported that by 2040, demand for scandium is set to increase by 2.7 times, and demand for iridium could soar five-fold compared to 2018, mainly for the technology used to split water into hydrogen and oxygen molecules through the use of electricity: the proton–exchange membrane. While scandium is available relatively widely, iridium is much rarer: 80–85 per cent is currently produced in South Africa, most of the rest in Russia. However, hydrogen's additional need for critical minerals is limited compared to other technologies.

Figure 4: Mineral demand for clean energy technologies by scenario



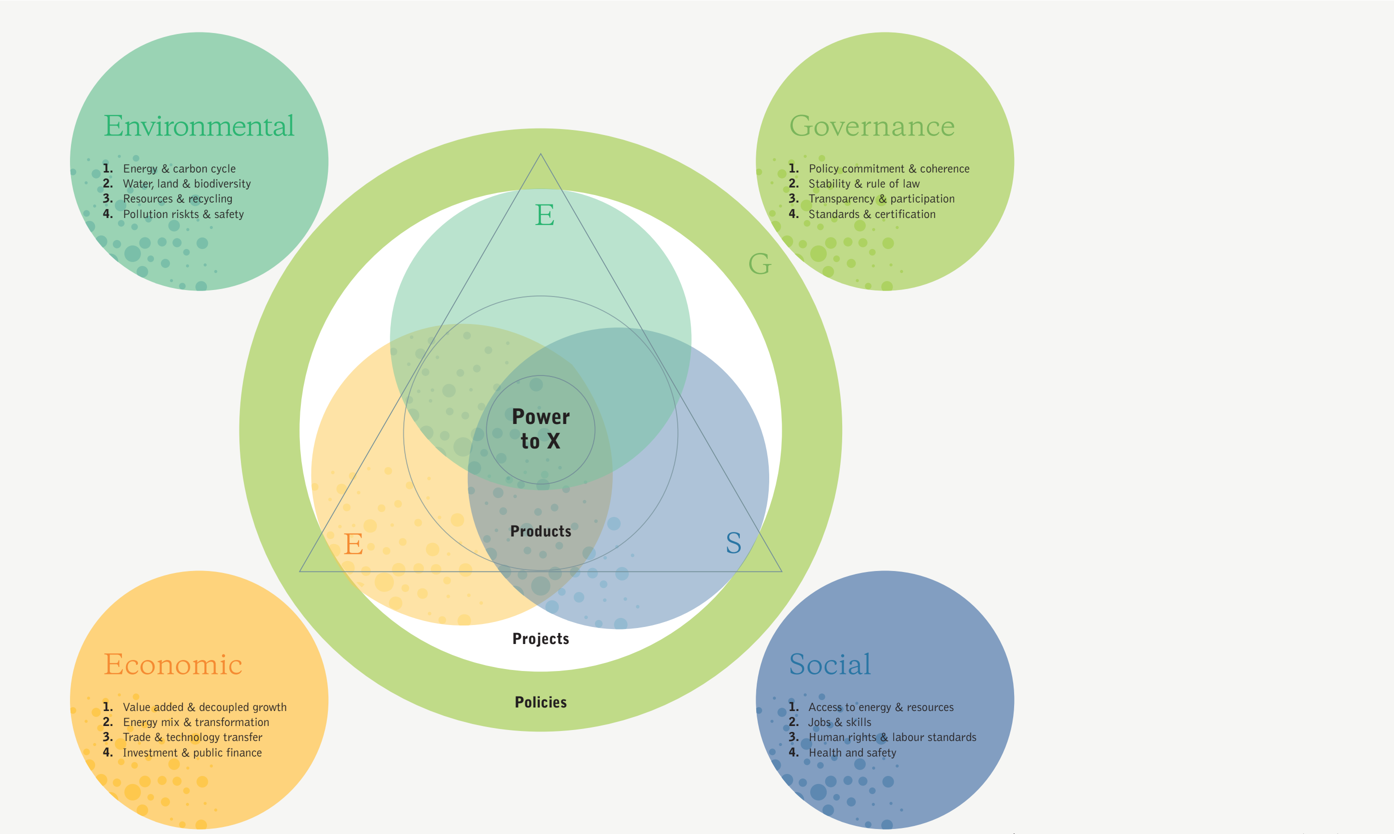
Source: IEA WEO; 2021.[40] **Notes:** Mt = million tonnes; ren. = renewables. Includes most of the minerals used in various clean energy technologies, but does not include steel and aluminium.

3.3 The need for socio-ecological policies & criteria

To mitigate these risks and ensure a positive approach for the emerging hydrogen production and trade, workshop participants have developed recommendations that broadly pertain to environmental and social aspects and incentivise "green" over "other colour" hydrogen. At the highest level, hydrogen produced for export needs to be embedded in a country's overall strategy, including respecting the goals of the Paris Agreement as well as recognising a country's development and energy goals, such as accelerating energy access for all, reducing energy poverty, and promoting the transition to a 100 per cent renewable energy-based economy. Such strategies need to include protecting ecosystems, generating economic prosperity, promoting social inclusion and cohesion, respecting human and social rights, ensuring public acceptance and multi-stakeholder participation, and promoting good governance and transparency. In summary, for hydrogen trade to be useful to all, it was concluded in stakeholder consultations that it needs to be embedded in the overall energy transition process.

The "sweet spot" for green hydrogen is thus when it encompasses all these factors, as illustrated in the following figure:

Figure 5: Projected trade map and volumes in green hydrogen in 2050



Source: International PtX Hub (n.d.).[41]

32. An additional opportunity is the production of fossil-free "green" fertilisers. However, this should only be to support the overall reduction in the use of such synthetic fertilisers in industrial agriculture and finding more environmentally friendly versions, see Facundo Calvo (2022), Why We Must Rethink the Use of Nitrogen Fertilizers, https://www.iisd.org/articles/analysis/tackling-hunger-nitrogen-fertilizers.

33. Power Shift Africa (2022), Civil Society Perspectives on Green Hydrogen Production and Power-to-X Products in Africa, https://www.powershiftafrica.org/publications/civil-society-perspectives-on-green-hydrogen-production-and-power-to-x-products-in-africa.

34. UK Department for Business, Energy & Industrial Strategy (2022), Atmospheric Implications of Increased Hydrogen Use, https://www.gov.uk/government/publications/atmospheric-implications-of-increased-hydrogen-use.

35. P. Wolfram, P. Kyle, X. Zhang et al. (2022), Using Ammonia As a Shipping Fuel Could Disturb the Nitrogen Cycle, Nat Energy, https://doi.org/10.1038/s41560-022-01124-4.

36. https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/mineral-requirements-for-clean-energy-transitions

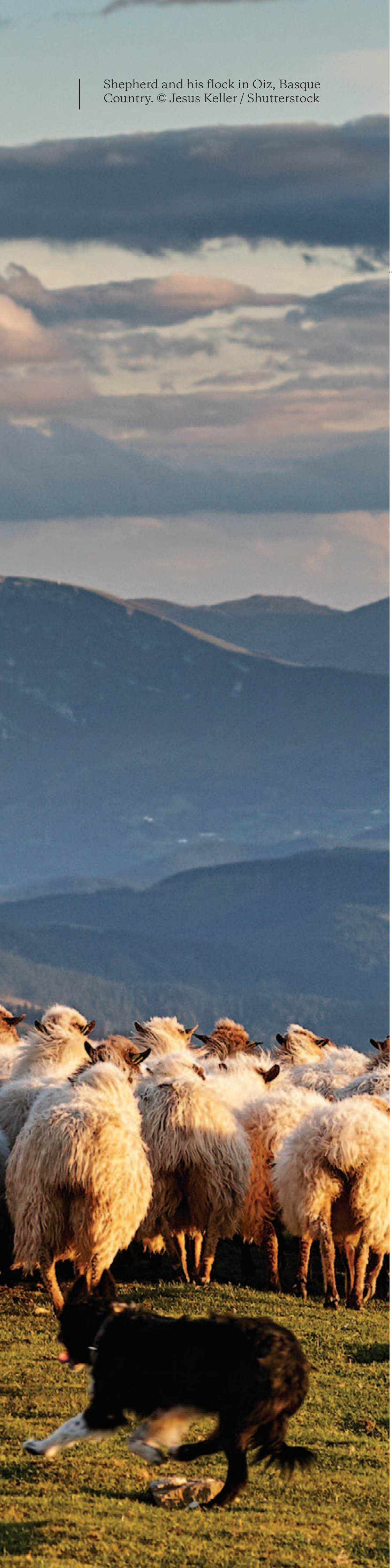
37. IEA (n.d.), The Role of Critical Minerals in Clean Energy Transitions, https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/executive-summary.

38. Initiative for Responsible Mining Assurance (n.d.), The Standard for Responsible Mining, https://responsiblemining.net/what-we-do/standard/.

39. Deutsche Rohstoffagentur (2022), Mineralische Rohstoffe für die Wasserelektrolyse, https://www.deutsche-rohstoffagentur.de/DERA/DE/Downloads/DERA%20Themenheft-01-22.pdf;jsessionid=CEF4AF826D5E40112BEA2B4A96D3ED40.1_cid331?__blob=publicationFile&v=2.

40. P. 272 https://iea.blob.core.windows.net/assets/4ed140c1-c3f3-4fd9-acae-789a4e14a23c/WorldEnergyOutlook2021.pdf

41. International PtX Hub (n.d.), PtX.Sustainability Dimensions and Concerns (Scoping Paper), https://ptx-hub.org/ptx-sustainability/.



Shepherd and his flock in Oiz, Basque Country. © Jesus Keller / Shutterstock

04

Key recommendations

This chapter summarises the recommendations from the policies paper "Pathways Towards a Global Market for Green and Sustainable Hydrogen",[42] developed on behalf of the Heinrich Böll Foundation and Brot für die Welt by the Ecologic Institute. It was discussed and commented upon in an international workshop attended by a group of experts and stakeholders. Also included are the policy proposals emerging from the in-country workshops carried out during this project. These policies, standards, and measures are recipes for the successful development of green and sustainable hydrogen production and trade.

While much of the emerging hydrogen trade is likely to be regional in the beginning due to transport costs – IRENA assumes that 75 per cent of hydrogen demand in 2050 will be produced and used locally/regionally – a transnational hydrogen market is also likely to emerge.[43]

To achieve cost degression and rapid scaling, the hydrogen market will ultimately need to be organised as a competitive market – with suppliers competing on a single, global market on the basis of their marginal production costs, favouring those suppliers that can produce at least cost – provided that environmental and sustainability criteria are fulfilled (and can be documented and traced). One of the pitfalls is therefore to ensure that producers do *not* compete on the rigidity of sustainability standards (or how strictly they are adhered to), which could lead into a "race to the bottom" whereby laxer / less well enforced standards have a competitive advantage – but instead *only* on the basis of their production costs after having complied with agreed minimum standards.[44]

The policies and standards needed to achieve a sustainable hydrogen trade must therefore be actively set, and countries can develop uni-, bi-, pluri-, or multilateral policies to ensure sustainability.

Key recommendations continued

As an overarching principle, policies need to be shaped in a way that producer countries benefit from the full value chain of green hydrogen production and trade. Hydrogen should only be used for sectors that cannot be electrified – there is in general greater efficiency, lower costs, and lower emissions for renewable energy-based electrification than for hydrogen. Export strategies therefore need to carefully consider the balance between hydrogen and renewable energy production for local use, and external revenue creation from exports. In parallel, what gives green and sustainable hydrogen its commercial value is its green property – the fact that it has been produced (near) carbon-free. This property needs to be monitored and verified in a transparent and reliable way, in accordance with established and internationally agreed criteria, which need regulation and oversight. As countries and their industries – including the sectors for which emission reductions are tougher to achieve – transition to using green hydrogen in order to reduce the carbon content of their products, this will also positively affect carbon-related taxation policies, thereby reducing potential import barriers, such as the European Union's (EU) planned Carbon Border Adjustment Mechanism.

The global market for green hydrogen and its derivatives is only starting to emerge. Consistent international cooperation and regulation is needed for the development of a sustainable international green hydrogen trade. To establish such a market, and to ensure its proper functioning, several elements must be in place:

- A **tracking and accounting system** for green hydrogen and its derivatives to document the green property of traded hydrogen. This could take the form of a hydrogen registry that documents the origin of the traded hydrogen (or derivatives) and its embedded emissions.[45]
- **Standards for green and sustainable hydrogen**, including **oversight and grievance mechanisms**, to ensure compliance with the standards and to specify remedies in case of non-compliance. Recommendations specifically targeting environmental and social concerns can be found in Sections 6.1 and 6.2).
- **Arrangements for the actual trading** (which commodity is being traded on which platform under which conditions; which financial products apply; how trades are cleared).
- **Assurances/guarantees to investors** regarding the conditions under which they can market the hydrogen produced in planned investment projects.

These elements can be arranged at different levels:

- Social and environmental criteria and standards can be ensured at the **national** (or regional/local) **level**,
- At the **bilateral level**, cooperation between two countries (typically one prospective supplier and one prospective importer),
- At the **plurilateral level**, agreed between a limited group of like-minded countries with shared interests, for example the EU (possibly with partners), or initiatives out of the G7/G20 orbit, such as the International Partnership for Hydrogen and Fuel Cells in the Economy,
- As a **multilateral** initiative that is, in principle, open to any country and applicable to any country that is a member of the initiative.

4.1 Specific Environmental recommendations

- Monitoring requirements and control mechanisms to prevent leakage from hydrogen pipelines and strict penalties, should these occur, to ensure a deterrent for lax oversight, as well as a clear commitment to exclude any hydrogen imports that involve major leaks. It may also be recommendable not to trade hydrogen in its gaseous form, but rather as a derivative.
- Water use and desalination: Minimise water use and make desalination safe and clean. Green hydrogen projects must not jeopardise local water supplies. If new water sources (e.g. desalination plants) are developed for hydrogen production or further processing, they should also contribute to reducing water stress and increasing water availability for the local population in the production region as a whole. In case of desalination plants, they must be accompanied by an impacts assessment and measures ensuring that no negative impacts occur – for example, the resulting brine must be minimised and adequately diluted and diffused. This requires tracking water use through the entire production chain of green hydrogen.

- Environmental licensing and impact studies: Licensing must be required for all projects, with the production of independent Strategic (which allow for proper planning and management of a large number of projects across the region or country) and Specific Environmental Impact Studies and reports. This includes assessing the potential impacts on biodiversity preservation and carbon sinks from projects and proof of optimal locations for installations. In the evolution of the licensing and impacts determination process, governmental actors and private companies must ensure the organisation and respect of public hearings.
- Spatial planning – ensure optimal locations for installations: Although green hydrogen has low GHG emissions, it can generate significant impacts on territories and communities. Many projects proposed are large-scale in order to generate electricity at low cost. Solar or wind power plants, water demand or desalination plants, transport, storage, and port infrastructure will generate different types of impacts and risks. Without proper land-use planning, projects could end up having negative effects on surrounding communities and ecosystems. Hydrogen production should be excluded in certain vulnerable areas, such as biodiversity hotspots or where no co-use can be achieved for arable land. Solar and wind atlases should be updated to ensure compliance with environmental policies and laws, and areas important for water source protection, biodiversity, agroecological production zones, and small farm areas should be take into account. As part of a national hydrogen strategy, a comprehensive zoning should be completed to define priority areas for large-scale renewables development for hydrogen production. Prior to this, there needs to be a mapping of traditional land use (including temporal grazing), indigenous cultural heritage, and high-value biodiversity ecosystems. In addition, the construction of the plants in areas already classified for industrial use should be prioritised in order to avoid conflicts with communities.
- Resource use: Solar panels, wind turbines, and electrolysers use materials, such as rare earths, that involve mining. Extractive industries have repeatedly been associated with environmental degradation and human rights violations. Hence, hydrogen production should demonstrate reliance on materials sourced under environmental and human rights standards for extractive activities. For instance, one requirement could be that renewable energy sources and hydrolysers include materials from countries that are signatories to the Extractive Industries Transparency Initiative.[46] Recycling of used materials needs to be increased in a circular economy approach.

Figure 6: Projection of solar installation in Namibia for a hydrogen project

Source: Hyphen Hydrogen Energy (n.d.).[47]

Key recommendations continued

4.2 Specific Social recommendations

- **For importing countries**, require their procurement and certification frameworks for green hydrogen and include international human rights as well as social and environmental standards.
- **Governance and citizen participation – democratising the energy debate:** Strengthen the dissemination of information about energy in simple and accessible language that enables communities, social movements, and civil society to follow and intervene on the issue, to understand the need for a fair and sustainable energy transition, and to engage in the political debate. In the case of planned projects, promote public consultations with local communities and civil society organisations. These must provide meaningful input into the decision-making process and not be mere "ticking the box" exercises, and they must occur regularly during the planning, implementation, and monitoring of projects. Effective participation requires investing in capacity-building for local stakeholders, establishing transparent grievance mechanisms, and creating formats in which citizens can actively participate in decision-making. Such multi-stakeholder engagement and civil society participation can potentially ensure buy-in and ownership and should therefore also be in the interest of project developers.
- **Promote local community involvement** from the very design of the project and generate incentives that promote local and distributed development, mainly through small enterprises. Consider land and water use as well as the ancestral property rights of indigenous communities in the design of the projects. Ensure that land-using communities have the legal support to negotiate with energy companies and access independent mediation in case of conflict. It should be also ensured that within local communities all have a say, for example that men do not decide for women (gender-related differences/discrimination).
- **FPIC and consultation protocols:** In the case of projects that take place in indigenous and traditional communities that are directly affected, prior consultation must be conducted, as provided for in ILO Convention 169. Local communities must be granted the right to refuse unfavourable energy projects on their land.
- Promote synergistic uses of land to avoid land use conflicts, for example combinations of solar and agricultural and rangeland uses of the same land (agro-photovoltaics).
- **Create job security and training** through inclusive planning for hydrogen infrastructure, thereby ensuring skills training for local communities so they are qualified to fill the jobs created by the hydrogen production in their region. Ensure fitting and stable working conditions.
- **Promote the best new technologies:** The wind and solar industry have seen great technological advances, including the increasing power of wind turbines and noise reduction. For solar, the agro-photovoltaic concept has advanced in several countries, allowing the joint production of energy and food. These advances need to be pushed further to make hydrogen production compatible for local populations. Research can also promote capacity-building and skills in the region (role of regional universities).

Box 4

Additionality

Ensure that hydrogen projects contribute to energy access and overcoming energy poverty by making parts of the additional renewable energy/ hydrogen generation available to the local population. Producing green hydrogen must focus on renewable energy deployment, production, and both the local and domestic uses of hydrogen, not just exports. This could be resolved if renewable energy for hydrogen production is unambiguously "additional", that is, that it would not have been installed in the absence of green hydrogen production. Additionality is necessary to ensure that the development of the sector is not detrimental to the energy transition as a whole. Additionality requirements should be mandatory to ensure that the growth of the green hydrogen market leads to the growth of the renewable energy sector and positively impacts the energy transition. Yet, there is no easy way to ensure additionality other than to monitor energy sources, energy distribution and access, and overall reductions in energy poverty in producer countries. In principle, additionality would be ensured if only hydrogen could be traded that has been produced from sources that are not connected to the nation's power grid. Yet, such island solutions would be economically costly and would run counter to the objective that hydrogen production ought to serve national energy system transformation. Another option could see grid connection if the carbon-intensity of electricity (i.e. emissions per kilowatt hour – kWh) is below a certain threshold. This could provide an incentive for countries to decarbonise to become eligible to export hydrogen. Furthermore, the required carbon-intensity could be adjusted dynamically over time to ensure that this incentive is maintained.[48]

4.3
National policies and Standards

Appropriate national policies operationalising the mentioned criteria and standards are a precondition for a successful and sustainable green hydrogen trade. Many policies relating to advantaging green over other colour hydrogen sources, as well as ensuring social and environmental criteria (see also above in Sections 4.1 and 4.2) can be created at the national level, though international agreement on what the criteria should be – and international adherence to such standards and policies – would obviously be helpful to avoid a complicated or fragmented market.

- Develop and orient **national and regional energy plans and strategies**, integrating the country's green hydrogen strategy into these, congruent with the country's climate and development goals. Make sure all relevant ministries (environment, development, etc.) are included in the planning, not just energy or economic ministries. The dissemination of roadmaps and national strategies is a necessary step to provide a long-term vision for hydrogen. This includes defining whether to install centralised green hydrogen production plants (easier for exports) with subsequent distribution, or whether to produce it in different places in order to decrease the distributed volume after production (better in case of mainly domestic use). This is relevant for the planning process, especially when it comes to infrastructure.
- Develop a **dedicated comprehensive hydrogen law** that incentivises the development of green hydrogen and ensures social participation mechanisms from the initial design of the project. Making the hydrogen strategy transparent and acceptable by involving different stakeholders (communities, independent researchers, civil society) in its elaboration will increase acceptance and buy-in. Also, even if the immediate objectives are export, social and economic benefits in the country where green hydrogen is produced must be ensured, including the development of technology for the production of green hydrogen, value chains for manufacturing, installation and maintenance of equipment and production systems, etc.
- **Generate and/or adapt legislative and regulatory frameworks** that create conditions for the market to develop and scale up and that are also clear, precise, and with a timeframe that provides predictability for investors and industry. Promote decentralised management that allows for transparency and efficiency through the use of blockchain networks.
- Until recently, green hydrogen was significantly more expensive than fossil fuel-based hydrogen. The high gas price resulting from the Russian invasion of Ukraine has significantly changed the relative attractiveness of green vs. fossil-based hydrogen. Experts believe that cost parity will be reached in some regions of the world by 2030 (presumably earlier if high fossil and nuclear prices persist), rendering green hydrogen increasingly attractive. To incentivise green hydrogen quickly, the most important factor is **closing the price gap** to non-green hydrogen:
  - Generate **financial instruments that encourage green hydrogen** incorporation into the energy systems and, in turn, discourage subsidies to fossil fuels, for instance, redirect subsidies currently received by fossil fuels to favour and boost the energy transition, including the development of green hydrogen.
  - **Create labels** for imported hydrogen and derivatives that comply with (higher) standards.
  - Indirectly, green hydrogen could also benefit from **support measures for renewable energy**. For instance, only hydrogen that meets the requirements stated in the EU's Renewable Energy Directive can be counted towards the achievement of the targets specified there. For this reason, financial support, that is, in the form of revenue from tradable quota schemes, is restricted to hydrogen that meets these criteria – regardless of whether it is imported or produced within the EU.
  - A **carbon price** to incentivise green hydrogen can also be aimed at the domestic level in order to make hydrogen competitive with conventional fuels where it is otherwise not an economic option.
  - Establish a **minimum price** for the producer to provide stability to the enterprises for a reasonable period.
  - Promote **loans and green bonds** to leverage investments in initial infrastructure.
  - **Encourage targeted payment** in the form of a contract-for-difference that covers the price gap between green and conventional hydrogen, matching sources of demand and of the supply of green hydrogen. This guarantees a price that allows investors to invest, while also remaining competitive with conventional hydrogen.

Key recommendations continued

- **Ban fossil alternatives:** This includes market-access restrictions for hydrogen and derivative products that fail to comply with standards, for example in the case of the EU, banning imports on the basis of EU supply chain legislation or guidelines. This could also take effect as the end state of dynamic standards with increasing ambition/ tightening standards. Concerns are commonly raised about lacking compatibility with World Trade Organization rules, which set demanding requirements to imposing barriers based on a product's production process. How well-founded these concerns are, however, remains to be investigated.[49] Alternatively, the import ban could also be implemented as a (domestic) phase-out obligation for non-green hydrogen and derivatives (be it imported or domestically produced), banning their sale and/or use after an announced phase-out date.
- **Create/guarantee demand:** Quotas and obligations or blending requirements for the use of green hydrogen guarantee a fixed demand, and thus greater certainty for suppliers. Public procurement (e.g. green steel in public construction projects) with the intention of creating a lead market for green hydrogen and derivatives could also be included in this category.
- Assess the need for **specific legislation to address hydrogen projects** (e.g. safety standards, environmental safeguards) to adopt sustainability and renewable certification schemes for green hydrogen production. Establish legal frameworks defining the parameters of local community participation and benefits (monetary or otherwise) from renewable energy installations.
- From the beginning of the planning project, **involve** the regional/local governments in places where green hydrogen plants are planned to be installed and promote public–private partnerships. Fiscal promotion and business incubators should be developed with the aim of promoting the involvement of actors at the local level in the energy transition. In parallel, also explore alternatives to the public–private partnership paradigm, encouraging and facilitating the financing of energy cooperative projects and avoiding unequal competition between large companies as well as small and medium-sized companies.
- Anticipate and prevent ecological risks by setting up **mandatory environmental impact studies** in parallel with the development of the hydrogen strategy.
- **Develop programmes for:**
    - Facilitating the transfer of knowledge and ensuring training and education for job seekers, both in small and medium-sized companies.
    - Ensuring access to information and education in general for the rapid adoption of new technologies and the incorporation of the subject in higher-education programmes.
    - Deepening R&D on green hydrogen in scientific organisations.
    - Adding the exporting country to global initiatives and international cooperation on green hydrogen.

4.4 Bilateral Policies

Alliances between supplier and buyer countries, plus the private sector and civil society, can play an important role to de-risk the transition to green hydrogen for both sides: They can pave the way for longer-term contracts, including price guarantees, investment support (and investment protection), technology transfer, or direct financial assistance. They can ensure that criteria for the traded hydrogen are formulated in ways that conform with development priorities and capacities in producing countries and align with their national strategies for energy transition, as well as encourage social and environmental standards.

Strengthening partnerships may also involve the combination of existing bilateral partnerships to form "minilateral" initiatives combining different partners, for example as a cooperation of Germany with its Benelux neighbours, who are already closely connected through their tightly connected gas infrastructure. Bringing in more partners allows for pooling resources, and by putting the cooperation on a broader footing, it can help to increase (transformative) ambition: The Just Energy Transition Partnership between several G20[50] countries and South Africa may serve as an example in this regard, which could be applied also to other countries. Likewise, existing support instruments such as the German H_2Global initiative could be extended to also include other (EU) countries – thereby coordinating and consolidating demand – and use the resulting economic leverage to promote green and sustainable trade.

There are also drawbacks to bilateral agreements. A proliferation of bilateral agreements could lead to a **proliferation of standards**, thereby reducing transparency and creating the risk of cherry-picking or a "race to the bottom" – if one country considers the standards proposed by its trading partner to be too strict, the hydrogen will be sold elsewhere. Besides, a proliferation of diverging standards would create problems in **internationally integrated value chains**, for example if green hydrogen sourced from different countries is used to

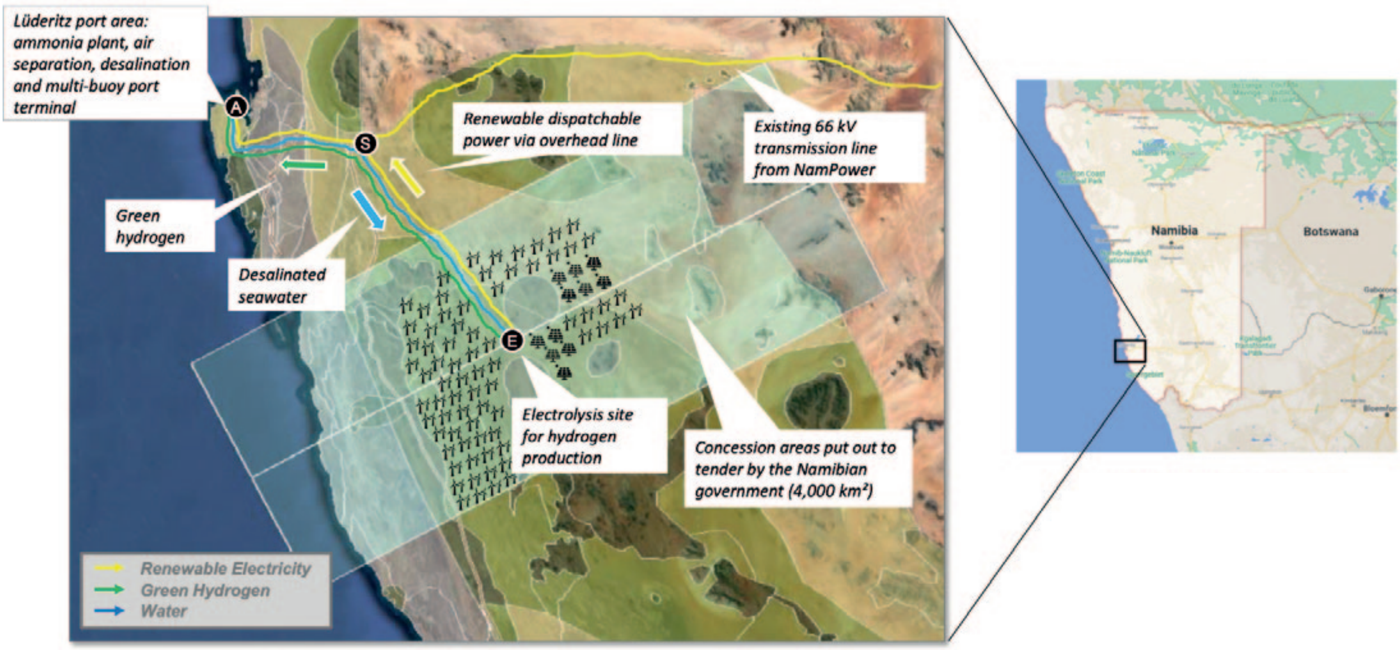
„Cooperation between countries is essential to ensure common standards and criteria gain wide acceptance - but these standards need to be set at a high level to ensure true sustainability."

produce low-carbon steel, which is then sold on (and marketed as low-carbon). If the hydrogen used in steelmaking comes in different "shades" of green, this would mean different batches of steel produced would have diverging carbon footprints, making it yet more difficult to track, label, and market them. Finally, bilateral agreements could lead to a **fragmentation of the market** – different standards would suggest diverging prices for green hydrogen and its derivatives. Smaller markets would incur a greater price volatility and prevent diversification, so that importers would remain dependent on producers that meet the agreed standards, and vice versa.

Bilateral policies can include:

- **Energy partnerships, including long-term contractual arrangements** between supplier and buyer countries, as a way to de-risk investments for both sides, possibly supported by public guarantees for investors, export credits, or similar instruments.
- **Investment subsidies/ public–private partnerships and strategic public enterprises:** This would include public support for investments in infrastructure and logistics, possibly in the form of public–private partnerships or joint-ventures, including funding agencies from the buyer and supplier countries as well as risk-sharing arrangements between public and private investors/funders. Public enterprises could play an important role in establishing a green hydrogen infrastructure and underpin bilateral agreements with concrete investments.

Figure 7: Exemplary illustration of a planned hydrogen project of HYPHEN in Namibia



Hyphen is a Namibian green hydrogen development company, specifically formed to develop green hydrogen projects in Namibia for international, regional and domestic supply. The total area foreseen for hydrogen production is 25,000km² of which 4,000km² were awarded already to Hyphen through a tender by the Namibian government.

Source: Hyphen Hydrogen Energy (2022).[51]

Key recommendations continued

4.5 Plurilateral: Could a plurilateral initiative help to advance green and sustainable hydrogen trade?

A plurilateral initiative on green hydrogen could, for instance, see the EU taking action together with other like-minded countries. Elements of this initiative could include a joint agreement on ambitious standards for green and sustainable hydrogen, and a joint tracking and reporting system for green and sustainable hydrogen. This could also include the option of forming a common market with shared access – where hydrogen (and derivatives) recognised as green in one market would also be regarded as such by the other "Club" members. That would mean that the Club would be constructed around a common good: access to the common market for green hydrogen, mutual recognition of standards and the procedures to ascertain them (certification of green hydrogen), as well as related protocols (e.g. grievance mechanism, review). In the future, the Club could also extend its activities to joint procurement or mechanisms to coordinate the procurement of green and sustainable hydrogen as a way of increasing security of supply.

4.6 Multilateral: New initiatives and institutions for global trade in green hydrogen

The "Club" option described above should be inclusive and aim for broad participation – it could thus pave the way for a multilateral agreement. At the same time, there are also other routes towards a multilateral agreement on core parameters, such as a tracking and accounting system for green and sustainable hydrogen and derived products, as well as an agreement on global standards for green and sustainable hydrogen. These include:

- Extending the mandate of an existing initiative and equipping it with the necessary resources, for example the International Partnership for Hydrogen and Fuel Cells in the Economy. Although this initiative stems from the G20 orbit, it achieves the relatively broad participation of 21 countries and the EU – but it lacks members from some important world regions, for example the Middle East and Africa (other than South Africa).
- Tasking an existing intergovernmental organisation to establish the standards and infrastructure for a future green hydrogen market such as IRENA or the IEA.
- The framework for a future global market for green hydrogen could be laid out in a dedicated international agreement, analogous to the resource treaties that exist for numerous agricultural products (cocoa, olive oil, sugar, tropical timber), or the study groups for natural resources (tin, copper), which are tasked with promoting markets' transparency and proposing standards and procedures.

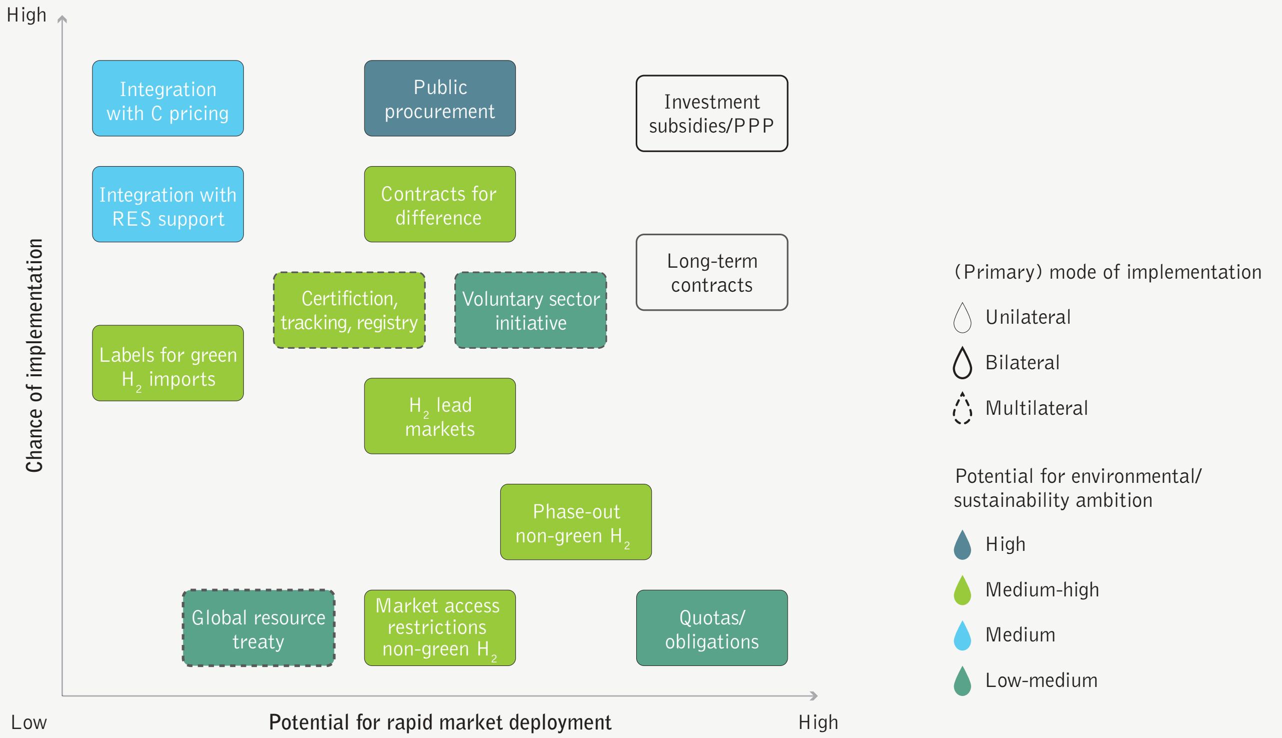
Specific measures could consist of:

- **Certification, tracking, registry:** Tracking and reporting systems for green and sustainable hydrogen and derivatives (documented along the value chain), for example in the form of an international registry to ascertain the origin of the hydrogen and its compliance with the applicable standards – including embedded emissions during the production process.
- **Global resource treaty:** Similar to existing resource agreements for many internationally traded commodities and resources (copper, tin, etc.), a global resource treaty on green and sustainable hydrogen could define properties and anchor standards of traded green hydrogen and establish procedural elements (such as certification and tracking, compliance and sanctions) and designate supporting institutions and their roles.
- **Voluntary sector initiative:** As a non-binding and narrower alternative to a global resource treaty, a voluntary initiative comprised of public regulators, private companies, and civil society could agree on standards for green and sustainable hydrogen. Similar to existing initiatives (Equator Principles, World Commission on Dams), such an initiative could establish a de facto standard.

What should be avoided is an international carbon-offset market for green hydrogen, as that would not contribute to reducing GHG emissions, but rather displace them from one place to another.

„A green hydrogen club of countries could be the avant-garde, setting best-practice criteria and standards, mutually profiting from environmental and socially sound green hydrogen trade."

Figure 8: Not all of these instruments have the same likelihood of passing:



Source: Pathways Towards a Global Market for Green and Sustainable Hydrogen.[52]

42. Benjamin Görlach, Michael Jakob, and Ramiro de la Vega (2022), Pathways Towards a Global Market for Green and Sustainable Hydrogen: Need for Action and Policy Options, https://www.boell.de/en/green-hydrogen and https://www.brot-fuer-die-welt.de/themen/gruener-wasserstoff/.

43. IRENA (2022), A Quarter of Global Hydrogen Set for Trading by 2050 Tweet, https://www.irena.org/newsroom/pressreleases/2022/Jul/A-Quarter-of-Global-Hydrogen-Set--for-Trading-by-2050.

44. Benjamin Görlach, Michael Jakob, and Ramiro de la Vega (2022), Pathways Towards a Global Market for Green and Sustainable Hydrogen: Need for Action and Policy Options, p. 14, https://www.boell.de/en/green-hydrogen and https://www.brot-fuer-die-welt.de/themen/gruener-wasserstoff/.

45. Once hydrogen is produced, it is not possible to say with which energy source it was made. Thus, hydrogen plants connected to the power grid could have their green hydrogen classification challenged. It is therefore necessary to establish a certification system designed not to make the production chain too expensive or unfeasible, while containing sufficient information for consumers and policy-makers. This should include a harmonised definition of green hydrogen so that "green" indeed means 100 per cent renewable.

46. Benjamin Görlach, Michael Jakob, and Ramiro de la Vega (2022), Pathways Towards a Global Market for Green and Sustainable Hydrogen: Need for Action and Policy Options, https://www.boell.de/en/green-hydrogen and https://www.brot-fuer-die-welt.de/themen/gruener-wasserstoff/.

47. Hyphen Hydrogen Energy (n.d.), https://hyphenafrica.com/wp-content/uploads/2022/05/ETAPA-4-ZONA-1-1_Moment-Medium.jpg.

48. Benjamin Görlach, Michael Jakob, and Ramiro de la Vega (2022), Pathways Towards a Global Market for Green and Sustainable Hydrogen: Need for Action and Policy Options, https://www.boell.de/en/green-hydrogen and https://www.brot-fuer-die-welt.de/themen/gruener-wasserstoff/.

49. A variation of this approach would be to include hydrogen imports in a border carbon adjustment measure, such as the Carbon Border Adjustment Mechanism proposed by the European Commission as part of its "Fit for 55" package. This would pose a penalty on carbon emissions generated in the production of hydrogen, could make grey hydrogen uncompetitive and be less problematic from the trade law perspective, as it ensures equal treatment of foreign and domestic producers and non-discrimination between different export countries. Yet, as this instrument only addresses carbon emissions, it would not be able to distinguish between renewable-based and other, less sustainable but low-carbon varieties of hydrogen (e.g. hydrogen using Carbon Capture, Utilisation, and Storage or hydrogen using nuclear power).

50. The members of the G20 are: Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Republic of Korea, Mexico, Russia, Saudi Arabia, South Africa, Turkey, the United Kingdom, the United States, and the European Union. Spain is also invited as a permanent guest.

51. Hyphen Hydrogen Energy (2022), First Gigawatt-scale Green Ammonia Project in Namibia, https://hyphenafrica.com/wp-content/uploads/2022/05/Hyphen-World-Economic-Forum-Presentation-24-May-2022.pdf.

52. Benjamin Görlach, Michael Jakob, and Ramiro de la Vega (2022), Pathways Towards a Global Market for Green and Sustainable Hydrogen: Need for Action and Policy Options, https://www.boell.de/en/green-hydrogen and https://www.brot-fuer-die-welt.de/themen/gruener-wasserstoff/.

A hydrogen pipeline illustrating the transformation of the energy sector away from fossil fuels. © petrmalinak

05

Annexes

Annexes continued

5.1
Country Summaries

5.1.1 Argentina

Argentinian participants in the consultation saw two major factors affecting the future of green hydrogen: 1) the Russian invasion of Ukraine shifting global energy demand and supply, 2) Argentina's external debt situation, currently being negotiated with the International Monetary Fund. These factors create doubts regarding the future of the Argentinian economy and how this situation could affect foreign investments. There is a growing interest in the development of green hydrogen in Argentina. It is seen as an opportunity to drive the energy transformation and to be beneficial for the economy as well as for new skilled jobs and retraining opportunities, as hydrogen exports would result in a greater flow of foreign exchange income.

Most of those consulted agree that green hydrogen production should, in a first stage, be for export – as long as there is a clear plan for economically profitable domestic use that also supports the development of regional economies and is environmentally sound. Participants also argue that green hydrogen promises storage alternatives that strengthen the development of intermittent renewable energies, while also allowing for the improvement of technologies for desalinisation and the purification of seawater. Social and environmental actors would have to be involved in the development of hydrogen projects from the start to avoid and minimise potential conflicts or negative effects in the future; this would also facilitate the investment and transfer of knowledge.

Unfortunately, no indigenous communities were included in this consultation. The most important green hydrogen project currently being carried out is in the province of Río Negro, where around 30 communities are settled that have not been part of any consultation or FPIC. However, the province has already approved the transfer of more than 600,000 hectares traditionally occupied by these communities.[53] According to one consultee who talked about this with indigenous communities, in contrast to other extraction projects, green hydrogen is being sold as a chance for socio-ecological transformation. Therefore, indigenous communities expect projects to be accompanied by strategies to profoundly transform the consumption and production of energy on a global scale, strategies that should include their involvement along the entire process.

The Argentinian government has no hydrogen strategy yet. However, there is a 2021 document, "Towards a national hydrogen strategy 2030",[54] with input from several ministries, private-sector representatives, universities, and others. The document reviews hydrogen potentials, the ability of national systems to contribute to their development, and other factors. To date, there is no information on aspects related to sustainability in the planned national hydrogen strategy, except for the legal requirements adopted by the provinces where each project will take place. In 2020, a group of companies formed a Hydrogen Economy Development Consortium (H_2ar). In 2006, the Congress adopted a Hydrogen Promotion Law; however, this law was never fully applied and will likely now be updated. Finally, there are three initiatives related to the production of green hydrogen:

- An Australian company is looking to invest $8.4 billion to produce green hydrogen in the province of Río Negro. The project is in the pre-feasibility study stage – it currently presents a conflict concerning the use of land with indigenous communities.
- The provincial government of Jujuy is promoting initiatives for the development of green hydrogen based on the Cauchari solar park. The investment for the first phase would be $150 million. The province is preparing a corresponding law.
- A US company announced in May 2022 an investment of $500 million to produce green hydrogen in the province of Tierra del Fuego with the objective of exporting mainly to the Asian and European markets.

Consultees see **opportunities** with green hydrogen: The country has the potential to compete in the international market, as it offers deep water ports, wind resources, and a medium-ready infrastructure. Argentina can use its gas infrastructure for the transport of green hydrogen, and it has trained experts and service companies associated with this industry. There is also an opportunity to develop more skilled labour for better jobs and salaries. There is a perception that the renewables industry is modern and inclusive and that there are opportunities to strengthen universities and technology centres for the development of the industry. Social acceptance of these projects is assumed because people associate hydrogen with a "green future".

Consultees were also asked about the main **threats and barriers** to the development of green hydrogen and identified the lack of a national energy policy and the difficulties in obtaining initial investments, which they felt are closely related. Both are based on a lack of confidence in the country to attract investment, a culture of non-compliance with regulations, and a lack of confidence in the direction of Argentina's energy policy. Changes in government and the consequently changing visions of energy matters make it very difficult

„Each participating country, depending on their geographical, developmental and political situation, had different priorities - yet, the preoccupations regarding environmental and social issues were remarkably similar."

to develop an industry in the long term that needs certainty and stability. Also difficult are the barriers concerning the lack of flexibility of the regulatory framework and national energy policy to adapt to a changing context, as well as a fossil fuel industry that will seek to promote legislation not just for green, but also gray and blue hydrogen.

Although green hydrogen is likely to find widespread social acceptance, there is also concern about the resistance to the transformation of the energy system in general, motivated by the fear of energy shortages that the transformation could trigger. While most of those consulted (94 per cent) consider green hydrogen to be a viable part of the energy transition in Argentina, they do not see its implementation as being feasible in the short or medium term.

The use of freshwater for the production of green hydrogen is the most relevant environmental concern, because it competes with other uses of freshwater. Therefore, consultees highlighted the importance of not using water for hydrogen in areas with water stress. Additional problems of further concern were, for example, the technology, such as its low efficiency; the high costs of producing it with desalinated water; and finally, the lack of knowledge about the possible impacts on the environment, depending on the volume of green hydrogen to be exported. Finally, it was mentioned that, at present, the economies of several Argentine provinces depend on continuing investments in the fossil fuel sector, which explains resistance, as they perceive green hydrogen to be competition.

5.1.2 Brazil

Green hydrogen may be the missing link for the decarbonisation of the economy, and its use could avoid the emission of 75 Mt of CO_2 by 2040 in Brazil.[55] Yet currently, hydrogen development seems to be aimed mainly at exports for Europe, and the country recently published in August Brazil's national programme on hydrogen (looking at all hydrogen sources).[56] In the state of Ceará, as of May 2022 only one of the memorandums of understanding presented the prospect of contributing to the domestic energy transition.[57] There are objectives in the national renewables and biofuels plan 2018–2022 aimed at hydrogen, mainly for vehicular and stationary use in power generation and fuel production, for example R&D networks in hydrogen energy; promoting studies on the potential of hydrogen; and the encouragement of demonstration projects. A government-linked research institute unfortunately recommended that all hydrogen sources be looked at, not just renewable hydrogen.

The transport of hydrogen faces a series of technical and economic challenges. Therefore, exporting hydrogen as gas or in liquid form is not a viable alternative for Brazil at present. To make it economically viable, the best alternative would be the conversion of hydrogen into products whose transport over long distances has commercial solutions, for example green steel, ammonia, methanol, naphtha, and electro-fuels. However, the country has several characteristics that give it an immense potential in the production of green hydrogen at low cost for own use as well as for export to foreign markets that can pay a green premium. This could create jobs in the regions of production and, in some areas, provide the possibility of water desalination for hydrogen plants installed in regions with a shortage of drinking water. The north-east, which sees the most poverty among Brazilian regions, stands out for its potential for wind and solar generation. These opportunities need to be carefully planned, foreseeing, for example, the necessary training to allow the local population to occupy new jobs generated by these ventures. In addition, there must be a process to discuss the social and environmental impacts of the implementation of these production chains, with the active involvement of local communities from the very design of the project, so that the investments do bring positive impacts to Brazilian society.

The energy transition process in Brazil must not only ensure climate protection, but also contribute towards transforming the way we produce and consume in order to combat energy poverty and environmental racism. In order to achieve this, the dialogue between government and civil society needs to be significantly improved. A positive example is a resolution of the State Council of Environment of Ceará that establishes the procedures, criteria, and parameters applicable to environmental licensing – including for green hydrogen production enterprises.[58] It was developed in consultation with civil society. Environmental licensing must not be weakened under the pretext that hydrogen is green – due process must be followed.

Three main potential hydrogen opportunities for Brazil were identified:[59]

1. Use in the direct reduction of iron ore to produce sponge iron in HBI (Hot Briquetted Iron) format for export or for domestic low-carbon steel production.
2. Use in combination with renewable CO_2 for the production of green naphtha as a synthetic substitute in the production of petrochemicals and fuels.
3. Use for the production of green ammonia as an input in the production of chemicals and fertilisers or as an energy carrier for export and use in shipping.

One of the threats identified for hydrogen development is the attempt of companies to produce a "greenwashing" of their brand, presenting "sustainable" advertisements without actually promoting a structural change in their activities, which in many cases still emit substantial amounts of GHGs and possible human rights violations.

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The cost of green hydrogen is a major barrier. To increase its competitiveness, advancing carbon pricing is a crucial tool. Additionally, decentralised production or onsite consumption allows for circumventing transport costs in the initial expansion of hydrogen.

Further risks exist if not managed properly: the issue of water demand; land use; additional unsustainable mining due to the demand for ore plates to capture hydrogen. Additional problems could emerge in large-scale renewables installations, as already happened for large wind energy installations for example real estate speculation; impacts on artisanal fishing and marine biota (in offshore farms; frequent privatisation of common use spaces – places that are forbidden to people because of the wind-turbine exclusion zone; limiting or preventing access to commerce, economy, and local livelihoods). To alleviate the issue of water use, large-scale desalination of seawater could be started, which has a relatively low potential cost (ca. $0.02/kg of green hydrogen).[60] Environmental impacts to marine biodiversity or to artisanal fishing need to be avoided as well as impacts on agriculture, handicrafts, and local-based tourism, for example thorough large-scale offshore wind installations. In Ceará, for the 17 new projects for concentrated photovoltaic solar energy in analysis on May 2022, the total vegetation suppression could be almost 11,000 hectares of unique native vegetation.[61] Onshore wind installations in the same state have led to denouncements concerning the violations of the rights of coastal populations and the degradation and suppression of dune and mangrove ecosystems. Socio-environmental conflicts came from a lack of compensation, mitigation, and dialogue as well as a lack of prior consultations with local communities. In parallel, already damaging agri-businesses might continue their unsustainable soybean exports by profiting from the ammonia produced with hydrogen. Last but not least, large renewable energy installations only need to submit a Simplified Environmental Report (RAS) – this "flexibility" of impact studies and environmental licensing procedures for hydrogen enterprises is a problem that appears often in an undemocratic manner while ignoring the perspectives of affected communities.

Specific recommendations:

- **Avoiding socio-environmental impacts is crucial:** Wind installations (more than 7,000 wind turbines, total power: 21.5 gigawatts, GW) since 2011 have caused socio-environmental damage, with large projects disrespecting rights such as the right to exist, to come and go, to health, to water, etc. Smaller facilities can decrease environmental impacts, stimulate decentralised generation, and avoid the suppression of vegetation. Also important are independent reviews of companies' practices to meet transparency requirements, and integrity in land cession agreements.
- **Strengthening of regulatory agencies:** In recent years, there has been a decrease in resources and in the capacity of the environmental agencies and boards at the federal level to promote inspections and controls. It is necessary to reinvest and adapt the human and financial resources necessary for the agencies to have autonomy and the ability to perform such inspections and controls.

5.1.3 Chile

For this national consultation, 62 people participated in total via 5 workshops held with civil society organisations and public and private institutions, and through 15 interviews at the national and sub-national levels.

Civil society participants reported little knowledge about the green hydrogen development in Chile. They had concerns about potential socio-environmental impacts and the lack of participation from civil society in the planning and implementation of green hydrogen projects so far. Transversally, participants highlighted the advantageous conditions and opportunities of Chile for the production of green hydrogen, the important role of green hydrogen in the process of decarbonisation of the country, and, being a new industry, the opportunity to "do things right", for example not replicating extractivist industries and creating new sacrifice zones.

Summary of the most relevant recommendations:

- **Spatial planning and environmental standards** (especially for water use, desalinisation, and biodiversity) must be an essential part of the design and assessments of this new industry. Using current national instruments such as Strategic Environmental Assessment and Regional Land Use Plans is recommended for these purposes.
- **Local civil society actors and residents must be involved** in project planning, implementation, and monitoring, including FPIC, according to international agreements, when indigenous lands are involved.

To address these challenges, a robust governance model is required to contribute to energy sovereignty that improves the quality of life of Chileans. Otherwise, green hydrogen could have similar characteristics as existing extractive activities (energy and mining), with negative social and environmental consequences and possible social resistance to future projects. The development of green hydrogen could be an opportunity to abandon the paradigms of the fossil-energy era and spearhead a process of just and democratic energy transition. However, for this to occur, the institutional framework and governance model must effectively involve the various stakeholders and contribute to an energy sovereignty that improves the quality of life of Chileans. Chile's current energy matrix is concentrated in its ownership, with 63.1 per cent in only four companies, which pollute and offer little citizen participation.

Chile published its National Green Hydrogen Strategy in 2020[62] with high targets. By 2025, Chile is to be the first country in Latin America to make investments in green hydrogen. By 2030 it will be producing the cheapest green hydrogen on the planet (<$1.50/kg), be a global leader in exports of green hydrogen and its derivatives ($2.5 billion per year), and in green hydrogen by electrolysis with 25 GW. The strategy is also relevant for Chile's national determined contribution: Green hydrogen will be used for cargo transport, power applications in the mining industry, and offer thermal uses via pipelines. However, the strategy is not satisfactory: There are no concrete proposals for the state's role, nor the change that green hydrogen could bring about domestically, nor any territorial planning. Instead, it focuses on satisfying the needs of the Global North. There was also no effective participation from civil society or local communities in the strategy's formulation. Furthermore, the strategy does not adequately address the standards of decent work and effective social dialogue formulated by ILO.[63] Finally, the proposed governance lacks balance between government and the private sector on one hand, and civil society, which plays a marginal role, on the other. The new government (of Gabriel Boric) has not stated whether the strategy would be modified. As of 31 May 2022, there is one pilot project under construction for the production of methanol and gasoline from CO_2 and hydrogen, with an investment of $38 million. One project has been approved, but it is not yet under construction ($30 million), and finally another project is in the environmental qualification process.

The National Green Hydrogen Strategy presents this technology as a modern and clean industry, incorporating best practices and dialogue, and it claims that the projects will generate local hubs for investment, innovation, and economic activity. For this, it proposes the definition of standards to ensure the safety of operators, users, the public, the environment, goods, and infrastructure, and the creation of transparent participatory mechanisms between communities and projects. However, there has been no advancement on this front, except for guidance documents for the presentation of green hydrogen projects to the Environmental Assessment Service[64] and the Superintendency of Electricity and Fuels,[65] which aim at facilitating bureaucratic procedures for the investments rather than ensuring environmental and social standards.

Green hydrogen has been positioned as a great opportunity to achieve energy security, accelerate the process of decarbonisation and energy transition, and comply with international climate commitments. It could generate an economic sector comparable in magnitude with mining, with the consequent generation of employment, new R&D opportunities, and foreign exchange. Civil society participants highlight that there is still time to take measures to prevent possible negative impacts of large-scale green hydrogen production by applying sustainability principles, or by implementing public-community commissions that can closely follow the installation of the industry and actively participate in the planning processes. A new, adequate governance framework and the creation of new research nodes at the local level were also mentioned as relevant.

Renewable hydrogen projects will require large renewable energy facilities that entail environmental impacts such as land use change, noise, potentially high water use, and resource utilisation. Chilean scientists have warned of the risk of potential impacts in the Magallanes Region, where 40 to 60 species of migratory birds would be affected, given the significant number of wind turbines that will be required for the development of green hydrogen projects.[66] Producing 13 per cent of the world's green hydrogen with 126 GW of wind energy would imply a territorial sacrifice (social and environmental) of an estimated area of 13,000 square kilometres. To put this number in perspective, in all of Chile there is a total installed wind energy capacity of ca. 4 GW.[67]

In addition, there could be socio-economic implications for the local population experiencing energy poverty, including lack of access and difficulty paying electricity bills. There are also fears of an increase in precarious labour and scepticism about the real benefits that the regions will receive from the development of this industry.

Given the natural characteristics of the hydrogen molecules, safety standards for the storage (pressure) and transport (piping) of hydrogen are much more demanding than those for other fuels. This makes the storage and transport of hydrogen quite expensive in relation to natural gas.

5.1.4 Colombia

Although Colombia has an energy matrix based mainly on hydroelectric power, the Colombian economy has been heavily dependent on the extraction of oil, gas, and coal for export – hydrocarbons contributed 3.3 per cent of gross domestic product (GDP) in 2021 and accounted for 40 per cent of total exports. Under the Paris Agreement, Colombia agreed to reduce 51 per cent of its emissions by 2030. One of its strategies is to become one of the world's leading producers and exporters of hydrogen, both green and blue. The Ministry of Mines and Energy is betting on the production of green hydrogen and to promote it as one of the main export products. The main uses of hydrogen foreseen are in transport, energy generation,

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and industry. In terms of the energy transition, Law 1665 of 2013[68] introduces elements on alternative sources (Art. 3): renewable energies considered clean due to their lower pollution levels compared to fossil fuels. In parallel, there are Law 1715 of 2014,[69] which promotes the development and use of "Non-Conventional Energy Sources", mainly renewables, and Law 2099 of 2021,[70] which dictates inter alia provisions related to the energy transition and the dynamisation of the energy market. The latter is the most relevant in terms of hydrogen, as it classifies activities related or complementary to this energy vector – such as its storage, management, operation, and maintenance – as being of public utility and social interest.

Two ministries are responsible for the governance of hydrogen: the Ministry of Environment and Sustainable Development, in charge of environmental administrative sanctions and of determining environmental standards; and the Ministry of Mines and Energy, in charge of policy and the implementation of Law 2099. However, the regulation weakens existing environmental standards and international commitments, as it excludes the Environmental Diagnosis of Alternatives for companies implementing hydrogen facilities.

The law contemplates different tax incentives for supply, such as the exclusion of value added tax, the elimination of tariffs for importing technology, a 50 per cent reduction in the income tax burden, and accelerated depreciation. A worrying element in this regulation is that it lets the state declare hydrogen production to be of public utility, which could mean the possibility of imposing projects without the robust participation of civil society organisations in environmental issues and decision-making processes that may impact their territory assessments, or allowing the administrative expropriation of natural assets, such as land, which would add to the factors that have triggered internal armed conflicts in Colombia in the past. One threat is to the Wayuú people in La Guajira in Colombia, which might see the development of hydrogen plants in their area without being able to contribute to the project development meaningfully or profit from the plants. The change in land use associated with hydrogen projects could affect the right to food, as it means the loss of livelihoods and subsistence for the Wayúu communities and would thus constitute a violation of human rights.

Consultations with civil society on the use of hydrogen reveal their broad interest in the energy transition, although knowledge about and the monitoring of current studies are limited to wind and solar energy, given the barriers and asymmetries of power with which civil society can access official information and the plans of companies in this sector. As a result, we still find a profound lack of knowledge but much concern on the part of human rights and environmental organisations, who demand measures to disseminate public information on hydrogen. Coupled with the fact that this energy source is relatively new, this makes it difficult to understand the dimensions of the challenges ahead in terms of control over the energy produced, its destination, and the benefits for the communities in whose territories the technologies required for the transformation of hydrogen based on fossil fuels, such as gas, will be used. There should obviously be no fossil hydrogen development, as that could prolong the harmful exploitation of fossil fuels. But caution in the context of potential land conflicts and ensuring benefits for local communities is also warranted where the Colombian authorities could develop green hydrogen pilot projects.

Currently, there is a contradiction between the discourse of decarbonisation of the national energy matrix with renewable energies, the reality of most projects and initiatives being aimed at the production of hydrogen with export potential, and positioning the country as the main hydrogen exporter in Latin America.[71] This raises questions about access to energy and impacts on human rights, especially when the regional trend seems to point to the high cost of using green hydrogen as a secondary energy source in the context of a just energy transition.

5.1.5 Morocco

Morocco adopted a green hydrogen roadmap in 2021 aimed at domestic use and exports. The work carried out by the national partner focused on water use – with a study estimating how much water would be necessary to achieve the government's green hydrogen targets – and consulting with interested stakeholders in 40 interviews and three workshops to validate the study's results. Water use for a variety of purposes is increasing yearly (almost 90 per cent is used for agriculture, unfortunately with water losses at about 40 per cent), while the availability of water per person has decreased by 75 per cent over the last 60 years, with Morocco's climate being overall very dry. There are already several desalination installations contributing 1 per cent of water supply, with further ones being planned to overcome water shortages as well as for energy production. There are also existing projects and plans to purify used water for additional use. The goal is for desalinated and purified water to contribute 15 per cent of overall water consumption by 2035. Morocco has a water strategy in place to protect its water resources and to aid in the energy transition. There is also an ambitious energy strategy (from 2009) prioritising renewable energy sources, in particular wind and solar. The goal is for 64 per cent of renewables-based installed power-mix by 2030 to be achieved mainly by public–private partnerships. In parallel, there is an ambitious climate target – unconditional GHG reductions of 18.3 per cent and conditional (depending on foreign aid) reductions of 45.5 per cent by 2030, compared to the baseline scenario.

Regarding hydrogen, so far there are few production facilities serving different industrial clients. Morocco had an installed capacity of 10,968 megawatts at the end of 2021 with a production of 40 terawatt-hours, of which 12.6 per cent is provided by wind farms and 4.5 per cent by solar production. Morocco is currently a large importer of ammoniac – 10 per cent of global trade ends up here, mainly for the fertiliser industry. Morocco also spends significant funds to import petroleum products from abroad. This pressure on foreign exchange reserves has been exacerbated this year due to international conditions.

Morocco launched a green hydrogen roadmap in 2021, aiming for production to start in 2028, counting on its vast renewable energy potential. The roadmap covers the following main pillars:

- Technology, R&D, and local industry integration to meet the needs of the entire green hydrogen value chain
- Green hydrogen production
- Investment needs and preparation of infrastructure for the green hydrogen industry
- Conditions for storage, export, and use of green hydrogen

A cooperation agreement was signed with Germany in 2020, and the ports of Hamburg and Tanger Med are cooperating to facilitate hydrogen transport.

Initially, Morocco will produce green ammonia for local industries, primarily to produce fertiliser, and for export. It is also expected that Morocco could begin exporting green hydrogen as a liquefied fuel or gas in 2030. The use of green hydrogen in the electricity sector is expected to begin in 2035 as a storage medium, in the transport sector from 2037, and in the residential sector from 2047. Morocco aims to capture up to 4 per cent of the international green hydrogen market. Achieving the objectives of the national green hydrogen strategy requires a cumulative investment of 90 billion dirhams by 2030 and 760 billion by 2050. The main goals are to: reduce energy-import dependence, which accounts for almost 10 per cent of Morocco's GDP; create local added value, with positive spin-offs for employment (creating 12,000 direct and 60,000 indirect jobs by 2040) and the entire national economy; decarbonise the national economy (reduction of 6 Mt CO_2 equivalent by 2040). The existing energy system infrastructures, such as gas pipelines, can also serve the hydrogen economy.

Table 1: Comparative analysis of water requirements for fuel production:

Fuel	Estimation	Minimum	Maximum
Conventional petroleum extraction	0.29 l/kWh	0.13 l/kWh	0.5 l/kWh
Petroleum refining	0.14 l/kWh	0.09 l/kWh	0.21 l/kWh
Conventional natural gas	0.014 l/kWh	0.004 l/kWh	0.097 l/kWh
Shale gas	0.06 l/kWh	0.01 l/kWh	0.79 l/kWh
Green Hydrogen	0.55 l/kWh	0.27 l/kWh	0.7 l/kWh

Annexes continued

To achieve the national green hydrogen strategy, 7.7 million cubic metres (m^3) of water would be necessary by 2030 (37.35 million m^3 by 2040 and 85.25 million m^3 by 2050), with a larger part of the hydrogen being foreseen for exports. The current demand for water in Morocco amounts to 16.28 billion m^3 per year. The demand for hydrogen to be added from 2030 represents only 0.44 per cent of the demand for drinking, industrial, and tourist water (3.27 per cent by 2050). Morocco's planned water storage capacity of 27.3 billion m^3 by 2027 would mean that the volume of water needed for the production of green hydrogen in 2050 would represent only 0.3 per cent of the storage capacity established in 2027. In addition, Morocco plans to develop new seawater desalination projects with an annual accumulated capacity of 510 million m^3 per year by 2027. Therefore, the volume of water needed for the production of green hydrogen in 2050 would represent only 16.7 per cent of the water desalination capacity as of 2027. However, sustainability criteria and the opinions of civil society organisations and all relevant stakeholders should be integrated into the decision-making related to the use of water resources for green hydrogen production. Green hydrogen is better than fossil fuel production, which is very water-intensive: For every barrel of oil produced, six to eight barrels of water are required, and up to twelve barrels for "enhanced oil and gas recovery methods" such as fracking.

Stakeholders consulted insisted on the need to carefully evaluate implantations of green hydrogen project vis-à-vis their water use and to rely mainly on desalination for water use (with environmental safeguards regarding brine) as well as modern technologies to reduce water use significantly; to ensure that hydrogen production creates local jobs; and to promote sustainable and efficient social services and infrastructure. Green hydrogen production should help decarbonise the national economy, ensure the country's energy security, contribute to the country's territorial inclusion, and strengthen the social, economic, and environmental resilience of Moroccan regions. The reduction in fossil fuel production could free up considerable water resources for green hydrogen alternatives.

Morocco needs to establish a regulatory framework for the green hydrogen sector, ensuring a guarantee-of-origin system and covering the water supply for electrolysis plants. The supply of water for electrolysis must be clearly regulated, organised, controlled, and certified so as not to create negative impacts on the environmental or socio-economic environments in the country's very arid regions. Morocco should also impose a rigorous management of water resources that is based on local realities and invest in improving the local water infrastructure to reduce losses and evaporation. The involvement of all relevant stakeholders in green hydrogen projects from the start was mentioned as a key factor, not only in relation to water management, but also relating to land demand for renewable energy projects, related infrastructure (roads, power grids), financing, technology procurement, and opportunity creation.

5.1.6 South Africa

South Africa already has a (grey) hydrogen economy, which is small and tied to fossil fuels value chains. Sasol produces between 2 and 3 per cent of global hydrogen supply using coal gasification facilities. Combined with carbon, this hydrogen is used to produce synthetic liquid fuels using the Fischer-Tropsch process. Hydrogen is also used by PetroSA in its GTL refinery.

Expanding this sector has been of interest to the South African government since at least 2007, when the government launched Hydrogen South Africa – the 15-year R&D programme of hydrogen applications. At the time, the overriding interest was not in decarbonisation or green hydrogen specifically, but rather identifying and exploiting beneficiation opportunities related to platinum group metals (PGMs).

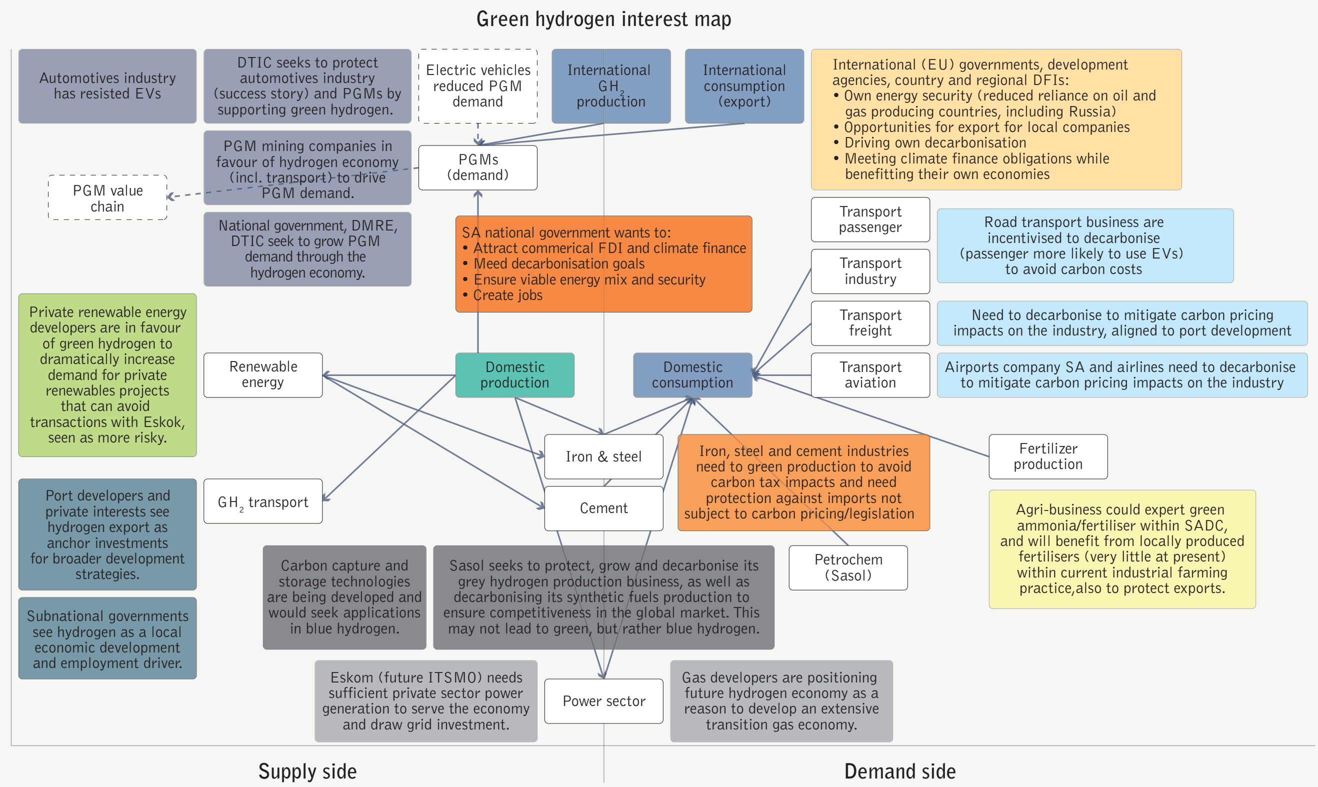
Responding to the growing international interest in green hydrogen, in 2021 the Department of Science and Innovation led a multi-stakeholder consultative process that resulted in the Hydrogen Society Roadmap for South Africa.

This high-level framework document identifies the expansion of the local hydrogen economy as being critical to achieving the national goal of "a just and inclusive net-zero carbon economic growth for societal well-being by 2050" through outcomes including:

- Decarbonisation of heavy-duty transport
- Decarbonisation of energy-intensive industries (cement, steel, mining, refineries)
- Enhanced and green power (electricity) sector (main and micro-grids)
- Centre of Excellence in Manufacturing for hydrogen products and fuel cell components (local production of hydrogen value chain components)
- Creating an export market for South African green hydrogen
- Increase the role of hydrogen (grey, blue, turquoise, and green) in the South African energy system in line with the move towards a net-zero economy

While South Africa has recently adopted a comprehensive "Just Transition Framework", existing hydrogen plans are high-level and aspirational rather than practical.

Figure 9: Interest map of influential actors in the emerging South African hydrogen economy



Source: Heinrich Böll Foundation South Africa.

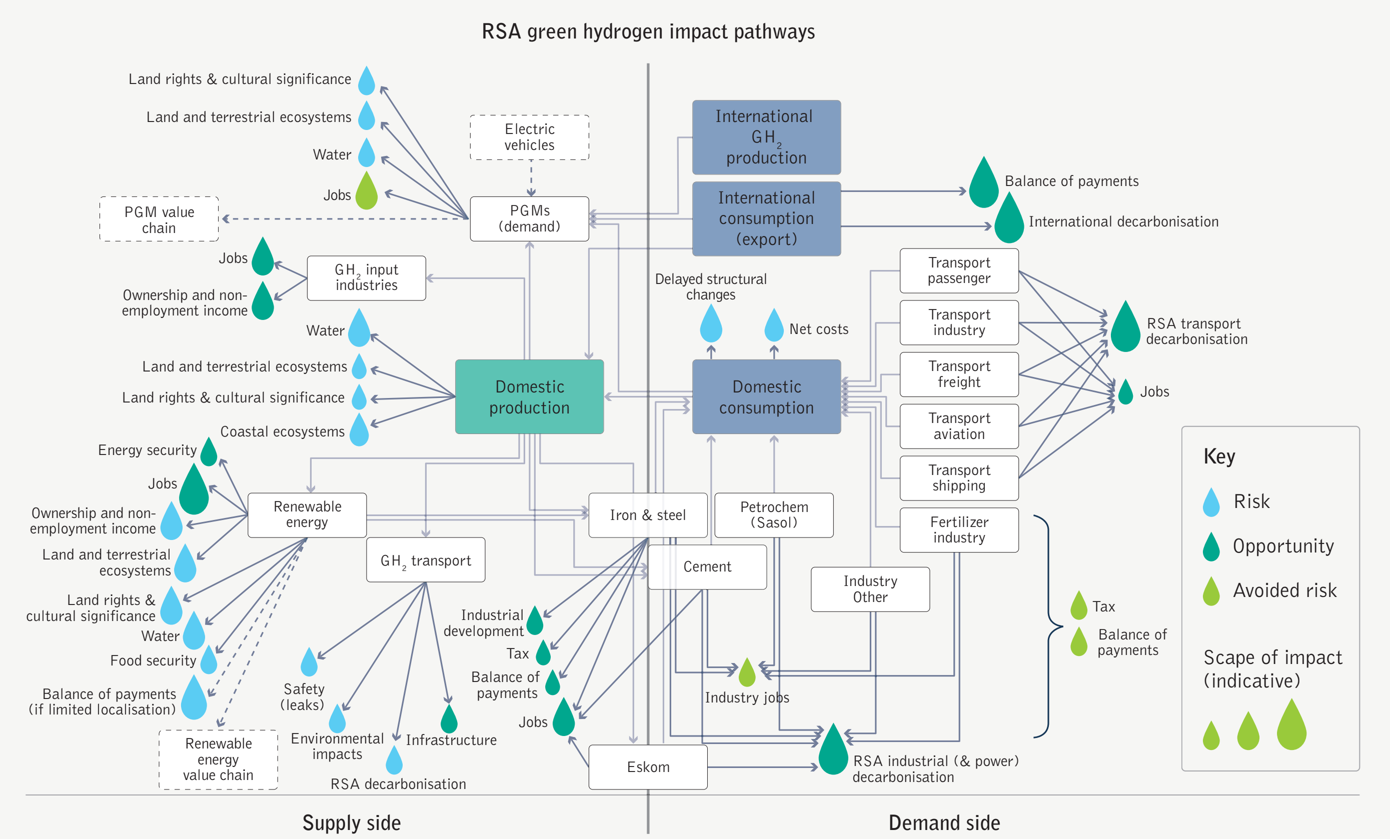
Annexes continued

While the Department of Science and Innovation process was a multi-stakeholder one, civil society in general, and community-based organisations in particular, were excluded. This can at least partially be attributed to the technical and economic complexities of the topic. The Heinrich Böll Foundation and Brot für die Welt project in South Africa has thus significantly invested in preparing the ground for informed consultations, which are ongoing.

Measures include:

- Development of a "State of Play" document on green hydrogen in South Africa, including analysis of actors and impacts across value chains
- Development of popular education material on green hydrogen that could be used in frontline communities
- Hosting workshops with affected groups – frontline communities and union members – to share information on green hydrogen and specific plans for various sectors/ geographical locations.

Figure 10: South Africa's Green Hydrogen Impact Pathways (Draft)



Source: Heinrich Böll Foundation South Africa.

The table below outlines risks that were identified through commissioned analysis and the concerns that emerged in frontline community or civil society discussions. Please note that as engagement is still unfolding, the material below is neither exhaustive nor representative.

Table 2: Identified risks and concerns

Impact	Description
Delayed decarbonisation	If South Africa's hydrogen decarbonisation pathway is posited on an initial increase in (grey or blue) hydrogen production, and greening at a later point, decarbonisation could in fact be delayed. This is not necessarily the case and depends on how policy, regulations, and incentives are deployed. However, this is a major concern for environmental groups, who see major polluters such as Sasol use this as a back door to continue and expand grey hydrogen production. Moreover, there are major concerns regarding the impacts of hydrogen leaks on GHGs, such as the consequence of extending the life of methane gases.
Climate finance	South Africa will be allocated finite climate finance at concessional rates. Directing these funds to support the feasibility of green hydrogen projects would mean that they would not be used in other urgent just transition priorities.
Water	South Africa is a water-scarce country with significant water governance challenges. Water needs to be allocated equitably for residential use as well as supporting economic activities in line with national and local sustainable priorities. In many communities that would host green hydrogen projects, water access is already severely curtailed.
Coastal ecosystems	Major concerns were raised regarding the disposal of brine discharge from desalination plants. Brine dumping could significantly damage ocean ecosystems, with devastating impacts on ocean-based livelihoods. Where green hydrogen projects are also envisaged as unlocking investments in port infrastructure, there are concerns regarding the impact of these major developments.
Land	Impoverished communities tend to be highly land insecure due to the legacies of apartheid, the slow pace of land reform programmes, as well as traditional governance structures. The significant land mass required for green hydrogen production could exacerbate such insecurities. As with coastal ecosystems, this could negatively impact food security.
Strain on available infrastructure	Where existing infrastructure is required to support hydrogen development (e.g. if the electricity transmission grid is utilised or roads are used for hydrogen transport), this may place further strain on South Africa's already aging and ailing network infrastructure, unless adequate maintenance is fast-tracked.
Governance and regulation	Even where adequate regulation is in place, government institutions, particularly at the local levels, lack the capacity to monitor and enforce regulations. It is further unclear whether or how trade-offs between local priorities such as food security or energy poverty and revenue creation will be made, given governance, transparency, and accountability failures. Competition between different municipalities or provinces to attract investment in green hydrogen could result in perverse impacts on environmental and social controls.
Conservation and safeguarding biodiversity	International developments suggest that the international demand for green hydrogen in the Global North can result in developing-country investments that undermine local environmental protections (such as investments in protected areas).
Safety	Workers have expressed concerns regarding the safety of hydrogen.
Jobs	The experience of mine- or renewable energy-hosting communities is that local residents often do not significantly benefit from jobs, which are either precarious or require specialised skills.
Social impacts	In-migration of job seekers, as well as intra-community conflicts related to land use permissions could destabilise communities.
Delayed systems change	The use of green hydrogen could enable societies to delay more difficult systemic changes. For example, greening the production of synthetic fertilisers could delay the transition to agro-ecological farming. Exporting green hydrogen to the Global North could enable the continuation of unsustainable lifestyles instead of measures to reduce consumption and increase efficiency.

Annexes continued

Table 3: The potential benefits for South Africa as a country

Impact	Description
Decarbonisation of "hard-to-abate" sectors	Green hydrogen can fully decarbonise the petrochemicals and chemicals sector, which today drives 13 per cent of the country's emissions. Specifically, it is key to decarbonising the coal-based synfuels sector, which represents 90 per cent of the petrochemicals and chemicals sector's emissions.
Green power generation	Green hydrogen production could be part of a holistic set of technologies to allow for a renewable energy-based power system to be adequately balanced (using hydrogen as an energy carrier and for energy storage).
Industrialisation	South Africa may have a significant competitive advantage in the development of a green hydrogen economy because of its renewable energy generation potential and theoretically available resources (such as land) to build this infrastructure.
Benefits for related sectors	The realisation of the hydrogen economy can support and augment other industries, as shown in the impact pathways above (renewable energy as well as hard-to-abate industries).
Investment in maintenance and new infrastructure	Green hydrogen investment can incentivise and enable investment in local infrastructure – both where existing networks will need to be augmented, and where new infrastructure projects require local anchor investments to make them financially viable. This would apply in the case of new port development in the Northern Cape, noting complexities and potential negative impacts of this development with caution.
Tax revenue	Increased industrial output would increase tax revenue generation. The Hydrogen Society Roadmap suggests the Platinum Valley Initiative could potentially add $3.9–8.8 billion to South Africa's GDP (including indirect contributions) by 2050.
Trade balance	Increased exports would positively impact South Africa's trade balance. For example, 1 Mt of green primary steel could yield similar export earnings to 5 Mt of iron ore or 7 Mt of coal.
Job creation	According to IRENA, "Identifying economic growth and job creation opportunities. As part of a strategy, policy makers should assess the value that the hydrogen sector would add to the economy and its effect on associated industries, quantifying the number of jobs generated in equipment manufacturing, construction and operation, and indirectly in the supply chain and supporting industries. [...] In addition, the local workforce needs to be able to perform the new jobs that will be created in these activities, and even in regulating the industry. Countries will therefore need education and training programmes to ensure a match between the skills needed and those currently available."
Collaboration	Collaboration on the deployment of hydrogen-related solutions (e.g. upgrade of the gas grid in a cluster of countries) allows the sharing of risks, lessons learnt, and best practices, which translates into lower costs.

5.1.7 Tunisia

In Tunisia, a strategy for the development of green hydrogen is being developed and is planned to be finalised in 2023. The strategy seems to aim at exports towards Europe as a main priority rather than domestic production, despite Tunisia's 97 per cent dependency on Algerian gas for its electricity production[72] and a stagnating energy transition. Currently, only 3 per cent of electricity is produced using renewables, 95% is produced from natural gas. The new strategy is being developed without any involvement of civil society, independent scientists, or mechanisms to guarantee benefits and safeguards for local communities.

With its abundant solar and wind resources and ambitious climate targets – 35 per cent[73] of its energy mix from renewable energy by 2030 and carbon neutrality by 2050 – the country wants to accelerate the implementation of renewable energy on its territory and intends to position itself on the green hydrogen market. The renewable energy targets also aim at reducing dependence on fossil fuels and increasing energy security. Yet, the hydrogen strategy so far does not seem to take the climate imperative or domestic renewable energy goals into account.

In December 2020, Tunisia signed a cooperation agreement with Germany to develop green hydrogen. Germany provides €31 million[74] – €6 million to develop a green hydrogen strategy and €25 million for the creation of a pilot project. Tunisia's existing laws on renewable energy will be added to with elements on green hydrogen to make Tunisia attractive to investors. The government sees this market as an important element of foreign currency gains, but it does not take into account potential social or environmental aspects, perpetuating the existing extractive raw-materials model and ignoring the domestic energy transition needs.

Furthermore, the strategies of the Ministries of Energy and Environment do not seem to complement each other. The Ministry of Environment's 2050 Carbon Neutrality[75] and Climate Resilience Strategy mentions green hydrogen as a low-carbon resource in a few instances. However, the energy sector reform plan as well as the Tunisian solar plan (2018), make no mention of green hydrogen, only the establishment of a grey hydrogen production unit.[76] The Ministry of Environment is so far not involved in the discussions on the national green hydrogen strategy.

As industry is the second-largest consumer of final energy in Tunisia – one-third of total consumption, most of it imported – it would be a good idea to provide them with green hydrogen. Yet, only the Groupe Chimique Tunisien is involved in discussions about green hydrogen for ammonia. The remaining industrial sectors – such as construction, the largest energy consumer in Tunisia, or the cement sector, generating the most CO_2 emissions in the country – do not seem to be among the beneficiaries of the project. Neither is the energy-intensive transport sector, which the Ministry of Environment is seeking to decarbonise by 2030 (Carbon neutrality and climate change resilience strategy for 2050).

Additional challenges could emerge from the transport of hydrogen. Storing and transporting hydrogen, a particularly volatile gas, is a challenge. Two options are envisaged: via pipeline or maritime transport. Tunisia has a large gas network used to supply itself and Europe – via Italy – with Algerian natural gas. Comprising part of the gas network is a submarine pipeline to reach the Italian coast. For hydrogen, the idea is to reinforce the existing network to inject a certain percentage of green hydrogen in gaseous form. Eventually, dedicated hydrogen pipelines could be installed. According to some observers, gas transport companies have pushed the hydrogen agenda to demand more gas infrastructure for when there is evidence that the current networks are sufficient and further expansion is more likely to serve a continued fossil fuel infrastructure. Another option is transport via gas tankers dedicated to transporting gas in liquid form. In order to be transported in liquid form, hydrogen requires cryogenic tanks that keep it at -253°C, requiring a considerable amount of very expensive energy and heavy infrastructure. If green hydrogen is to be transported by ship, it will surely be in the form of ammonia.

The social and ecological risks of a significant hydrogen infrastructure have only been briefly looked at in a preliminary study carried out by the German Agency for International Cooperation (GIZ). No impact studies are currently planned to accompany the national hydrogen strategy but only foreseen once projects are being implemented, under the assumption that green hydrogen is inherently positive for the environment. There are risks of land use conflicts in view of the large surface areas that will be needed to produce green hydrogen. The current framework tends to favour foreign investments in marginalised areas, exploiting land resources without appropriate compensation for local communities.[77]

An additional problem stems from the significant water use needed for hydrogen production. Tunisia is among the driest countries in the Mediterranean basin. Desalination is thus envisaged as the solution for the large-scale production of green hydrogen. Desalination can be a polluting, energy-consuming, and expensive technique. One litre of desalinated water requires two litres of sea water.[78] The liquid reject of this process, brine, contains a very high concentration of salt and is discharged into seas and oceans every day. When mixed with chemicals designed to prevent the fouling of systems, brine is toxic and causes severe pollution of marine ecosystems and a rise in water temperature.

Annexes continued

Marine ecosystems are accustomed to a concentration of about 30 grams of salt per litre, while the concentration of brine can rise to more than 100 grams of salt per litre. If these discharges continue over decades, the effects are dire and the biodiversity damage could be irreversible. The dilution and brine diffusion techniques can reduce this risk, but there is no guarantee that they will be respected. It would be extremely important to study in detail the quantity of water needed to be desalinated and the amount of brine being produced – and consequently exposed – along with the anti-clocking chemical residues per coastal area to assess the feasibility and economic viability of larger investments into the production of green hydrogen in Tunisia.

A further danger could be the continuation of an extractive economic model based on the overexploitation of natural resources destined for export to world markets. With hydrogen exports as the priority for the government, this ignores the energy needs of the country, the social and environmental costs, and the financial debt that the implementation of these projects could represent. Thus, because of the perpetuation of the undemocratic exploitation of resources that it implies, privatisation should be avoided, contrary to the path currently taken by Tunisia. Basing its selection criteria on experience and the available financial resources, the Tunisian government mostly calls on foreign companies that have already developed large-scale projects elsewhere.[79] In addition, the liberalisation of the renewable energy sector will accentuate the withdrawal of the Tunisian state, to the benefit of foreign investors instead of local communities and domestic energy security.[80] As a better model, energy cooperatives could construct local renewable capacity that serves local communities and sells the surplus to the national grid. An equitable production of green hydrogen would therefore require that the decarbonisation objectives of the exporting countries, in parallel with the needs of their populations, be the starting point of a sustainable strategy.[81] It is fundamental that mechanisms of transparency and guarantees for the populations concerned, in the long term, be put in place.

5.2 Further Reading

1. Heinrich Böll Foundation Hydrogen Site: https://www.boell.de/en/green-hydrogen
2. Bread for the World Hydrogen Site: https://www.brot-fuer-die-welt.de/themen/gruener-wasserstoff/
3. Pathways Towards a Global Market for Green and Sustainable Hydrogen: https://www.boell.de/en/green-hydrogen
4. Technical potential and challenges of renewable Hydrogen: Issues in the global south: https://www.boell.de/en/green-hydrogen
5. Joint NGO Declaration to the G7 on hydrogen: https://www.bund.net/fileadmin/user_upload_bund/publikationen/energiewende/energiewende_g7_wasserstoff_forderungen.pdf
6. G7 hydrogen pact: https://www.rechargenews.com/energy-transition/g7-unveils-controversial-hydrogen-action-pact-to-tackle-climate-crisis-and-russian-gas-reliance/2-1-1228275
7 Civil society perspectives on Green Hydrogen production and Power-to-X products in Africa: https://www.powershiftafrica.org/storage/publications/Green%20Hydrogen%20Position%20Paper.pdf
8. GH_2 - Industry led hydrogen Standards Initiative: https://gh2.org/article/industry-leaders-welcome-launch-global-green-hydrogen-standard
9. IRENA coalition for Action certification recommendations: https://coalition.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Mar/IRENA_Green_Hydrogen_Certification_Brief_2022.pdf
10. Hydrogen potentials and perspectives: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Sep/IRENA_Hydrogen_2019.pdf
11. Risks of hydrogen leakage for the climate: Global warming consequences of replacing natural gas with hydrogen in the domestic energy sectors of future low-carbon economies in the United Kingdom and the USA https://www.sciencedirect.com/science/article/pii/S0360319921023247
12. Paper on large renewable energy installations and pastoralism: https://www.boell.de/en/2022/05/18/pastoralism-and-large-scale-renewable-energy-and-green-hydrogen-projects
14. Popular education materials on green hydrogen: https://www.boell.de/en/2022/08/15/green-hydrogen-hype-or-beacon-hope
15. Hydrogen and biomass – why biomass is a counterproductive feedstock for hydrogen: https://www.biofuelwatch.org.uk/2022/hydrogen-biomass-briefing/
16. Explanation - what is hydrogen – German Blog https://www.brot-fuer-die-welt.de/blog/2022-was-ist-eigentlich-wasserstoff/

Box 5

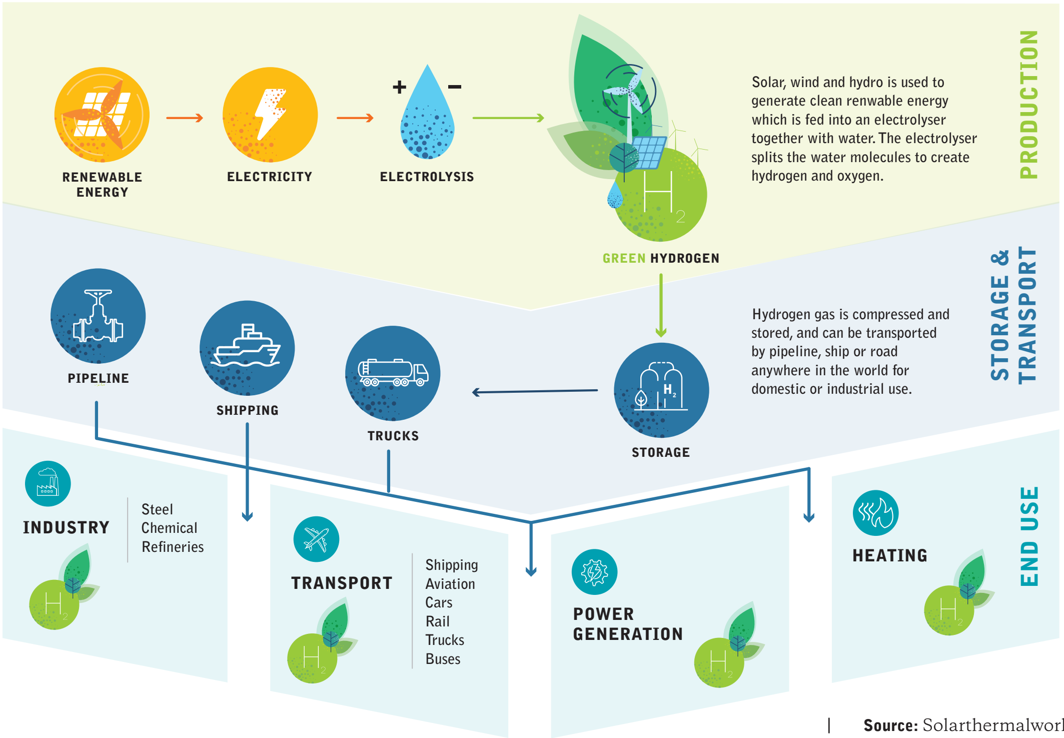
How is Green Hydrogen produced and what are the "colours" of hydrogen

Colloquially, we are speaking of hydrogen but are referring to the hydrogen molecule, which consists of two hydrogen atoms, that is, molecular hydrogen. This gas does not occur naturally but can be synthesised using several starting materials. It is important to understand that hydrogen is not an energy source in itself like the sun and wind, but an energy carrier, a storage medium, and a feedstock.

The production of green hydrogen is facilitated by electrolysis. Electrolysers separate water into hydrogen (H_2) and oxygen (O_2). The hydrogen produced can be stored in either a gaseous or a liquid state. To produce emissions-free "green" hydrogen, it is vital that the energy used stems from renewable energy sources.

Apart from specific industrial applications, green hydrogen can potentially play a significant role in reaching the Paris climate goal. To this end, it is crucial to realise the difference between green and fossil-based hydrogen. At the end of the production process, the hydrogen molecule is always the same, but the decisive factor is the method of production.

Figure 11: How is green hydrogen produced?



Source: Solarthermalworld (2020).[82]

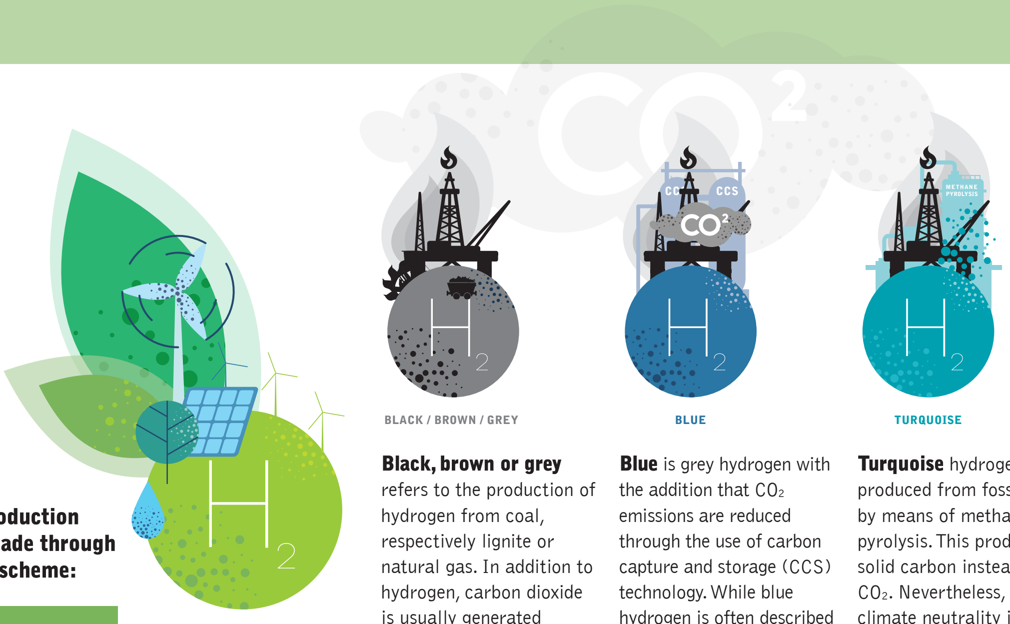
Annexes continued

Box 5 - continued

How is Green Hydrogen produced and what are the "colours" of hydrogen

It is helpful to bear in mind this colour spectrum differentiating between green and non-green. Since all other coloured hydrogens rely on the use of fossil raw materials, only green hydrogen can be considered as one of the available options on the path to a just transition and a fossil-free future. Even with relatively emissions-free production, non-green hydrogens perpetuate the demand for fossil raw materials. They thus prop up industry with high CO_2 emissions, which is the largest contributor to climate change. Therefore, this paper exclusively focuses on renewable hydrogen as the only climate-friendly technology, excluding biomass as mentioned previously.

Figure 12: The big difference between green and other hydrogen



The distinction in production methods is usually made through the following colour scheme:

The big difference between green and other hydrogen.

GREEN

Green denotes production with water as the feedstock and electrical energy from renewable sources.

BLACK / BROWN / GREY

Black, brown or grey refers to the production of hydrogen from coal, respectively lignite or natural gas. In addition to hydrogen, carbon dioxide is usually generated during the fossil fuel production process. The greenhouse gas emissions from fossil-based hydrogen are considerable.

BLUE

Blue is grey hydrogen with the addition that CO_2 emissions are reduced through the use of carbon capture and storage (CCS) technology. While blue hydrogen is often described as climate-neutral, it is in fact problematic. The long-term consequences of CO_2 storage remain unknown, leakage can lead to emissions, and the use of natural gas should generally be avoided.

TURQUOISE

Turquoise hydrogen is produced from fossil gas by means of methane pyrolysis. This produces solid carbon instead of CO_2. Nevertheless, climate neutrality is likewise hardly possible, since emissions are produced during the extraction and transport of the starting material, which is fossil gas.

Source: Heinrich Böll Foundation (2022).[83]

„We reject the use of fossil fuel based hydrogen due to its continuation of harmful fossil extraction, associated greenhouse gas emissions such as e.g. methane in the case of „blue" or „turquoise" hydrogen. We also object to nuclear hydrogen, in view of risky nuclear practices. Equally, hydrogen from bioenergy does not reduce greenhouse gas emissions and has a very high impact on land use, and therefore is not an adequate source for hydrogen. All of these hydrogen types are not compatible with a safe and 1.5°C compatible future and should therefore be excluded by policies fostering hydrogen production and use."

53. Rio Negro (2022), Ambientalistas de Río Negro cuestionan el proyecto Hidrógeno Verde, https://www.rionegro.com.ar/sociedad/ambientalistas-de-rio-negro-cuestionan-el-proyecto-hidrogeno-verde-2305843/.

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"The climate crisis will not be averted without a rapid expansion of the renewable energy industry. However, a net-zero carbon future can and must go hand in hand with sustainable development, poverty reduction and reducing inequality (...). A narrow focus on short-term return on investments regardless of the harm to people and the environment has led fossil fuel companies to lose legitimacy and social licence to operate. If the same happens to renewable energy companies, it will only slow our expansion to a net-zero carbon future. That's why we need clean energy that respects human rights. A transition that is fast, but also fair."

Mary Robinson, Climate Justice (2020)

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