Building Bridges:

Make Hydrogen Work – International Approach

UN Global Compact Network Netherlands Young Professionals Program

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About the United Nations Global Compact Young Professionals Program

United Nations Global Compact (UNGC) Network Netherlands aims to accelerate and upscale the positive impact of the Dutch business community on the Sustainable Development Goals (SDGs) with the purpose of improving the lives of current and future generations. Guided by the Ten Principles and the 17 SDGs it supports companies and stakeholders in understanding what responsible business means within a global and local context and provide guidance to translate sustainability commitments into action.[1] One of the programs it offers is the Young Professionals Program (YPP). This 12-month program is action-based learning in which a multidisciplinary team of young future leaders delivers an SDG-related project, learns more about sustainability concepts, and develops leadership and teamwork skills.[2]
The SDG project of the fourteenth YPP cohort aims to contribute to the skills gap in the green hydrogen transition, with a focus on ensuring a fair and just transition.

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About GroenvermogenNL & Make Hydrogen Work

GroenvermogenNL (GVNL) executes the Human Capital Agenda (HCA) of the National Hydrogen Program. The GVNL HCA program has introduced the Make Hydrogen Work initiative, which aims to develop a competent and skilled labour market for the hydrogen transition. This program involves the collaboration of seven Dutch regions in creating roadmaps and working together on developing a competent workforce. The "Make Hydrogen Work" initiative features collaborative campuses that offer training and educational modules related to hydrogen, developed by a partnership between companies, educational institutions, and government bodies. Additionally, the concept incorporates nationwide tools to support regional implementation and emphasises individualised development paths for professionals. Furthermore, the initiative seeks to establish national certification with micro credentials and aims to extend its reach internationally by leveraging existing collaborations and creating a network of campuses for knowledge exchange and professional training on an international scale.

1 https://unglobalcompact.nl/en/
2 https://unglobalcompact.nl/en/young-professionals-program/

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Foreword

To develop the international proposition of the Dutch Make Hydrogen Work (MHW), GroenvermogenNL commissioned the YPP team to conduct a study to understand how The Netherlands can help other countries build their local labour markets for the green hydrogen transition. This research includes understanding the current hydrogen value chain and transition, the skills developments and needs for hydrogen, and providing advice for the offering of MHW in an international context. To identify the skills needs in countries developing their knowledge related to hydrogen and with high potential for collaboration with the Netherlands, research was conducted focusing on South Africa, Namibia, and Morocco.

Make Hydrogen Work Sounding Board
To support the YPP and GroenvermogenNL team in their research, a sounding board was set up. This board includes various stakeholders from the hydrogen industry, educational organisations, and public institutions. These stakeholders possess the expertise and network necessary to effectively support the project roll-out of the international Make Hydrogen Work proposition.

The sounding board is composed of the following people:

- Marsha Wagner (Program Director Human Capital, Topsector Energie / GroenvermogenNL)
- Jorg Gigler (Managing Director of the Dutch New Gas Innovation Team, TKI New Gas)
- Han Feenstra (Hydrogen International Programme Manager and senior policy advisor, Ministry of Economic Affairs and Climate Policy of the Netherlands)
- Mena Leila Kilani (Senior Project Manager, SDG Nederland)
- Mirjam Brüggemann (Programme Manager Middle East & North Africa at Nuffic)
- Ronald Kleijn (Program Manager GroenvermogenNL, Make Hydrogen Work)
- Willem Hazenberg (Regional Liason Noord-Oost, GroenvermogenNL)
- Representative from Dutch Ministry of Foreign Affairs
- Representatives from Invest International
- Representative from Young GroenvermogenNL

We would like to express our sincere gratitude to the sounding board members for their invaluable time and contributions to our research and this report. Your expertise and feedback have played a crucial role in shaping the report and ensuring its accuracy and relevance.

Executive summary

Chapter 1 ("The global green hydrogen landscape") presents a comprehensive overview of the global green hydrogen landscape, discussing its potential, challenges, and opportunities, with a particular focus on the role of the Netherlands and African economies in this emerging sector. It emphasises the need for policy support, investment, and collaboration to fully realise the potential of green hydrogen as a key component of a sustainable energy future. It discusses the current state and prospects of green hydrogen as a sustainable energy source and highlights key trends and developments in the global green hydrogen transition, with a focus on the challenges of scaling up supply and demand structures. Furthermore, the chapter provides an overview of the green hydrogen value chain, from production to consumption, and discusses the potential for local value creation in green hydrogen value chain development. These developments are discussed considering the potential of African economies, particularly Namibia, South Africa, and Morocco, to benefit from these opportunities due to their abundant wind and solar potential. In doing so, special emphasis is put on the need for a fair and just transition, ensuring that green hydrogen supports the decarbonisation of all countries and meets domestic energy needs.

Chapter 2 ("Skills development for the green hydrogen economy") discusses the importance of skills development for the green hydrogen transition. It highlights that the transition to clean energy can create job opportunities and support economic activity while advancing the global decarbonisation agenda. The chapter further explains the different skill levels required in the energy transition, ranging from low to high skills, and the need for upskilling and reskilling, and emphasises the importance of developing human capital for countries that have put hydrogen as an important component in their energy strategies. Current knowledge and skills gaps in the green hydrogen value chain are identified, and an overview of the key skills required for producers of green hydrogen is provided. These include, among others, engineering skills, chemistry skills, energy management skills, water management skills, environmental and regulatory knowledge, project management skills, and safety skills.

It also discusses the key challenge of providing adequate training and upskilling to support hydrogen energy roll out through a detailed analysis of the green hydrogen skills gap in Namibia, South Africa, and Morocco, highlighting the unique challenges and opportunities in transitioning to a low-carbon economy in each country. After comparing the skills gap for hydrogen in Namibia, South Africa, and Morocco, it is evident that each country has unique challenges and opportunities in transitioning to a low-carbon economy. In all three countries, there is a critical need for inclusive and just transitions that ensure all citizens are prepared for and benefit from the transition to a low-carbon economy.

Finally, the chapter discusses the availability of skills programs in the European Union and provides key insights for effectively transferring knowledge and skills. It emphasises the need for tailored solutions per country, fostering international collaboration, local capacity building, collaborative partnerships, and addressing infrastructure challenges. It concludes that there is a lack of specific hydrogen education and training programs and suggests ways to address this gap.

Chapter 3 ("Make Hydrogen Work proposition and the Dutch offering") introduces the Make Hydrogen Work proposition and discusses opportunities and challenges for rolling out this proposition in Namibia, Morocco, and South Africa. Key opportunities include that Dutch private and governmental organisations have been actively engaged in fostering collaboration and building networks in Morocco, Namibia and South Africa; Knowledge institutions in Namibia, South Africa and Morocco are open to collaboration with Dutch (European) partners to develop and refine curriculum offerings tailored to their specific needs; The Netherlands harbours vast experience with institutional capacity building and capacity building is regarded as an essential component of public-private partnerships.

Key challenges include the need for contextualisation of the proposition for each country; a willingness to really listen to local needs and build from demand-perspective rather than supply-perspective; difficulty of determining the exact needs for hydrogen capacity and skills development; and challenges due to projects being focused on low production cost of hydrogen, rather than focusing on building a system in which local communities are employed and have a stake. To address these challenges and promote the Make Hydrogen Work proposition, The Netherlands can focus on its unique selling points, including its established networks, government involvement, infrastructure development expertise, and strong institutional capacity building.

To ensure an effective and efficient organization for Make Hydrogen Work, several strategic and operational actions are identified. It is argued that strategic actions will help the development of the international proposition to have a long-term focus in which the bigger picture is taken into consideration. It aims to set up strategic partnerships across organisations. On the other hand, the operational actions stimulate getting into action mode rapidly and starting pilots for collaboration with knowledge institutions in Namibia, South Africa and/or Morocco.

Chapter 4 ("Conclusion and recommendations for Make Hydrogen Work-international") summarises the key insights and addresses additional recommendations for setting up the international proposition. It describes the clear opportunity for Make Hydrogen Work, summarises the unique selling points of the Dutch proposition and highlights key action points. Make Hydrogen Work can be expanded internationally by adding new knowledge institutions and campuses to the network on a local basis. This can be achieved through collaborations with Dutch embassies, and existing initiatives created by RVO and Nuffic, targeting the specific needs on skills development in the region. Other programs and countries can also be leveraged to create a collaborative approach on complementary topics, avoiding duplication of efforts, and maximizing the collective impact.

It is key to listen to and engage with international campuses to identify the needs in the region and set up tailored collaborations. Make Hydrogen Work does not have a commercial business model, and thus safeguarding sufficient funding to roll out activities is important. Therefore, a steering committee could be set up, and access to funding must be ensured to maximize the impact of the initiative. Ultimately, the Make Hydrogen Work proposition can contribute to sustainable development and promote a fair and just transition in the region that is inclusive, mutually beneficial and focused on respect.

Chapter 1:
The global green hydrogen landscape

1.1 Key trends and developments in the global green hydrogen transition

Despite some progress, building and scaling up structures for supply and demand of green hydrogen and derivatives remains challenging. While the deployment of green hydrogen has steadily increased since 2020, it needs to be accelerated if the 2030 goals of 60-70 Mt/year are to be achieved. To date, most pilot projects are in Europe and Asia, and only in the announcement phase, while most projects have not yet reached a final investment decision. In this context, there is a pressing need for governments and companies to reinforce demand signals, and shift from targets to policies and from commitments to contracts.[3]

By the end of 2021, 64 countries had pledged or legislated targets for achieving net zero over the coming decades, in line with the Paris Agreement, covering 89 percent of global emissions. Countries including Canada, Japan, New Zealand, and those in the European Union — responsible for about 17 percent of global emissions combined — have already signed net-zero targets into law, while others, including China, the United States, and Australia — responsible for 72 percent of emissions combined — have pledged to reach net zero by 2050 or beyond.[4] This transition is further accelerated by recent geopolitical events such as the Russian invasion of Ukraine and resurgent rivalry between the United States and China, which have led to a reemergence of energy supply security, energy autonomy and resilience as central paradigms of both energy policy and foreign policy more generally.[5]

The high potential of hydrogen is in part due to its versatility: hydrogen can be used to produce, store, and move energy in a variety of ways, and has several uses, especially in hard-to-abate sectors such as long-range modes of transportation and heavy industry (such as the steel industry). The application of hydrogen to new end uses is expected to rapidly scale after 2030, especially in these hard-to-abate sectors where direct electrification is not a viable alternative.[6] The industrial sector is anticipated to remain a large consumer, but demand from oil refining is expected to decline in Paris-compatible scenarios where future oil demand decreases. Near-term demand is mostly anticipated in existing industrial centres in Europe, the United States, China, Japan, and Korea and lags for much of the Global South.[7]

Green hydrogen could be cost competitive by 2030

While hydrogen is already used in many industries, it has not yet realised its full potential to support the clean energy transition by replacing fossil fuels in industrial process, mobility and applications in many sectors that are hard to lower greenhouse gas emissions.[8] One obstacle to scaling up green hydrogen is its relatively high production costs, especially when compared to grey hydrogen. To ramp up green hydrogen production, it is crucial to drive down production costs and close the gap between green and grey hydrogen. The primary cost factors are renewable electricity and electrolyser facilities.[9] In addition, grid connection costs and capital costs for hydrogen are high.[10] Access to finance and high financing costs pose additional challenges, especially in developing countries. Green hydrogen production is capital-intensive and requires large investments. Investments in renewable energies in general, including end uses, totalled USD 0.5 trillion in 2022, representing only about one-third of the average annual investment required to stay aligned with the 1.5°C Scenario. Furthermore, these investments are geographically concentrated in a few countries.[11]

Current capital flows for green hydrogen projects are insufficient to complete their full implementation.[12] The OECD Clean Energy Finance and Investment Mobilisation (CEFIM) programme estimates that the green hydrogen sector requires USD 9.4 trillion by 2050, with USD 3.1 trillion going to developing and emerging economies.[13] According to a study undertaken by McKinsey for the Africa Green Hydrogen Alliance (AGHA), meeting the green hydrogen ambitions by leading African countries alone would require up to USD 55 billion in investment by 2030 and USD 900 billion by 2050.[14]

3 Breakthrough Agenda Report 2023 (irena.org)
4 AGHA-Green-Hydrogen-Potential-v2_Final.pdf (unfccc.int)
5 The Geopolitics of Hydrogen - Stiftung Wissenschaft und Politik (swp-berlin.org)
6 Hydrogen - IEA
7 iea.blob.core.windows.net/assets/ecdfc3bb-d212-4a4c-9ff7-6ce5b1e19cef/GlobalHydrogenReview2023.pdf
8 AGHA-Green-Hydrogen-Potential-v2_Final.pdf (unfccc.int)
9 Green hydrogen cost reduction (irena.org)
10 Evaluation of the levelised cost of hydrogen based on proposed electrolyser projects in the Netherlands (overheid.nl)
11 International co-operation to accelerate green hydrogen deployment (mc-cd8320d4-36a1-40ac-83cc-3389-cdn-endpoint.azureedge.net)
12 summary-report-roundtable-on-renewable-energy-and-green-hydrogen.pdf (oecd.org)
13 Finance for a just renewable energy and green hydrogen economy roundtable - OECD
14 AGHA-Green-Hydrogen-Potential-v2_Final.pdf (unfccc.int)

While the investments required are significant, they are comparable to investments of USD 5.7 trillion made in upstream oil and gas in the past decade (from 2010 to 2019).[15]

As momentum toward green hydrogen builds — including an exponential rise in project announcements for electrolyser capacity — the cost of producing it is expected to fall by approximately 60 percent globally by 2030. Policymakers are increasingly moving to support the adoption of green hydrogen technology, electrolyser capacity is rising, and the cost of renewable energy continues to fall. This, together with the introduction of CO_2 tariffs as a response to decarbonisation pressure, could mean that green hydrogen is at cost parity with grey hydrogen as early as 2028. Grey hydrogen could be totally supplanted, while blue hydrogen, making up 30 percent of total hydrogen production, would likely be limited to regions such as North America and the Middle East, where costs of natural gas are lower and carbon capture and storage is more likely to be economical. [16]

Global hydrogen demand and supply are mismatched, creating a significant import market
Today, global hydrogen demand and supply are mismatched, potentially creating a significant import market. While hydrogen can be produced in almost every global region, competitiveness across regions varies significantly. Consequently, governments around the world are positioning their economies to take advantage of the opportunities that the hydrogen economy could bring, including increased energy security, new jobs, low-carbon industries, and export opportunities.[17]

African economies could be well-positioned to benefit from these opportunities. The continent's abundant wind and solar potential put it in a strong position to export green hydrogen and its derivatives to international markets, including Europe and Asia. And more importantly, if African countries can develop and scale this new industry effectively, this will offer abundant applications for green hydrogen in domestic markets, helping boost energy independence, foster new green industries, and create new and sustainable jobs. Green hydrogen could also help enable and accelerate the deployment of renewable energy across the continent, helping Africa meet its electrification needs, while also meeting rising global demand.

1.2 The green hydrogen value chain

The green hydrogen value chain, ranging from production to consumption, is composed of multiple elements interlinked with the wider energy sector. Each element has its own barriers and challenges. At present, the supply chain for green hydrogen is minimal, and the use of green hydrogen is limited to a few small projects. Therefore, rapid growth is necessary for industry to scale up to the size needed to make a significant contribution to the energy transition.[18]

Upstream
The upstream stage covers the production of hydrogen. In the upstream hydrogen supply chain, the focus is on the production of green hydrogen using renewable energy sources. Electrolysis is employed to generate green hydrogen without greenhouse gas emissions. Renewable energy assets, including solar, wind, and hydroelectric power, play a critical role in powering the electrolysis process, ensuring the sustainability and environmental friendliness of the hydrogen produced.

Midstream
Once produced, hydrogen needs to be stored or transported to its point of use, which can be achieved through pipelines or shipping, similar to the current methods employed in the oil and gas industry. Storage facilities, including tanks and underground caverns, are utilised to store hydrogen for future use, while conversion processes may involve the production of derivatives such as ammonia or methanol for various industrial applications. Transportation methods such as pipelines, trucks, or shipping vessels are employed to distribute hydrogen to end-users across different geographical locations. Transporting hydrogen poses a challenge due to its low energy density. To make transportation easier, it needs to be compressed, turned into a liquid, or combined with other substances like nitrogen to produce ammonia or liquid organic hydrogen carriers.

15 International co-operation to accelerate green hydrogen deployment (mc-cd8320d4-36a1-40ac-83cc-3389-cdn-endpoint.azureedge.net)
16 AGHA-Green-Hydrogen-Potential-v2_Final.pdf (unfccc.int)
17 AGHA-Green-Hydrogen-Potential-v2_Final.pdf (unfccc.int)
18 Green hydrogen supply: A guide to policy making (irena.org)

Downstream
Finally, the downstream hydrogen supply chain refers to the utilization of hydrogen in various sectors such as fertiliser production or steel manufacturing. In these downstream applications, hydrogen serves as a clean and versatile energy carrier, contributing to decarbonisation efforts and reducing reliance on fossil fuels. Overall, the hydrogen supply chain encompasses a range of interconnected activities, each playing a crucial role in enabling the widespread adoption of hydrogen as a sustainable energy solution. This process from production to end use is further displayed in Figure 1 below:

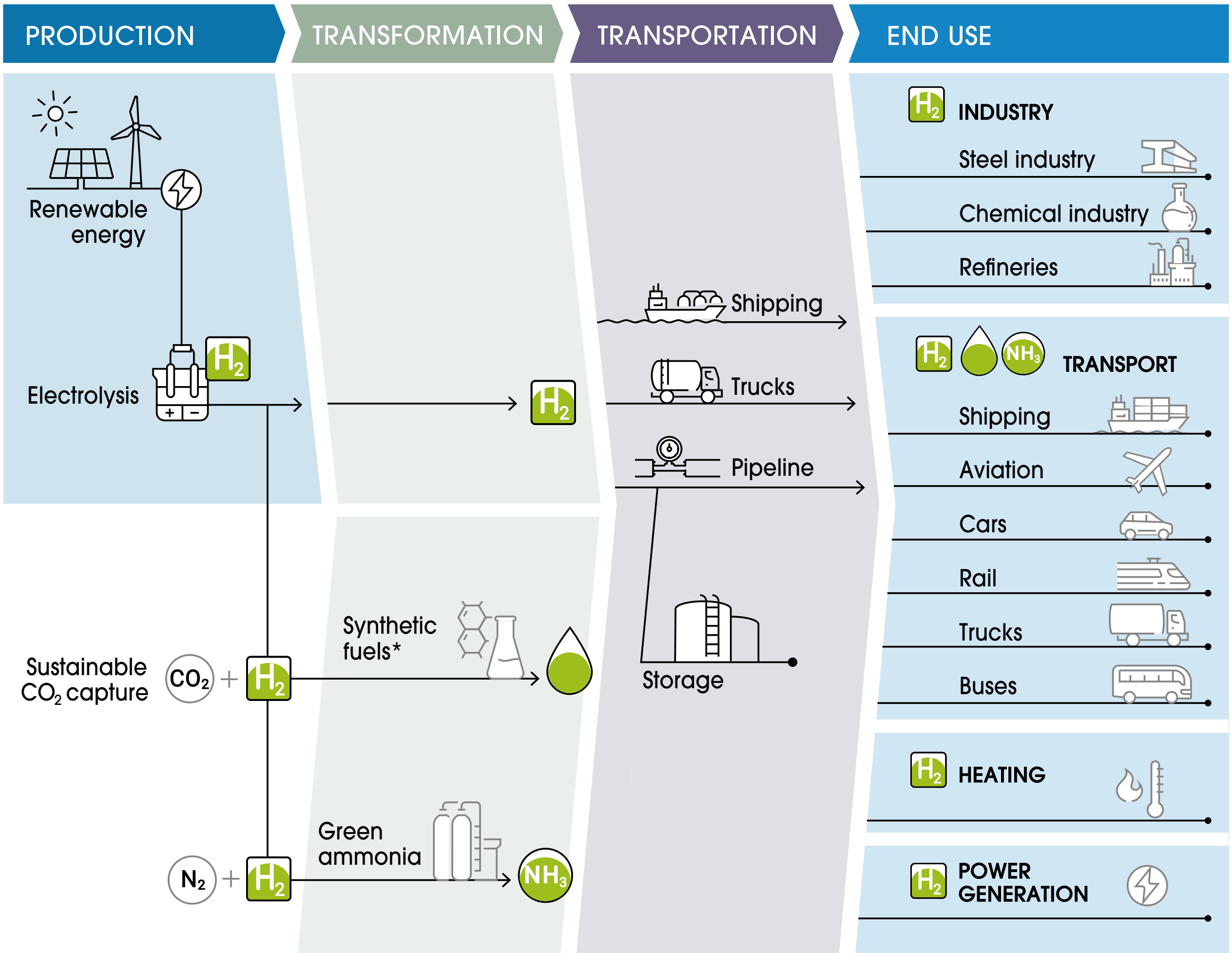

Figure 1. Green hydrogen value chain (IRENA, 2021)[19]

Maximising local value creation in green hydrogen value chain development
The growth of green hydrogen value chains in potential/possible producer countries (such as Namibia, Morocco, and South Africa), spanning upstream, midstream, and downstream segments, has the potential to foster economic development, enhance local infrastructure, and promote job creation when value is harnessed within the local context. Nonetheless, it is essential to recognise that advantages extending beyond diversifying export revenues and attracting foreign direct investments are not automatic. In order to safeguard such benefits, local value creation should be integrated into producers' and importers' hydrogen strategies and in any future international criteria for sustainable green hydrogen to avoid missed opportunities for producers.[20]

Although there is significant local development potential, establishing green hydrogen value chains carries inherent risks due to the uncertain scale of future demand and the high costs associated with required technologies. There is risk that developing and emerging countries take on substantial debt for initial investments in hydrogen infrastructure, only to find projects are not sufficiently profitable, resulting in adverse debt consequences. To hedge this risk, an integrated value chain approach should be taken to secure domestic demand for green hydrogen.[21]

19 Green hydrogen supply: A guide to policy making (irena.org)
20 The role of green hydrogen in a just, Paris-compatible transition (newclimate.org)
21 E3G-Report-Making-clean-technology-value-chains-work-for-EU-economic-convergence.pdf

A smart strategy is necessary to reduce the risks for developing countries, including burden sharing between exporting and importing countries as well as safeguarding long-term offtake contracts for developers of green hydrogen. In countries with existing industrial capacities, domestic hydrogen demand can be facilitated by setting demand quotas to boost market uptake or setting local content requirements to support the development of upstream and downstream industry. Other measures to support value chain development include local content requirements for parts of the value chain, pre-defined local workforce requirements, and investments in capacity building and knowledge sharing to skill the work force and build up and maintain expertise in the country.[22] In addition, the development of regional green hydrogen corridors can connect hydrogen production hubs with regional off-takers, which subsequently diversifies buyers, and reduces the risk of being a price taker.

1.3 Safeguarding a fair and just transition

For green hydrogen to support a globally just, sustainable energy transition, it is essential it supports the decarbonisation of all countries, and not only meets demands from the Global North. Where possible, domestic energy needs and decarbonisation should be prioritised over exporting green hydrogen. While renewables account for a growing share of global energy generation, in many emerging and developing countries, renewables make up only a small share of the energy mix today with most domestic energy demand reliant on fossil fuels or traditional biomass.[23] Green hydrogen should be seen as more than just a climate mitigation tool: it represents a developmental opportunity for emerging and developing economies. A green hydrogen economy should not be at the expense of exporting countries and not exacerbate existing inequalities. Instead, new age energy and trade partnerships should present opportunities for countries with rich renewable resources to further their sustainable development priorities and decarbonise domestically.[24]

Scaling green hydrogen production can directly or indirectly impact several sustainable development goals (SDGs) including SDG 6 (clean water and sanitation), SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth), and SDG 13 (Climate Action). Investments in renewable energy capacities could facilitate the expansion of energy access for local populations. However, there is risk that developing green hydrogen in regions with high energy deficits further stretches grid capacity and reduces access for local use. Checks for Paris-alignment should consider whether the renewable energy capacity addition dedicated to hydrogen production decreases the speed of overall energy sector decarbonisation. For example, if electrolysers are connected to the grid, they could compete with domestic energy demand in areas where renewable energy installations are scarce. Progress on national energy priorities should not be hindered by the allocation of available renewable energy to green hydrogen generation and in regions where domestic access to modern energy is not covered. Rigorous checks are needed to ensure clear socio-economic benefits for local populations, including significantly advancing domestic access to energy.[25]
Future energy trade should not only support decreased dependence on fossil fuel commodities globally, but also address local development needs in a way that decreases economic disparities between developed and developing countries. Unequal trade dynamics between countries exporting raw materials and those exporting manufactured goods have remained persistent over time and exacerbated economic disparities between developed, developing and emerging economies.[26] Power imbalances in trade relations result in the impact of excessive resource consumption largely felt in the Global South where extraction and low value-added segments of the value chain are located. Hence, the potential appropriation of resources without capturing value locally poses a threat to sustainable development and global justice.

Safeguarding sustainable land use and access to water

Large-scale green hydrogen production requires significant land and water resources, potentially affecting local communities and ecosystems. To mitigate the impact, land rights and the principle of free, prior, and informed consent must be respected. Project planning should involve local stakeholders' voices and adopt a consultative approach to minimise disruptions to the environment and communities. Water sourcing and management must be responsible and not compete with local demand, harming aquatic ecosystems and livelihoods. The hydrogen economy can facilitate investments in water infrastructure, for example, circular solutions and wastewater treatment practices could be implemented. Policymakers and project developers should consider the potential impact of privatising water infrastructure and should guarantee access to clean and affordable water for everyone. In this space it is essential to adopt a collaborative approach amongst projects, to avoid duplication of efforts and maximise impact.

22 Fair Green Hydrogen (rosalux.de)
23 World Energy Balances - Data product - IEA
24 The role of green hydrogen in a just, Paris-compatible transition (newclimate.org)
25 Fair Green Hydrogen (rosalux.de)
26 "What You Exported Matters: Persistence in Productive Capabilities acro" by Isabella M. Weber, Gregor Semieniuk, et al. (umass.edu)

Safeguarding local community involvement
Fostering community involvement, and thus bolstering social acceptance, is critical in the implementation of new energy technologies. Especially for those that involve large-scale infrastructure development, such as that required to meet future demand for green hydrogen. Hence, local stakeholders should be actively engaged in the development of a green hydrogen economy from the start to address risks and align priorities.

Job creation is frequently cited as a socio-economic benefit for developing countries seeking to produce green hydrogen and derivatives. However, quantifying the potential socio-economic impact of green hydrogen in developing countries remains challenging, with only a handful of such projects under development thus far. Additionally, assessing the sustainability of high-value jobs beyond the construction phase presents a challenge at this stage.[27] Further, education and training programmes are needed to prepare and develop a skilled workforce for the uptake of the green hydrogen sector. The green skills gap for the hydrogen transition will be central in the remainder of this[28]. As the hydrogen industry is nascent, an inherent risk exists that people will not be able to find a job after receiving training programs. A human capital strategy focused on matching supply and demand is key to ensure industry readiness. To conclude, environmental, social, and governance aspects of green hydrogen production must be considered for the long-term viability and success of green hydrogen value chains. Sustainability criteria should be developed, accounting for the renewable share of the energy mix, hydrogen and derivative emissions, inclusive policy frameworks, participation of local communities, and economic interest of producing countries.[29] A collaborative approach between all stakeholders, including public and private sectors, investors, and local communities, is crucial for an inclusive green hydrogen economy that benefits people and the planet.[30] The Netherlands and the EU must consider ethical aspects and collaborate with producing countries in the Global South.

1.4 The role of the Netherlands in the global green hydrogen economy
The Netherlands has set ambitious goals for the use of renewable energy, including hydrogen, as part of their commitment to reducing greenhouse gas emissions.[31] In the Dutch Climate Agreement (2019) the low-carbon hydrogen economy was identified as a key part of the carbon emission reduction strategy. Central to the Dutch hydrogen strategy is the National Hydrogen Programme, which originated from the Dutch Climate Agreement. The main task of the National Hydrogen Programme, a public-private partnership, is to investigate and stimulate the contribution of hydrogen to the realization of the energy transition.[32]

The Dutch government takes an integrated approach to developing hydrogen value chains, focusing on production, import, transportation, storage, as well as the demand side, potential revenue models and on how to deal with safety and regulatory issues. With its vast experience in system integration, regional development of green hydrogen valleys, and experience with gaseous molecules, the Netherlands is ideally placed to be a leader in this field and to play a crucial role in European hydrogen development.[33] The Netherlands can act as a key demand aggregator for not only green hydrogen and its derivates, but also essential value chain technologies such as electrolysers, fuel cells, and solar cells, as well as hydrogen products such as green steel and cement.

There is also an eagerness in Dutch companies and knowledge institutes to develop substantial and long-lasting (trade) relationships and seize investment opportunities, and a willingness to cooperate with other EU-countries, like Germany through their H2global project.[34] With regards to knowledge development and capacity building, The Netherlands harbours vast experience with institutional capacity building of vocational training and university programs, through public-private partnerships focused on knowledge development and application.

27 Make Hydrogen in developing nations: share prosperity while meeting our climate goals - Energy Post
28 International co-operation to accelerate green hydrogen deployment (mc-cd8320d4-36a1-40ac-83cc-3389-cdn-endpoint.azureedge.net)
29 Position Paper: Sustainability criteria for import projects for renewable hydrogen and PtX products (wasserstoffrat.de)
30 Achieving a Green Hydrogen transition built on equity and consensus | Industrial Analytics Platform (unido.org)
31 Dutch Green Hydrogen proposition for South Africa (rvo.nl)
32 The Netherlands as a Future Hydrogen Hub for Northwest Europe: Analysing Domestic Developments and International Engagement (clingendaelenergy.com)
33 The Netherlands: a global hub for hydrogen import, transport and storage (tno.nl)
34 home - H2Global Project (h2globalcluster.eu)

Besides domestic production, the Dutch government also stimulates the import of hydrogen and its derivates. It is expected that in the long term at least 50% of local demand will have to be met by import. Furthermore, a substantial part of the German demand will be supplied through Dutch ports.[35] As it is of strategic importance to the Netherlands to maintain its current energy hub function in the future low-carbon hydrogen economy, the government and industry are actively pursuing potential import relationships with future prospective exporting countries.[36] Although the initial volumes will be small, in the future the Netherlands expects to import hydrogen from a growing number of countries within and outside of Europe.[37] The Netherlands was actually the first country to assign a dedicated hydrogen envoy and has so far established MoU's with Namibia, Chile, South Africa, Canada, Uruguay, UAE, Saudi Arabia, Oman, Morocco, Spain, Portugal, Norway, US, Japan, and Australia.[38] These MOUs outline specific areas of cooperation, joint projects, and mutual goals. To highlight one example, in the case of Namibia this has concretely led to a Namibia-Europe supply chain feasibility study by the Port of Rotterdam with Nampower, the development of a Luderitz Port Masterplan by the Port of Rotterdam with Namport and Hyphen, and the development of the 'SDG Namibia One Fund' by the Environmental Investment Fund of Namibia, Climate Fund Managers and Invest International.[39]

1.5 Green hydrogen developments in Namibia, South Africa, and Morocco

Among the African countries leading the charge in the green hydrogen transition are Namibia, South Africa, and Morocco. Situated in different regions of the African continent, each of these nations boasts unique geographical advantages and renewable energy potential, making them ideal candidates for pioneering green hydrogen initiatives. From abundant solar and wind resources to strategic geographic locations, Namibia, South Africa, and Morocco are seizing the opportunity to capitalise on their natural assets and emerge as key players in the burgeoning green hydrogen market. All three countries have announced their intention to intensify collaboration toward the development of green hydrogen projects on the African continent as member states of the African Green Hydrogen Alliance (AGHA).[40]

A recent study focusing on the Africa Green Hydrogen Alliance (AGHA – consisting of Egypt, Kenya, Mauritania, Morocco, Namibia, and South Africa) estimates that, by 2050, the African continent could self-supply its full domestic demand potential of between 10 to 18 Mt of hydrogen equivalent, as production costs in Africa are expected to be significantly lower than the landed cost of importing these products to Africa.[41] This implies that roughly a third of total hydrogen equivalent produced could be for local demand.

The development of green hydrogen infrastructure could lead to significant (foreign) direct investment - resulting in (in)direct jobs created. This is especially important in Southern Africa, with both Namibia and South Africa having unemployment rates above 30 percent. It is expected that the green hydrogen transition could create 2 to 4 million jobs by 2050 in AGHA member countries. Furthermore, it is estimated that by delivering on AGHA's green hydrogen potential, member countries could help abate around 6.5 Gt of cumulative CO2 emissions globally by 2050, roughly equivalent to the combined CO2 emission in the United States and Europe in 2021.

Below we explore the latest developments, initiatives and challenges in green hydrogen production and adoption in Namibia, South Africa, and Morocco, highlighting their potential to revolutionise the energy landscape and drive sustainable development across the African continent and beyond.

Namibia

Namibia boasts immense renewable energy potential, particularly in solar and wind resources. With abundant sunlight throughout the year and vast stretches of windy terrain, the country possesses ideal conditions for harnessing renewable energy. Namibia's solar irradiation levels are among the highest globally, presenting significant opportunities for solar energy generation. Additionally, coastal regions experience consistent winds, making them suitable for wind power projects. Namibia enjoys both political stability and a great investing environment. In addition to that, it has a small population, which provides the opportunity to export lots of produced hydrogen since it will not all be needed to cover local demands.[42]

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35 The Netherlands as a Future Hydrogen Hub for Northwest Europe: Analysing Domestic Developments and International Engagement (clingendaelenergy.com)
36 (overheid.nl)
37 Hydrogen Roadmap (nationaalwaterstofprogramma.nl)
38 Internationale samenwerking | Nationaal Waterstof Programma
39 Microsoft Word - 20230618 Joint statement Namibia - orange triangle 19jun23_ (002) (portofrotterdam.com)
40 Climatechampions.unfccc.int/wp-content/uploads/2022/11/AGHA-Green-Hydrogen-Potential-v2_Final.pdf
41 AGHA-Green-Hydrogen-Potential-v2_Final.pdf (unfccc.int)
42 The Opportunities, Challenges and Potentials for Hydrogen in Africa (pbl.nl)

Several green hydrogen projects and initiatives are currently underway in Namibia, aiming to capitalise on the country's renewable energy resources to produce green hydrogen for export markets and signal their credibility as a supplier to the market. The Netherlands and Namibia have formed a partnership to cooperate on green hydrogen infrastructure that will lead to new hydrogen supply chains from Lüderitz to Rotterdam and its hinterland, whilst Namibia and Germany signed a partnership in August 2021 to develop green hydrogen, with the aim of putting both countries at the forefront of clean energy innovation.[43] Similarly, Belgium and Namibia signed a Memorandum of Understanding (MoU) on cooperation in the field of green hydrogen during the COP26 in Glasgow.[44]

Namibia's progress in green hydrogen development is supported by partnerships, policies, and investments aimed at fostering a conducive environment for renewable energy projects. The government has shown commitment to advancing the green hydrogen agenda through policy frameworks that incentivise investment in renewable energy infrastructure and it aims to establish a special economic zone (SEZ) with favourable conditions for private sector-led development.[45] Separate to the generic challenges experienced across contexts, a challenge specific to the case of Namibia is that it has no previous history in the oil and natural gas industry. This means that the country lacks infrastructure, experience and knowledge for production and transport of energy.[46]

South Africa

South Africa possesses a diverse renewable energy landscape with significant potential for green hydrogen production. The country boasts abundant solar resources, particularly in regions like the Northern Cape, where sunlight levels are among the highest globally. Furthermore, South Africa's coastal areas experience strong and consistent wind patterns, making them conducive to wind energy generation. The country's favourable natural conditions, coupled with its commitment to renewable energy transition, positions it as a promising hub for green hydrogen production and export, however electricity supply shortages continue to severely impact the country's socio-economic development and growth potential.[47]

To initiate a robust hydrogen economy, the government, in collaboration with the private sector, has identified nine pivotal projects which are being fast-tracked. These encompass:
- The Prieska Power Reserve in the Northern Cape
- The Ubuntu Green Energy Hydrogen Project in Northern Cape
- Boegoebaai Green Hydrogen Development Programme in the Northern Cape
- Atlanthia Green Hydrogen in the Western Cape
- Upilanga Solar and Green Hydrogen Park in the Northern Cape
- Sasolburg Green Hydrogen Programme in the Free State
- SASOL HySHiFT (Secunda) in Mpumalanga
- HIVE Ammonia in the Eastern Cape
- Hydrogen Valley Programme of Anglo-American and their JV Partners

The successful implementation of these flagship projects is anticipated to yield approximately 500kt of hydrogen annually and generate a minimum of 20,000 jobs by 2030. Furthermore, these initiatives aim to contribute at least USD 5 billion to the Gross Domestic Product (GDP) of the economy by the year 2050.[48] It is noteworthy that 2.4 million tons of grey hydrogen is already manufactured domestically in South Africa and used for consumption, making up 2% of the global grey hydrogen supply.[49]

The South African government has introduced various initiatives and policies to promote the adoption and investment in green hydrogen technologies. Achieving a just energy transition is central to the work of the Presidential Climate Commission[50] for ensuring that the lives and communities that are tied to high-emitting energy industries (e.g., coal) are not left behind in the shift towards a low emissions economy. A clear example is the Just Energy Transition partnership

43 AGHA-Green-Hydrogen-Potential-v2_Final.pdf (unfccc.int)
44 Belgium-Namibia MoU on green hydrogen – Policies - IEA
45 Green hydrogen for sustainable industrial development: A policy toolkit for developing countries (mc-cd8320d4-36a1-40ac-83cc-3389-cdn-endpoint.azureedge.net)
46 The Opportunities, Challenges and Potentials for Hydrogen in Africa (pbl.nl)
47 Africa_Energy_Outlook_2023_Final_Digital.pdf (deloitte.com)
48 The Opportunities, Challenges and Potentials for Hydrogen in Africa (pbl.nl)
49 Dutch Green Hydrogen proposition for South Africa (rvo.nl)
50 https://www.climatecommission.org.za/just-energy-transition

(JETP) which was forged at the COP26 Climate Summit in 2021 between South Africa and France, Germany, United Kingdom, United States, and the European Union. The JETP followed engagements between the parties on the unique economic and social challenges of transitioning South Africa's fossil fuel dependent economy in a just manner. The Integrated Resource Plan (IRP) for electricity, which outlines the country's energy mix strategy, includes provisions for green hydrogen production and utilisation.

South Africa has also demonstrated that it can attract private domestic and foreign resources to finance new investments in the energy transition, as evidenced by REIPPPP (Renewable Energy Independent Power Producer Procurement Programme) and many other flagship initiatives.[51] As of December 2023, South Africa announced green hydrogen projects totalling USD 17.8 billion between 2022 and 2032[52] and aims to become a major producer and exporter of green hydrogen, capturing a 4 percent global market share by 2050. The country's vision is guided by its Hydrogen Society Roadmap (HSRM) which sets clear targets to reach by 2050. South Africa aims to deploy 10 gigawatts (GW) of electrolysis capacity in Northern Cap by 2030 and produce about 500 kilotons of hydrogen annually by 2030. South Africa's world class renewable energy resources also allow a highly competitive production cost of H2 below 1.60 $/kg[53] by 2030, putting South Africa as potentially one of the largest global exporters of green H2 and green fuels. Despite South Africa's abundant renewable energy resources and the government's commitment to transitioning to a greener energy mix, several roadblocks hinder progress. One significant challenge is the vested interests and political influence of the coal industry, which has historically dominated the country's energy sector. Resistance to change, coupled with entrenched interests in maintaining the status quo, pose barriers to the expansion of renewable energy and the phasing out of coal-fired power generation. In addition, South Africa's water scarcity requires caution in the production of green hydrogen to avoid stressing the already vulnerable water system. Desalination is key to preventing this, and projects in coastal areas like Boegoebaai and Saldana Bay can supply water for hydrogen production while also benefiting the local community through the improvement of water supply for local communities and business. It will be important for investments in green hydrogen to consider the costs associated with desalination, as well as implementing better wastewater management and reusing treated acid mine drainage.[54] Other challenges hindering investments include pervasive corruption, political instability, and a fragile energy grid within the country. These factors serve as substantial deterrents for potential investors in engaging in green hydrogen projects in [55]

Morocco
Morocco boasts abundant renewable energy resources and the country's geographic location provides it with exceptional solar irradiation levels, making it one of the world's prime locations for solar energy generation. Additionally, Morocco benefits from strong and consistent wind patterns, particularly along its Atlantic and Mediterranean coastlines, making wind power a viable renewable energy option. Having reached universal electricity access in 2020, the country has shifted focus to reducing its reliance on imported fossil fuels and boosting clean energy, though today about 90% of Morocco's primary energy consumption is from imported oil and coal.[56]

Morocco has demonstrated active involvement in green hydrogen projects and partnerships, leveraging its renewable energy expertise and strategic positioning. One nascent hydrogen project will start in Tanger where a new port is being built. Tanger port will provide great opportunities for Europe when it comes to exporting hydrogen from Morocco to Europe. However, one of the challenges in the case of Morocco is that a large amount of the produced hydrogen will be needed locally. As such, not much will be left of the hydrogen to export to Europe.[57] The country's ambitious renewable energy targets and supportive regulatory framework create an enabling environment for green hydrogen development and investment. Furthermore, Morocco's green hydrogen capacity adds to its attractiveness for renewables investment, being in the top three in the world for GH2 potential and the third most competitive industry in terms of cost of GH2 production.[58]

51 Africa_Energy_Outlook_2023_Final_Digital.pdf (deloitte.com)
52 The Opportunities, Challenges and Potentials for Hydrogen in Africa (pbl.nl)
53 https://www.nbi.org.za/wp-content/uploads/2021/08/NBI-Transition-Chapter-Decarbonising-SA-power-11-Aug-2021.pdf
54 A first look at water demand for green hydrogen and concerns and opportunities with desalination - PtX Hub (ptx-hub.org)
55 The Opportunities, Challenges and Potentials for Hydrogen in Africa (pbl.nl)
56 Africa_Energy_Outlook_2023_Final_Digital.pdf (deloitte.com)
57 The Opportunities, Challenges and Potentials for Hydrogen in Africa (pbl.nl)
58 Africa_Energy_Outlook_2023_Final_Digital.pdf (deloitte.com)

Despite Morocco's progress in renewable energy deployment, several roadblocks hinder the transition to a fully green energy system. One significant challenge is water scarcity. Morocco ranks 22nd in the national water stress ranking of the World Resources Institute (WRI). According to World Bank data, the agricultural sector, which accounts for 14% of Morocco's GDP, is the largest consumer of water, accounting for almost 88% of total demand.[59]

Namibia, South Africa, and Morocco – Shared challenges

Namibia, South Africa, and Morocco face several shared challenges in advancing green hydrogen initiatives, despite their differing contexts and renewable energy landscapes. The challenges, including policy and technology uncertainty, complexity of the value chain, local labour market shortage and skills development, and lack of regulations and standards, still need to be addressed to harness the full potential of green hydrogen.[60]

1. **Financing and investment:** So far, hydrogen investment projects in Africa are in an early implementation or planning stage.[61] Access to affordable financing, investment incentives, and risk mitigation mechanisms is crucial for attracting private sector investment and leveraging public funding for green hydrogen initiatives. Limited access to finance, coupled with perceived investment risks, may impede the development of green hydrogen projects in all three countries.

2. **Skills development and capacity building:** All three countries are facing significant challenges in equipping their workforce for the green hydrogen transition. Hence, addressing skills gaps, promoting vocational training, and fostering partnerships with educational institutions and industry stakeholders are critical for building a robust workforce in the green hydrogen sector. Stakeholders could invest in local upskilling initiatives; for example, Namibia established the Green Hydrogen Research Institute in October 2021 to act as a national hub for hydrogen R&D, helping upskill Namibians and develop local businesses.[62] Additionally, Morocco established its first green hydrogen production system, which will also train and upskill professionals,[63] while South Africa's Chemical Industries Education & Training Authority (CHIETA) is currently in the lead to establish a Centre of Specialisation for Green Hydrogen Skills to close the hydrogen skills gap in the country.[64]

Namibia, South Africa, and Morocco – Shared opportunities

Collaboration, technology transfer, and capacity building among Namibia, South Africa, and Morocco present several opportunities for advancing green hydrogen initiatives and accelerating the transition to sustainable energy systems. Some of these opportunities include:

1. **Policy harmonization and alignment:** Aligning policies, regulations, and incentives for green hydrogen development across Namibia, and South Africa can create a more enabling environment for investment and innovation. By facilitating a policy blueprint from the Netherlands or the EU based on the hydrogen policy developments here, the set-up of new policies can consider the lessons learned. By harmonising standards, streamlining permitting processes, and coordinating policy initiatives, they can reduce regulatory barriers and promote cross-border collaboration in the green hydrogen sector. Policy alignment can also facilitate market integration, trade, and investment flows, unlocking new opportunities for cooperation and mutual benefit.

2. **Skills development and capacity building:** Investing in capacity building and skills development is essential for building a qualified workforce and fostering local expertise in green hydrogen technologies. As all countries are currently focusing on skills development for the transition, this offers an opportunity to further investigate if Namibia, South Africa, and Morocco can collaborate on training programs, vocational education initiatives, and technical workshops as well as training on soft skills. By sharing training resources, curriculum development, and educational materials, there is a shared opportunity to enhance human capital and empower local communities to participate in the green hydrogen value chain.

59 Green Hydrogen market in Morocco: needs and barriers (atalayar.com)
60 The Opportunities, Challenges and Potentials for Hydrogen in Africa (pbl.nl)
61 The Opportunities, Challenges and Potentials for Hydrogen in Africa (pbl.nl)
62 AGHA-Green-Hydrogen-Potential-v2_Final.pdf (unfccc.int)
63 Morocco Establishes Its First Green Hydrogen Production System (moroccoworldnews.com)
64 SA to establish Green Hydrogen Skills Centre to plug skills gap – DFA

Chapter 2:
Skills development for the green hydrogen economy

2.1 The importance of skills development for the green hydrogen transition

The transition to clean energy can create job opportunities and support economic activity while advancing the global decarbonization agenda. Many aspects of this transition – including investments in renewable energy; grid strengthening to absorb variable renewable power; decentralised generation, including for energy access; digitization of the energy sector; energy-efficient appliances; and energy efficiency in buildings, industry, and transport – have significant potential to create both domestic and local employment[65]. Analyses undertaken by the International Renewable Energy Agency (IRENA) and the International Energy Agency (IEA) commonly acknowledge that many aspects of the transition to zero-carbon power have significant potential to create local employment. Nevertheless, estimations have been mainly at a global level, while quantification at a local level remains a challenge.[66]

Studies show that the energy transition creates both low- and high-skilled jobs—jobs in construction and production on the one hand and in engineering or project management on the other hand (see Box 1 for a definition of skill levels).[67] In addition, there is a need for lawyers, incident responders, licensing officers, communications specialists with specific knowledge on hydrogen to support the value chain.

Box 1. What are low, mid-range, and high skills?

According to the International Standard Classification of Occupations 2008 (ISCO-08), occupations are classified by the skill level—low, medium, and high—as follows:

High skills: Occupations requiring high skills often require one to six years of higher education. They involve the performance of complex tasks, either technical/practical or theoretical, that require decision-making capacity and include a complex problem-solving dimension. These occupations could include managers, technicians, and associated professionals.

Mid-range skills: Occupations requiring mid-range skills generally require a secondary education and involve performing tasks such as operating machinery and electronic equipment, driving vehicles, performing maintenance and repair, or manipulation. Many occupations at this skill level require advanced literacy and numeracy, as well as good interpersonal and language skills. These occupations comprise clerical support workers, service and sales workers, craft and related trades workers, and plant and machine operators and assemblers.

Low skills: Low-skilled occupations require some form of primary education or at least on-the-job training. They involve the performance of simple and routine physical or manual tasks. Many of these jobs require physical strength and endurance. For some jobs, basic numeracy and literacy skills may be required, although they are not a significant part of the job in this case. These occupations include labourers and simple artisanry.

Developing countries that have put hydrogen as an important component in their energy strategies need to anticipate the technical sustainability of the value chain. Human capital development is at the core of any striving economy and the hydrogen economy has the potential to create economic value and millions of jobs. Nevertheless, most of these new jobs are expected to be technically skilled. Different occupational profiles required along the value chain, ranging from low to high skills, will need to be upskilled and re-skilled, from technicians to assemblers, to engineers, to accompanying services such as qualified maintenance technicians and certifiers, who need to be prepared to take advantage of the benefits of the hydrogen ecosystem.[68]

65 Tracking Jobs in Projects Focused on Clean Energy and Productive Uses of Electricity. Washington, DC: World Bank eBooks.

66 https://openknowledge.worldbank.org/server/api/core/bitstreams/69911554-020a-49b2-aea9-46dcc11c8685/content

67 https://documents1.worldbank.org/curated/en/099012324071522189/pdf/P1705461161e5d8813e9114dbf-1b92a137252142a242.pdf

68 Skills | UNIDO Green Hydrogen

All countries transitioning to a hydrogen economy will face a key challenge of providing adequate training and upskilling to support hydrogen energy roll out.[69] An important caveat is that the skills required to operate assets in the hydrogen economy must be developed locally if the benefits are to be accrued by countries situated in the Global South. Addressing skills and knowledge gaps, especially in countries which have not previously integrated downstream value chains is key for a successful green hydrogen transition.[70] To fully leverage the potential of the hydrogen economy, meet the ambitious hydrogen development targets and deliver on national and regional strategies, developing countries thus need to prepare upskilling and reskilling strategies to face the challenge of limited workers and skills - and training gap of today to prepare their human capacities and skills. In addition, it is imperative to focus on declining sectors and encourage employees to adjust/enhance their (technical) skills to align with the needs of the expanding hydrogen economy.

2.2 Current knowledge and skills gaps in the green hydrogen value chain

In the green hydrogen industry, job opportunities span across the entire value chain, encompassing infrastructure development and water management, renewable hydrogen production, hydrogen handling, storage, transport, and end-use applications, including further processing to other chemicals and steel. Professionals in overarching fields of work, such as in government or agencies responsible for health and safety, will also need to understand Power-to-X (PtX) specific concepts.[71]

Professionals with an academic background in the renewables-based PtX industry are needed for their technology-specific in-depth knowledge and expertise. They typically hold advanced degrees in relevant fields such as chemical engineering, electrical and power systems engineering, industrial engineering, mechanical engineering, civil engineering or materials science. These professionals play critical roles in renewable power and PtX system project planning and design, implementation and plant operation, and process design, but also in research and development, and in policy and regulation formulation.

On the other hand, professionals undergoing Technical and Vocational Education and Training (TVET) or similar programs are set to play a crucial role in the practical implementation and operation of the renewables-driven hydrogen and PtX systems. They possess specialised technical skills, enabling them to perform hands-on tasks related to renewable power generation, the production of hydrogen and its derivatives, equipment maintenance, system monitoring, safety compliance, and logistical operations. These professionals may include technicians, operators, maintenance personnel, and skilled artisans.

To summarise, some of the key skills required for producers of green hydrogen are:

- **Engineering skills:** Engineers are needed to design, build and maintain hydrogen production facilities, as well as develop new technologies for more efficient and cost-effective production methods. A good knowledge of electricity system is key to ensure that the whole ecosystem is hydrogen ready. Upcoming and current power plants need to become H2-ready as they are adapted for H2 utilization, a process challenged by a lack of definition for what constitutes "H2-readiness."
- **Chemistry skills:** Chemists are needed to understand the chemical processes involved in hydrogen production and identify ways to optimise these processes.
- **Energy management skills:** Professionals with expertise in energy management are needed to ensure that hydrogen production facilities are running efficiently and sustainably.
- **Water management skills:** Professionals with comprehensive water management skills are key as these projects present a complex and location-specific challenge. A good understanding of variability in water source reliability and quality across geographic regions is crucial for long term success of green hydrogen development.
- **Environmental and regulatory knowledge:** Professionals with expertise in environmental regulations and sustainability practices are needed to ensure that hydrogen production is done in an environmentally responsible manner.
- **Project management skills:** Strong project management skills are essential to ensure that hydrogen production projects are completed on time and within budget.
- **Safety skills:** Safety is of utmost importance in hydrogen production, so professionals with knowledge of safety regulations and best practices are essential.
- **Social and environmental skills:** Good balance of social and environmental skills is key in this field to ensure Community Development by supporting local communities through job creation, skills development, and infrastructure improvement to promote social and economic benefits from green hydrogen projects. Demonstrating a commitment to ethical and responsible business practices by investing in social welfare programs, community initiatives, and environmental conservation efforts is also key.

69 Skilling the green hydrogen economy: A case study from Australia (sciencedirectassets.com)
70 AGHA-Green-Hydrogen-Potential-v2_Final.pdf (unfccc.int)
71 https://ptx-hub.org/wp-content/uploads/2023/08/International-PtX-Hub_202308_Namibia-PtX-skills-needs-assessment.pdf

Besides the technical skills, transversal and soft skills appear essential in the energy transition professions. There is a growing demand for higher cognitive transferable skills such as critical thinking, complex problem solving, and reasoning, which are cross-cutting across the value chain as well as across skill levels.[72] Increasingly, communication and collaboration skills are needed to enhance collaboration between divergent stakeholders, including government agencies, industry partners, private sector, and local communities in-country. Also, most professions are increasingly demanding digital skills, due to the digitalization of the economy and the energy sector. Finally, developing regional and international research and development partnerships to support the growth of hydrogen skills on the African continent will be key.[73] In the subsequent sections of this chapter, we will focus on the skills gap in Namibia, South Africa, and Morocco specifically.

2.3 Identifying the green hydrogen skills gap in Namibia, South Africa, and Morocco

Namibia

The Namibian Government's Hydrogen Strategy aims to develop a supportive ecosystem for the green hydrogen and Power-to-X (PtX) sectors, fostering innovation and entrepreneurship. Skills development is key to equip Namibians with the necessary knowledge, expertise, and skills to participate in the green hydrogen and PtX industry, ultimately enhancing employability.[74]

Namibia made significant improvements in literacy and primary schooling over recent years, but access to secondary and tertiary education remains limited. Namibia's National Qualifications Framework (NQF) consists of 10 Levels that range from basic literacy and numeracy skills to highly specialised postgraduate qualifications, encompassing a diverse range of competencies and knowledge. The country's Technical Vocational Education and Training (TVET) sector with public, private and community-based training providers offers mostly electrical qualification programs registered from NQF Level 1 to Level 3 using a combination of Competence-Based Education and Training (CBET) and modular courses. As one of a few training providers, the Eenhana Vocational Training Centre (EVTC) offers programs on Solar Equipment Installation and Maintenance up to Level 5. The University of Namibia (UNAM) and the Namibia University of Science and Technology (NUST) as well as private universities provide higher education programs falling into NQF Level 7 to Level 10. [75]

Today, only 3% of any school-age cohort enrol in TVET or higher education. This amounts to 2,800 TVET and 4,000 university students every year out of a population of 2.3 million Namibians. The curricula often do not match industry needs, and there is also a shortage of experienced instructors and researchers. Owing to the low numbers and the limited employability of graduates, Namibian businesses across all sectors face skills gaps. A survey conducted in 2010 showed that out of more than 100 Namibian companies, 96% of respondents felt that the country is experiencing a skills shortage. In particular, specialist positions for managers, professionals and technicians remain vacant.[76]

A study commissioned by the German Federal Ministry for Economic Affairs and Climate Action (BMWK)[77] identified a gap between vocational education training providers and universities in terms of levels: most training providers stop at Level 3, so graduates from public vocational training centres cannot qualify for access to university. Moreover, the analysis of the Namibian TVET sector highlighted a lack of industry participation in apprenticeship programs, formal qualification for trainers, adequate training equipment and clarity on content for PtX upskilling programs. When it comes to higher education, universities reported difficulties with finding lecturers, in providing adequate laboratory equipment for PtX courses and in coordinating with institutions such as government and other (vocational) education institutions. The BMWK study clustered jobs into key occupational groups according to skills, areas of use, and approximate qualification levels.[78] It was found that all jobs identified as being in demand for the green hydrogen and PtX sectors already exist in the industry. In many cases, the base skills for these jobs need to be supplemented with PtX-specific skills. Engineers and technicians and artisans with appropriate PtX skills are expected to be in high demand, but it is the construction workers with either no formal qualifications or with qualification levels typically up to NQF Level 2 who will be needed in largest numbers. Renewable energies, green construction methods, water resource management as well as recycling and waste management are amongst the sectors that will require new sets of professional skills as well. This requires training systems to pair workers with new positions and to retrain workers to make the most of the skills they already possess. Challenges include a shortage of lecturers with PtX expertise, inadequate laboratory equipment, and difficulties in securing work-integrated learning placements. The TVET sector needs enhancement in curricula, training of trainers, and industry participation in apprenticeship programmes.

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72 https://documents1.worldbank.org/curated/en/099012324071522189/pdf/P1705461161e5d8813e9114dbf-1b92a137252142a242.pdf

73 https://climatechampions.unfccc.int/wp-content/uploads/2022/11/AGHA-Green-Hydrogen-Potential-v2_Final.pdf

74 Skills needs and gap analysis in Namibia's PtX sector - PtX Hub (ptx-hub.org)

75 Skills needs and gap analysis in Namibia's PtX sector - PtX Hub (ptx-hub.org)

76 Republic of Namibia (2012), National Human Resource Plan (2010-2025).

77 https://ptx-hub.org/publication/study-skills-needs-assessment-in-namibias-ptx-sector-2/

78 Überschrift des Kapitels (ptx-hub.org)

It is noteworthy that the National Planning Commission in Namibia recently expressed its concern regarding skills development in Namibia and requested Cabinet to approve the National Human Resources Plan (NHRP). The plan will assess the currently available human resources and skills in the country and match these with the demands of the economy in view of the realization of Vision 2030. In addition to this, the current lack of funding for projects forms a major hurdle to accelerate skills development in the country. This gives an impetus towards the skills development of the local population.

In conclusion, Namibia is lagging in its industrialization which has led to a lack of engineers and a need for various skills in hydrogen development, including technical knowledge, infrastructure, operational skills, and compliance with regulations. Universities in Namibia offer engineering programs, but there is a lack of focus on PtX technologies, including electricity conversion, storage, and reconversion. Concretely, higher education and vocational training programs should develop practical training, hands-on experience with relevant equipment, and internships to bridge the gap between theoretical knowledge and real-world application.

South Africa

In the Hydrogen Society Roadmap for South Africa 2021, developed by the Department of Science and Innovation[79], the importance of human capital development is addressed elaborately. A 2019 study estimates that up to 1.6 million jobs can be created in South Africa through energy-sector transformation by 2050.[80] However, most of these new jobs are expected to be categorised as skilled, requiring either university education or vocational training. Future demand for hydrogen needs will require:

- Engineers (e.g. chemical, environmental, automation, welding, software, electrical)
- Technicians and tradespeople (e.g. chemical processes, plant operator, electrician, welder)
- Specialists (e.g. geologist, geophysicist, water management expert lawyer, economist)
- Managerial occupations (e.g. plant manager, maintenance planner, project manager)
- Elementary-level occupations (e.g. guard, cleaner, caretaker, assembling labourer)

In the past, MSc and PhD students have been supported in the development of new knowledge and skills. However, it is acknowledged that currently the TVET college system does not cater fully for skills that are specifically relevant to the hydrogen economy. Given the estimation that one-third of TVET graduates in South Africa are unemployed, there is a need to address the critical skills gap between industry demands and the public college offering and provide an offer for lifelong learning. Hence, it is important to continue to research how the TVET system could be leveraged to develop skills for the hydrogen economy, while addressing the high unemployment rate among the TVET graduates.

In comparison with Namibia, the South African workforce is well equipped with energy, energy management and other related skills from its well-developed coal and oil industry. To better position itself for the green hydrogen transition, the country requires upskilling in hydrogen specific areas where gaps exist. Interviews with experts indicate that high-skilled specialists are likely to be flown in when initiating new hydrogen projects. Therefore, local workforce could specifically focus on acquiring the skills needed for maintenance and operations jobs relating to hydrogen in the near future. The lack of practical skills on project development is another hurdle for the country, leading to projects being started up, but not being efficiently managed throughout the full development stage.

In a future sustainable hydrogen society in South Africa, sectoral job opportunities for skilled graduates are expected to range from operations and maintenance to management of PGM mining, refining and beneficiation, transportation and construction, and industrial manufacturing. These job opportunities will require artisanal, technical, digital, and other skills related to the relevant stages of the value chain. A clear roadmap is critical to fulfil this gap, aligning the country's TVET college system with real industry needs, and creating opportunities to improve labour absorption. A sectoral alignment with industry-specific requirements will facilitate a just labour transition, where potential job losses in the traditional coal-mining industry, for example, are mitigated through the upskilling, retraining and on boarding of workers.[81] Due to the highly dynamic landscape, skill requirements will change over time and require flexibility. Because of this, solid occupational and transferable core skills are crucial. The green hydrogen economy requires soft skills such as collaboration, communication, adaptability, problem solving and time management. Currently, these skills are found to be underdeveloped among South African graduates, resulting in delayed employment of graduates. Soft skills should therefore be included in higher education learning as well as upskilling in the workplace.[82]

79 https://www.dst.gov.za/images/South_African_Hydrogen_Society_RoadmapV1.pdf
80 https://www.cobenefits.info/wp-content/uploads/2019/03/COBENEFITS-Study-South-Africa-Employment.pdf
81 SAIIA_SR_GreenHydrogenTVet.pdf
82 https://saiia.org.za/wp-content/uploads/2022/06/SAIIA_SR_GreenHydrogenTVet.pdf

In the aforementioned Hydrogen Society Roadmap for South Africa 2021 developed by the Department of Science and Innovation[83], several key recommendations are presented in order to enhance the readiness of a green hydrogen workforce, including:

- Nano and micro education for broader social inclusion: a modular approach to skills development enables flexible forms of learning, as the program can be customised. However, it should be built on a sound base of knowledge progression tied to learning pathways.
- Strengthening skills-employment linkages for women in the green hydrogen economy: female participation and qualification rates within the South African TVET system are high, but women still face exclusion from the labour market. There is a need to foster collaboration between government stakeholders and private industry to strengthen the linkage between skills and employment for marginalised women. Targeted skills building programs and industry-based apprenticeships can play a role.
- Support for re-orientation of TVET skills ecosystem: support for the reorientation of the TVET skills ecosystem is needed to meet the needs of the green hydrogen economy. Courses have to be redesigned in both content and structure. Focus should be on providing support for technology enhanced learning, as well as building communities of practice along the skills value chain in the green hydrogen economy.

Morocco

Morocco's commitment to increasing its renewable energy capacity and reducing greenhouse gas (GHG) emissions is part of a broader strategy to position itself as a leader in the region's energy transition. While the government's target of reducing emissions by 42% by 2030 is ambitious, the necessary funding and skilled workforce have yet to be fully developed, hindering progress towards achieving this target. However, recently the government has been taking steps to address these obstacles. One of the key initiatives taken is to create various strategy documents, including the green plan and national energy strategy, which focuses on transitioning to a more sustainable energy mix, promoting the installation of renewable energy, and creating an estimated 50.000 jobs in the clean energy sector. To support these ambitions, the government has also been implementing a training program to prepare workers for jobs in the renewable energy sector.[84]

Furthermore, the government published Circular n° 03/2024 on 11 March 2024. The Circular offers various guidelines to investors wishing to develop projects that integrate the entire value chain of green hydrogen production, including renewable energy production, electrolysis production, storage, transport, and logistics.[85] In addition, Morocco's National Employment Strategy 2025 focuses on developing a national action plan on employment that mainstreams youth employment. A series of capacity building programs and national policy dialogues will be set up, to strengthen national capacity.[86]

Morocco's national TVET Strategy includes a provision for the creation of regional commissions to coordinate TVET activities, build collaboration, manage regional programs and evaluate effectiveness. Too few young people are entering TVET, in particular, rural women and youth have limited access to TVET institutions. TVET suffers a poor image, while technicians are in high demand (especially climatic, electrical, and mechanical engineering.[87]
Apart from these initiatives, there is also a need to address the shortage of skilled workers in the renewable energy sector, which is a significant obstacle to job creation in Morocco. Large companies have been calling for more investment and support for newer technologies like hydrogen and carbon capture, as well as clear regulations to meet international standards for decarbonization initiatives.[88]

83 https://www.dst.gov.za/images/South_African_Hydrogen_Society_RoadmapV1.pdf
84 Skills development and inclusivity for clean energy transitions (iea.blob.core.windows.net)
85 https://insightplus.bakermckenzie.com/bm/energy-mining-infrastructure_1/morocco-green-hydrogen-the-moroc-can-offer
86 Support to the formulation of the national employment strategy and the national action plan prioritizing young people and women | International Labour Organization (ilo.org)
87 https://unevoc.unesco.org/pub/tvet_country_profile_morocco_revised_2020.pdf
88 https://www.unido.org/stories/morocco-developing-industrial-decarbonization-roadmap-framework

A recent World Bank study highlights the mismatch between skill supply and market needs as a major obstacle in Morocco.[89] Morocco needs more technical and vocational education and training (TVET) programs in regions with high solar and wind potential, and the promotion of apprenticeships is necessary. To achieve this goal, universities and engineering schools can cooperate with the private sector, which can facilitate the movement of workers across sectors and provide short-term courses, on-the-job training, and employment matching services.
Maintaining a just transition is also essential, ensuring that all Moroccans benefit from the green transition agenda.[90] For example, disadvantaged youth should have access to training through scholarships and boarding schools. Companies can adopt inclusive measures to increase women's access to job opportunities. Compartmentalising training can help workers easily acquire lacking skills, and distributing upskilling programs across the country could help bridge the gap between rural and urban areas, thus maximising the benefits of the energy transition agenda.
Overall, with increased investment, government support and more skilled workers in the renewable energy sector, Morocco can realise its ambitions to become a leader in the region's energy transition while promoting sustainable economic growth and job creation.

Conclusion
After comparing the skills gap for hydrogen in Namibia, South Africa, and Morocco, it is evident that each country has unique challenges and opportunities in transitioning to a low-carbon economy. Namibia has a relatively small population and workforce, which presents a challenge in terms of training workers for the emerging hydrogen sector. South Africa, on the other hand, has a more extensive workforce, but the traditional energy sector remains dominant, making it challenging to attract investments and develop a skilled workforce for the new hydrogen industry.
Morocco has already made significant strides in developing a renewable energy sector and has implemented various strategies to address the skills gap in hydrogen, such as offering training programs. However, there is still a need to address the shortage of skilled workers in the renewable energy sector in Morocco. In all three countries, there is a critical need for inclusive and just transitions that ensure all citizens are prepared for and benefit from the transition to a low-carbon economy.

2.4 Availability of skills programs in the European Union
Diverse actors in the European context are engaged in developing, aligning and diffusing programs to bolster the current and future hydrogen workforce. To effectively educate, upskill and reskill individuals and address the needs of the hydrogen sector, a set of six strategic axes have been proposed for consideration:[91]
- Develop modular trainings
- Define training standards for hydrogen
- Improve access to continuing professional development
- Establish an online hydrogen community
- Encourage the uptake of mobility for education in hydrogen
- Promote the attractiveness and raise awareness of the hydrogen sector

In today's landscape, there are programs on a European level and national-led initiatives. One such European initiative is the Green Skills for Hydrogen (GreenSkills4H2)[92] program, which is an Erasmus+ Project, co-funded by the European Union. It is coordinated by the Karlsruhe Institute of Technology and has a total of 34 hydrogen sector partners from 15 Member states of the European Union. It focuses on enabling workers to access new employment opportunities within the hydrogen sector by rolling out VET programs across Europe and establishing a partnership between Industry and Education. National initiatives, such as Germany's National Innovation Program for Hydrogen and Fuel Cell Technology (NIP), demonstrate strong government commitment to fostering hydrogen research, innovation and expertise. Furthermore, Germany aims to collaborate with export markets to encourage partnership in vocational training and intensifying the endeavours to enhance capacity through specific programs.[93] An example of this is the partnership between research institutions in Germany and the WASCAL graduate schools in West Africa through which students are enrolled in the new International Master's Programme in Energy and Green Hydrogen (IMP-EGH), sponsored by the Federal Ministry of Education and Research (BMBF).[94]

89 https://documents1.worldbank.org/curated/en/099012324071522189/pdf/P1705461161e5d8813e9114dbf-1b92a137252142a242.pdf
90 https://documents1.worldbank.org/curated/en/099012324071522189/pdf/P1705461161e5d8813e9114dbf-1b92a137252142a242.pdf
91 Green-Skills-for-Hydrogen-European-Hydrogen-Skills-Strategy-last-update-24102023.pdf (greenskillsforhydrogen.eu)
92 https://greenskillsforhydrogen.eu/
93 https://www.bmwk.de/Redaktion/EN/Publikationen/Energie/report-of-the-federal-government-on-the-implementation-of-the-national-hydrogen-strategy.pdf?__blob=publicationFile&v=1
94 https://www.deutschland.de/en/topic/knowledge/german-african-masters-programme-i-green-hydrogen

Annex 2 offers an overview of relevant actors and skill programs available on European level (non-exhaustive). Based on our analysis, these existing hydrogen training programs across Europe offer a robust foundation in hydrogen technologies, leveraging strong academic collaboration, extensive research components, and partnerships with industry leaders. They provide comprehensive coverage of the hydrogen value chain, from production to application, and emphasise sustainability, innovation, and policy integration. These programs cater to diverse audiences, including university students, researchers, vocational trainees, and industry professionals, ensuring that participants gain theoretical knowledge and some practical experience. However, there are areas where these programs could improve to create a more holistic and globally relevant training ecosystem. A significant gap lies in the limited practical, hands-on training opportunities which are crucial for real-world application and industry readiness. Additionally, most programs have a predominantly European focus and do not sufficiently address the unique needs and conditions of emerging markets and developing countries. There is also room for enhanced integration with industry partners to provide more direct insights, internships, and real-world project experience. Furthermore, a new program could better address financial and economic aspects specific to diverse global contexts and incorporate cultural and societal adaptation strategies to ensure broader acceptance and implementation of hydrogen technologies.
By addressing these gaps and ensuring funding with win-win commercial partnerships, a new program could offer a more practical, globally adaptable and accessible, and industry-integrated training experience, fostering a skilled workforce capable of driving the global hydrogen economy forward.

Looking at the current offer, the actors in the space are mobilised by different interests: while some actors are offering courses because of the attractive financial business case behind this, others are motivated by developmental aspects in contributing to the Sustainable Development Goals and supporting countries in the Global South to reach their development objectives and Nationally Determined Contributions (NDCs). Not a lot of funding is available in developing markets to purchase such courses to upskill/reskill their workforce. Hence, it is important to fully understand the aim of the different programs available to identify which players are focused on establishing long-lasting relationships to stimulate win-win thinking over commercial benefits.

Despite all the mapping opportunities into African focus countries' needs and all the excellent work being done across Europe, it can be concluded that there is a lack of specific hydrogen education and training programs. On-the-job training, shared experiences within teams and internal knowledge accumulation are currently addressing the gap of hydrogen qualifications. Looking specifically at skills, industrial players are mainly concerned about the technical and safety aspects of hydrogen in their demand for qualified personnel. The need for hydrogen education has also been identified within public actors (e.g. government or local officials) across all levels. The lack of competences of these actors, specifically regarding safety and risks aspects of hydrogen projects can be a burden for the development of the sector. Indeed, these occupational profiles have no previous experiences with such projects, and hence regulatory approvals and permits from public actors will be needed to move ahead. Hydrogen training is necessary from local to global policymakers, in order to define and implement strategies, public fundings and regulatory approvals.[95]

2.5 Key insights

Transitioning knowledge and skills on hydrogen towards countries like South Africa, Namibia, and Morocco requires a nuanced approach that considers the specific contexts, needs, and challenges of each country. Please see below for a summary of some of the key lessons and takeaways for effectively transferring knowledge and skills:

- **Tailored solutions per country**: Regarding the content of the curriculum, one-size-fits-all solutions will not work. Each country has unique socio-economic, environmental, and technological characteristics that must be considered when designing hydrogen training programs;
- **Foster international collaboration**: Facilitate knowledge sharing and collaboration between European experts and local stakeholders in South Africa, Namibia, and Morocco via embassies. Leverage existing international partnerships and initiatives to access funding, expertise, and good practices;
- **Local capacity building**: Investing in local capacity building and skills development is a clear opportunity. It gives local communities the opportunity to participate in the development and have a voice. It can play an empowering role;
- **Collaborative partnerships**: Fostering partnerships between government, industry, academia, and international expertise is important to leverage expertise, resources and funding opportunities. Collaboration can accelerate progress and enhance the effectiveness of hydrogen projects;
- **Address infrastructure challenges**: Prioritise the development of hydrogen infrastructure, including production, storage, and distribution networks, to support the uptake of hydrogen technologies. Consider the availability of resources such as water and land for hydrogen production and deployment of infrastructure, consider diverse sources of electricity for energy security.

95 Final-deliverable-T2.1.pdf (greenskillsforhydrogen.eu)

Chapter 3:

Make Hydrogen Work proposition and the Dutch offering

3.1 Introducing Make Hydrogen Work-International

GroenvermogenNL (GVNL) focuses on accelerating a well-functioning market for the industrial use of green hydrogen.[96] In doing so, it executes the Human Capital Agenda (HCA) of the Dutch National Hydrogen Program. The central question in executing on this agenda is how to generate enough people with the right skills for the green hydrogen transition. With the Make Hydrogen Work initiative, GroenvermogenNL offers professionals who want to acquire hydrogen skills a route to obtaining the right skills. The program distinguishes seven regions in the Netherlands who have created roadmaps in 2023 with a regional pathway to sufficient human capital for the hydrogen transition. These roadmaps contain the approach, projects, as well as priorities in the regions, and offer a platform for national coordination through which the regions come together to develop smart investment strategies.

Nationwide tools are being developed which are used and implemented regionally. The concept also shows what regional supply is available or currently under development. A crucial component in Make Hydrogen Work is that the modules are linked to individual learning paths. Skills-gap analyses show the specific skillsets required for employees to successfully transition into the green hydrogen economy. As part of this, Make Hydrogen Work also offers a guidance program for professionals who require on-the-job training or reskilling.

GroenvermogenNL coordinates the Make Hydrogen Work concept at the national level, while the seven regions are responsible for its execution in The Netherlands. The ambition of Make Hydrogen Work is to work internationally with, for example, campuses in Europe and producing countries in the Global South, with the ultimate goal of creating an international network of campuses for knowledge sharing and to skill professionals needed to execute on the green hydrogen transition globally. In the remainder of this chapter, we will focus on the rollout of the international proposition of Make Hydrogen Work.

3.2 Opportunities and challenges for rolling out the Make Hydrogen Work proposition in Namibia, Morocco, and South Africa

Opportunities

In recent years, Dutch private and governmental organisations have been actively engaged in **fostering collaboration and building networks** in regions prioritising hydrogen development. While their focus is broad, attention has been particularly drawn to three countries where significant strides are being made in advancing hydrogen initiatives. Morocco, for instance, has emerged as a key player in the hydrogen landscape, driven by its status as a heavily import-dependent nation. In response, Moroccan leadership has expressed a keen interest in gaining energy independence through hydrogen technologies. This aligns with broader trends across the targeted countries, where political leadership is increasingly open to exploring hydrogen as a pathway to sustainable energy transitions.

One common thread among the nations in scope is the **recognition of a skills gap** in hydrogen development. To address this, efforts must be made to equip local institutions with sufficient capacity, to enhance practical learning opportunities in sustainable formats. Additionally, there is a growing need for contextualised content knowledge, with a focus on integrating hydrogen technologies with other Power-to-X (PtX) solutions. Job placement programs must also be prioritised to ensure that trained professionals can seamlessly transition into, or throughout, the workforce.

Universities in Namibia, South Africa and Morocco are **open to collaboration** with Dutch partners to develop and refine curriculum offerings tailored to the specific needs and capabilities of their local contexts. While the existing curriculum often falls short of addressing the nuanced needs, there is a shared interest in co-creating educational resources that reflect the unique challenges and opportunities in hydrogen development. Moreover, European universities and VET colleges stand ready to engage in knowledge exchange initiatives, presenting both local and Dutch stakeholders with valuable learning opportunities while also offering their own insights and expertise.

The Netherlands harbours **vast experience with institutional capacity building** of vocational training, applied sciences, and academic universities. Capacity building is regarded as an essential component of public-private partnerships. The Dutch government has been supporting post-secondary training institutions and tailor-made training programs in Sub-Saharan Africa through the Mena Scholarship programme (MSP) and the Orange Knowledge Programme for many years. Additionally, countries with fewer legislative restrictions have demonstrated **higher levels of (radical) innovation**. This highlights the importance of fostering environments conducive to experimentation and entrepreneurialism, where bold ideas can flourish without undue regulatory constraints. By embracing a **two-way learning platform** that encourages knowledge sharing and collaboration, Dutch stakeholders stand to benefit from the innovative approaches and fresh perspectives emerging from these dynamic regions.
As partnerships deepen and collaborative efforts gain momentum, the stage is set for transformative advancements in hydrogen development that promise to reshape energy landscapes and drive sustainable growth across borders.

96 Groenvermogen - Groenvermogen (groenvermogennl.org)

Challenges
Inherently challenging to the rolling out of a MHW proposition is the **contextualisation needed to adapt for relevancy in each setting**. The African context, whether North or South, differs greatly from The Netherlands and each focus country differs significantly from the others. Therefore, it is impossible to copy-paste Dutch training programs on hydrogen to these countries. Sensitivity to water scarcity, renewable electricity availability, poverty and other considerations must be embedded into all design and decision-making processes for a hydrogen system for it to be future proof and sustainable.

A willingness to listen to local needs and flexibility in means and methods of responding to them, will be needed. For example, flying in experts from abroad might be cheaper and/or more efficient for the installation and development phases of hydrogen projects. However, this should only be considered as an interim solution: to address local needs in the long term, it is essential to focus on capacity building and skills development locally to decrease dependencies between the Global South and North. There is significant high-level expertise available in the focus countries and there is an important role for European actors to further enable and scale the development of such skills in-country.

With no production yet running at scale, **the exact needs and opportunities are difficult to define**. The skills gap for hydrogen is still hypothetical, but in terms of numbers, the number of employees needed in the hydrogen, and the wider renewable energy sector, is likely to be lower compared to fossil industries. A potential solution would be for countries to create high-value (export) products with renewable energy and hydrogen. For example, not only producing hydrogen, but also producing methanol and sustainable aviation fuels, or also developing electrolyser components locally.

Another reality to reconcile is that **investment schemes are focused on producing hydrogen for the lowest price possible**. This is not likely to be the right incentive for focusing on local development and employing the local community. Any association with exploitative and/or neo-colonialist actions leads to an increasing amount of local opposition towards hydrogen developments. The voices of powerful lobbying groups in the fossil fuel and mining sectors are amplified when, for example, South Africans are doubly affected by losing their jobs while also experiencing extreme disruptions in energy provision in the form of load shedding.

3.3 In what ways can The Netherlands draw attention to its offering?
In drawing attention to the Dutch hydrogen offering, the Netherlands can employ various strategies to highlight its strengths and contributions to the global hydrogen economy. Our research has identified the following five unique selling points for The Netherlands:

1. **Established Networks:** Several Dutch organizations are significantly contributing to the development of hydrogen infrastructure in various countries. These organizations are not only investing in and leading hydrogen projects but also establishing local networks to foster collaboration, share knowledge, and ensure the successful implementation of hydrogen technologies.

2. **Dutch Governmental Involvement:** The Dutch government actively participates in hydrogen development through initiatives such as signing Letters of Intent and funding projects, demonstrating a commitment to driving the transition towards a hydrogen economy. These are often the result of trade missions[97] initiated by the Dutch government such as the trade mission on green hydrogen to South Africa held in October 2023. Going forward, the importance of skills development should be embedded much more prominently in the design of future trade missions, including the right partners from within the Dutch ecosystem to further capitalise on building mutually beneficial partnerships in skills development between Dutch players and institutions in-country.

3. **Systems Thinking Approach**: The Netherlands adopts a system thinking approach. Systems thinking in the hydrogen transition involves viewing the hydrogen economy as an interconnected whole, considering all components from production and storage to distribution and end-use. Systems thinking requires a holistic approach: from production (such as electrolysis) and storage (in tanks or underground facilities) to distribution (via pipelines or transport vehicles) and end-use (in industry or transport). It emphasises the interconnectedness between different systems and the feedback loops that can arise. For example, the demand for hydrogen in the transport sector can impact the required infrastructure for production and distribution, which in turn affects economic feasibility and environmental impacts. In the Netherlands, systems thinking is applied in the national hydrogen strategy. Systems thinking can be a unique selling point for the Make Hydrogen Work-international proposition because it allows for the development of an integrated and efficient hydrogen economy, setting the Netherlands apart as a leader in the energy transition.

97 https://tradewithnl.nl/sites/trade/files/files/2023-10/SouthAfrica1023_missieboekje_v3.pdf

4. **Just and Fair Transition**: By prioritising a just and fair transition, the Netherlands ensures that hydrogen projects consider social, economic, and environmental implications. Focusing on holistic, fair, and just hydrogen infrastructure development means going beyond technical expertise and incorporating these social, economic, and environmental considerations. This comprehensive approach ensures that the hydrogen transition benefits all stakeholders, supports sustainable development, and fosters a more equitable and inclusive society. By prioritising these values, the Netherlands can set a global example of how to build a just and sustainable hydrogen economy.

5. **Addressing Trade-Offs:** The Dutch approach acknowledges the complexities and trade-offs involved in setting up hydrogen systems in target countries, enabling informed decision-making and balanced solutions. The strong focus on topics such as inclusion and safeguarding a fair and just transition provide the Netherlands with a significant competitive advantage over other countries looking to import green hydrogen. In rolling out their hydrogen strategies, government entities in South Africa, Namibia and Morocco will increasingly look at the inclusion agenda of green hydrogen training programmes. As such, indicators such as job-creation in social-economically marginalised areas and economic cluster development of regions that supports a holistic development approach of poverty alleviation will play an important role in political decision-making processes. Currently, these areas score low on education and training facilities but could be designated as focus areas by local governments. By addressing these trade-offs and by showing a willingness to engage on such topics, the Netherlands can increase its leverage while simultaneously helping to meet political agendas.

3.4 What is the role of Make Hydrogen Work, and how can the Make Hydrogen Work program be organised effectively and efficiently?

To ensure an effective and efficient organization for Make Hydrogen Work-International, we propose to act on two levels which operate in parallel: 1. Strategic actions with long term focus; and 2. Operational actions with short term focus. This approach will allow to keep the bigger picture in mind and work on strategic collaboration across organisations, while also getting into action mode and starting pilots of collaboration with Namibia, South Africa and/or Morocco.

Strategic actions:

1. Develop strategic partnerships with other European stakeholders in the field. Building a hydrogen economy is a major undertaking, that no single country can achieve by itself. It is therefore imperative that the Netherlands continues to work in close international cooperation with its neighbouring countries in the European Union in research development, European policies, flagship projects and implementation of new technologies that the world can benefit from. For example, by better aligning with the European Commission's Global Gateway strategy set up by the European Commission in country initiatives in Sub-Saharan Africa, The Netherlands can further strengthen its position as an important player in the green hydrogen economy globally. Example projects include "Just Energy Transition Partnership in South Africa[98]" and "Inclusive Green Growth with Namibia[99]".

2. Build propositions per country: Align the Make Hydrogen Work proposition with existing roadmaps and strategies developed by the countries and/or continents in scope. For example, review Agenda 2063, Africa's strategic framework that aims to deliver on its goal for inclusive and sustainable development[100]. On a country level, further review the Hydrogen Society Roadmap of South Africa[101] and the Labour Market Intelligence report on Identification of Skills Needed for the Hydrogen Economy in South Africa[102] as well as the National Hydrogen Strategy of Morocco, which addresses the plans to set up a research and innovation cluster[103]. Reviewing these strategies is key for developing a curriculum for these specific countries, as it gives insight in the timelines and focus areas of these countries. For example, Morocco clearly focuses on hydrogen production for local feedstock and ammonia production in the short term. From 2030-2040 they will start working on production of hydrogen for export as well. On the other hand, South Africa focuses on creating high value export products, as they are already producing (brown/grey) hydrogen at the moment. For South Africa the focus will be more on renewable electricity production and producing high value export products while simultaneously meeting local demand.

98 Initiatives in Sub-Saharan Africa - European Commission (europa.eu)
99 Inclusive Green Growth with Namibia - European Commission (europa.eu)
100 Agenda 2063: The Africa We Want. | African Union (au.int)
101 South_African_Hydrogen_Society_RoadmapV1.pdf (dst.gov.za)
102 Identification of Skills Needed for the Hydrogen Economy | LMI (lmi-research.org.za)
103 National Hydrogen Strategy – Policies - IEA

3. Develop public-private partnerships in The Netherlands with a specific focus on international collaboration (outside of the EU) with a solid financial budget: to successfully roll out the MHW proposition internationally, availability of sufficient funding to finance activities will be key. Hence, we recommend forming a consortium of key stakeholders in the Dutch green hydrogen landscape, composed of public and private institutions, which in a concerted way can apply for available funding/subsidies, benefiting from each other's competitive advantages and added value in doing so. Current public-private partnerships set up by GroenvermogenNL can serve as a foundation for expanding internationally.

4. Collaborate with RVO for Make Hydrogen Work to play a role in the Combi Approach[104]. The Combi Approach Toolkit (in Dutch "Combi Aanpak Tool Kit") aims to combine trade, investments and development cooperation with the aim to tackle contemporary challenges like climate change. Different organisations contribute to solutions, including Dutch companies, knowledge institutes and societal organisations. Make Hydrogen Work could be one of the organisations that contributes to the listed Combi Approach Projects identified by RVO as well as ongoing skills development initiatives by Nuffic. Relevant projects include "Dutch proposition green hydrogen (GH2) to Namibia"[105] and "Dutch proposition green hydrogen (GH2) to South Africa"[106] (please note both projects are currently completed).

5. The Dutch Government, in collaboration with the Dutch private sector, should jointly identify knowledge gaps and define training and capacity-building priorities, strengthening the role of existing networks to share knowledge and provide guidance, tools, and resources to build capacity across these countries. This includes a focus on supporting developing countries with implementing and increasing the stringency of building energy codes. Countries should also work together to assist in curriculum design, implementation of training programmes and accreditation frameworks to enhance the transferability of skills and qualifications, and ultimately promote net zero and resilient building practices.[107]

Operational actions:

1. Identify relevant knowledge institutions/campuses in Namibia, South Africa, and/or Morocco for potential collaboration and invite them to become part of the Make Hydrogen Work network. The current network only exists of Dutch knowledge institutions: this could form the core network. The international network could be organised in a comparable manner around the core network. One such organization to collaborate with in this regard is Nuffic. The local Southern African office of Nuffic is currently conducting a study which has been commissioned by RVO to map the current training and skilling landscape in South Africa as well as its respective stakeholders. It is recommended that MHW joins forces with existing initiatives in-country that are already under development. This recommendation is further elaborated on in Chapter 4.

2. Set up a skills training program and/or knowledge exchange program with a knowledge institution close to a hydrogen development area. Take a local approach to determine on which areas to focus and what the scope of the training materials should be. A first successful pilot program could function as a case study to further develop the international proposition of Make Hydrogen Work. An initiative to be built on in this regard is the MENA Scholarship Programme (MSP) which Nuffic manages on behalf of the Dutch Ministry of Foreign Affairs. Nuffic and the Dutch Embassy in Morocco initiated a knowledge exchange program on port management and hydrogen between the National Ports Agency in Casablanca, Morocco and STC next, the Port of Rotterdam and Erasmus University Rotterdam.[108] Where possible, MHW should align with such existing initiatives.

3. Develop a course on creating fair and just transition for hydrogen in Namibia, South Africa and/or Morocco together with actors in country. It is crucial that such an exercise is undertaken in collaboration with local government actors and that the voice of local communities is taken into account. As such, the course should be aimed towards local communities that want to be involved in the hydrogen transition, to ensure they are empowered to speak up about local social and environmental issues, and to ensure local communities can equally benefit from economic development in their area. In this course, attention should be given to the trade-offs that come with green hydrogen development: is it ethical to use high amounts of water for hydrogen development in case of water scarcity? Is it ethical to use high amounts of renewable electricity if local energy availability is uncertain?

104 Combi Approach Toolkit (CATK) | Project Database CMS (rvo.nl)
105 Dutch proposition green hydrogen (GH2) to Namibia | Project Database CMS (rvo.nl)
106 Dutch proposition green hydrogen (GH2) to South Africa | Project Database CMS (rvo.nl)
107 The Breakthrough Agenda Report 2023 (mc-cd8320d4-36a1-40ac-83cc-3389-cdn-endpoint.azureedge.net)
108 MENA Scholarship Programme (MSP) | Nuffic

4. Ensure there is an important role for Make Hydrogen Work in upcoming trade mission to Namibia (September 2024) and beyond as well as in the development of future MoU's and LoI's. Our research has identified that that the skills development component is currently significantly underexposed in Dutch trade missions, and subsequent government to government agreements, whilst skills development should play an integral role. Knowledge missions also prove to be key in furthering the collaboration between countries.[109] Where possible, alignment between trade missions and knowledge missions should be sought. As indicated by James Mnyupe during the Green Hydrogen Summit in Rotterdam, the Netherlands (June 2024), skills development is an essential element for further hydrogen development in Namibia. Namibia is setting up a Green Hydrogen Research Institute.[110] For support on technical knowhow development, they are looking at the EU. Make Hydrogen Work should get involved with RVO in the short-term by offering a proposition on collaboration with local knowledge institutions in Namibia. In addition, MHW should work together with industry players in stimulating them to take up a more active role as a partner instead of only focusing on importing green hydrogen. This should take the form of a public-private partnership, including a stronger focus on R&D.

109 https://www.nwo.nl/en/news/knowledge-mission-to-south-africa-opportunity-for-science
110 https://www.unam.edu.na/nghri

Chapter 4:

Conclusion and recommendations for MHW international

We observe a clear opportunity for the international proposition of Make Hydrogen Work
The Netherlands is a frontrunner on hydrogen development and knowledge on the green hydrogen transition. The Netherlands set up MOUs with Namibia, South Africa and Morocco to collaborate on green hydrogen development. Important Dutch stakeholders like Port of Rotterdam and Invest International are already setting up a network and collaborate actively with these countries.

On the other hand, the African countries in scope are committing to play a role in the hydrogen transition. Each country has unique geographical advantages and renewable energy potential and have announced their intention to intensify collaboration toward the development of green hydrogen projects on the African continent as member states of the African Green Hydrogen Alliance (AGHA).

Morocco, South Africa and Namibia face several shared challenges for advancing green hydrogen initiatives, including policy and technology uncertainty, complexity of the value chain, and lack of regulations and standards. Attention points for further development are financing of projects and skills development and capacity building locally.
Job opportunities span across the entire value chain and require both practical skills and academic skills. Human capital development should be at the core of the energy strategy of a country, to really seize the opportunity for economic development and job creation. For highly industrialised countries like South Africa, focus should be on reskilling towards renewable energy and green hydrogen specifically. For Namibia, focus should be on developing the full hydrogen system, including infrastructure and other contextual factors. For Morocco, focus is both on strengthening the pool of technicians, while also ensuring sufficient training programs in the specific areas where large-scale renewable energy projects are planned.

The Netherlands can draw attention to its offering by focusing on its unique selling points
Unique selling points include the established networks of several Dutch organisations already contributing to the development of hydrogen infrastructure in several countries. Also, involvement of the Dutch government can accelerate rolling out the Make Hydrogen Proposition. The Netherlands has a lot of expertise on infrastructure development: best practice examples such as the Port of Rotterdam creating corridors for energy as well as existing knowledge from leading Dutch oil and gas companies on developing local gas networks can be leveraged in these countries. In addition, the Netherlands has established itself as a strong player in the field of institutional capacity building and vocational training, as well as Universities of Applied Sciences and academic universities. This forms an essential component of public-private partnerships in knowledge development and its applications. It also addressed the need for stronger regional economic cluster relationships between government entities, business development associations and professional/vocational education providers (promotion of the Triple Helix/Dutch Diamond approaches of Dutch MBO and HBO models).

In Europe, several hydrogen focused training programs have been developed, but often with a commercial business model. Adopting a holistic perspective of energy systems and hydrogen development provides an opportunity for Make Hydrogen Work. Focus should be on creating a fair and just transition that is mutually beneficial for all countries involved. The aim is to address sustainable development and economic development in these countries, taking a systems thinking perspective and addressing the trade-offs in the market (e.g. what is the best use of renewable energy?). Local communities should be educated to empower them to play a role in the transition and speak up for their rights.

To effectively organise Make Hydrogen Work, act on both operational and strategic level
It is important an actionable roadmap is developed on operational and strategic level simultaneously, as the discussion on knowledge development for hydrogen should be well structured and well organised. In this regard, it is important to develop a centralised and strategic approach. On the other hand, as time is of the essence, it is important to get started and start setting up best practice examples and pilots for international collaboration. Subsequently, these learnings can be used for the further development of the proposition internationally.

On a strategic level, it is important to focus on setting up partnerships with other European stakeholders in the field and to start aligning the Make Hydrogen Work proposition with country specific roadmaps and (human capital) strategies developed by the countries in scope.

Collaboration with RVO, the Dutch Ministry of Foreign Affairs (including embassies), and educational organisations such as Nuffic should be explored. Currently, there is momentum for an organisation like MHW, especially as local representatives in Namibia and South Africa are identifying the need for knowledge from the EU and the EU is organising trade missions and showing interest in these countries. By thinking big and acting bold, MHW can become an essential actor in the proposition of the Dutch government to collaborate with countries developing their hydrogen production. MHW should leverage the momentum and step up as MHW possesses a unique network of knowledge and a great organisational structure (network structure with public-private partnerships).

On operational level, it is important to start pilots and work on creating best practice examples for international collaboration of Make Hydrogen Work. In collaboration with stakeholders currently active in Morocco, Namibia and South Africa (e.g., RVO, Port of Rotterdam and Nuffic), MWH could find relevant campuses and knowledge institutions to start collaborating with in the short term. Together with these institutions, the international curriculum of MHW can be developed and shaped.

Content of the curriculum should play into the needs of the regions internationally
As previously highlighted in this report, it is important to consider the specific context of the region when developing the MHW-international curriculum for a specific country. In Chapter 2, several insights on the specific skills and knowledge gap are addressed.

Specifically for Namibia, it was found that there is a mismatch between what is taught in schools versus what the industry needs now and in the future. Research by GIZ[111] specifically recommends the need for developing industry-driven curricula: they recommend the educational institutions to collaborate with the PtX industry to design curricula that emphasise practical training and internships. With the experience of public private partnerships in The Netherlands, MHW-International could potentially facilitate these partnerships and this curriculum development. Another recommendation for Namibia is to start enhancing research and development initiatives. By promoting collaboration between universities, research institutions and industry partners, the quality of education specifically on PtX can be improved. MHW-International could take part in these partnerships and help to set up a local network.
In South Africa, being a highly industrialised country, focus should be on reskilling engineers for hydrogen technology specifically. This includes project managers, electrical engineers, and energy engineers. Universities offer engineering programs, and while degrees in energy studies are emerging, PtX is currently underdeveloped. Experts have suggested setting up skills programs that directly tap into local communities and are imparted by accredited institutions. As per a GIZ report on TVET in South Africa[112], technical and vocational education is crucial to prepare the labour force for a just transition, but these systems need to be strengthened and aligned with comprehensive social protection measures. In light of these challenges, South Africa will be setting up a Just Energy Transition (JET) desk to improve on skills coordination.

Morocco needs more technical and vocational education and training (TVET) programs in regions with high solar and wind potential, and the promotion of apprenticeships is necessary. To achieve this goal, universities and engineering schools are recommended to cooperate with the private sector, which can facilitate the movement of workers across sectors and provide short-term courses, on-the-job training, and employment matching services.
Maintaining a just transition is also essential in all three countries, ensuring that all local communities benefit from the green transition agenda. For example, disadvantaged youth should have access to training through scholarships and boarding schools. Companies can adopt inclusive measures to increase women's access to job opportunities. Compartmentalising training can help workers easily acquire lacking skills, and distributing upskilling programs across the country could help bridge the gap between rural and urban areas, thus maximising the benefits of the energy transition agenda.

In conclusion, with the experience of MHW-international, the proposition could play an accelerating role in addressing the skills gaps for green hydrogen in Namibia, South African and Morocco. In consultation with local knowledge institutions and campuses, the specific format of the collaboration should be agreed upon. Examples include exchange programs, online training courses, networking events, guidance on setting up public-private partnerships, and train-the-trainer programs.

111 https://ptx-hub.org/wp-content/uploads/2023/08/International-PtX-Hub_202308_Namibia-PtX-skills-needs-assessment.pdf

112 https://www.giz.de/en/downloads_els/paper%20Skills%20for%20a%20Just%20Transition%20to%20a%20Green%20Future%20final.pdf

The Dutch (network) structure of Make Hydrogen Work can be expanded internationally
MHW is a network of knowledge institutions, focused on developing tools nationwide, which are used and implemented regionally. In this concept, regional needs and supply are being considered. This way of working can be extended internationally, by adding new knowledge institutions and campuses to the MHW network on a local basis. By identifying interesting areas per country (for example Lüderitz in Namibia) and by collaborating with the Dutch embassies as well as existing initiatives created by RVO and Nuffic, MWH can help to target the specific needs regarding skills development in the region.

MHW works with modules linked to individual development paths. Skills-gap analyses are used to determine what skills development is needed for employees to transition into the green hydrogen economy. Also adopting this approach internationally can help to ensure education is linked to personal needs and organised efficiently. The use of micro credentials proves a promising mechanism to address skills gaps and should also be further explored in these international collaborations.

GroenvermogenNL can also serve as a best practice example internationally. For example, in South Africa several skills development programs are being set up, but they are not centralised and not connected as clearly to the implementation of a human capital agenda. South Africa is currently in the process of setting up a coordination body which must be South African led to ensure local ownership. GroenvermogenNL, which enables public and private actors to collaborate in setting up an integrated approach for developing a powerful national innovation ecosystem for hydrogen development, could play an important additional role in advising on and building out such structures. To ensure efficiency in this approach, it is important that GroenvermogenNL connects to already ongoing government to government discussions between countries.

To overlook the implementation of the actions identified for MHW-international, a steering committee could be set up. This steering committee could have the responsibility to keep oversight and ensure both the strategic action points as well as the operational action points are being implemented in parallel. The steering committee could meet on an ongoing basis, e.g. quarterly, to discuss the progress and any challenges that may arise. Both representatives from The Netherlands, as well as representatives from the countries in scope should be represented in the steering committee. Additionally, MHW-International could reach out to experts in The Netherlands on the topic of international collaboration for sustainable development, like KIT Royal Tropical Institue and Wageningen University (WUR). Representatives of these organisations could also play a role in the steering committee.

Collaborate with other programs and countries to work towards complementary approaches
As highlighted in Chapter 2.4, several other European training programs are already in place. Other countries like Germany and Belgium are also investing in a collaboration with hydrogen producing countries in Africa. MHW should consider leveraging the strengths and expertise of other countries to create a cohesive and impactful approach. Rather than working in silos, creating a collaborative approach on complementary topics can lead to a more effective and well-rounded strategy. It is important to avoid duplicating efforts and strive for alignment to maximise the collective impact. By focusing on both the unique selling points identified in Chapter 3.3 and contributing at the European level to the European Commission's Global Gateway strategy, a collaborative approach between countries focused on sustainable development and creating a fair and just transition can be achieved.

Do not overlook the importance and potential of having access to sufficient funding
To successfully roll out the MHW proposition internationally, availability of sufficient funding to finance skills development activities will be key. When looking at current sources of funding available for the green hydrogen transition, there seems to be a lack of funding flowing into skills development, with the majority of funding focusing on project development and construction stages. To turn this around, much more capital should be made available for skills development (i.e. in the form of technical assistance) in order to enable a successful transition: the green hydrogen economy will not come to fruition if the workforce is not sufficiently skilled.

MHW should take a coordinating role in bringing together a consortium of key stakeholders in the Dutch green hydrogen landscape, composed of public and private institutions, which in a concerted way can apply for available funding/ subsidies, benefiting from each other's competitive advantages and added value in doing so. As a first step, a mapping exercise should be undertaken in which donors and other funders (both at the national and international level) active in the area of skills development for green hydrogen are identified. In addition, the Dutch government could position itself better as an important and reliable partner in skills development for African economies if it would strategically label its pockets of funding for these countries to be specifically dedicated to skills development - instead of presenting funding for the green hydrogen transition more generally - as this demonstrates a strong willingness to engage in and support on skills development specifically which subsequently will help in strengthening government to government relations. MHW can play a facilitating role in this by putting skills development higher on the agenda for future Dutch and European trade missions.

By focusing on two-way learning, equal partnerships between countries can be realised
Make Hydrogen Work-international is not built on a commercial business model: its aim is to realise an international network of campuses for knowledge sharing and skills development to close the skills gap for the green hydrogen transition. To achieve this at the international level, it is key to listen first and act later: do not push the Dutch proposition or way of working internationally, but really engage with international campuses to see what their needs are and to identify where MHW can be additional. Based on the outcome of such conversations, MHW should focus on a tailored collaboration in which mutual learning is ensured.

When applying this strategy, Make Hydrogen Work-international will avoid competition with other European skills programs for hydrogen. This is fundamental as the skills development landscape has become hugely competitive over the past few years due to the multitude of programs and initiatives offered by European actors. By focusing on existing needs and gaps that have not yet been filled by other initiatives, Make Hydrogen Work-international can ensure added value and high impact creation.

Annex 1 – Interviewees and Sounding Board members

List of interviewees:

- Huba Boshoff (Nuffic)
- Armand Gaikema (Nuffic)
- Katharina Gihring (Nuffic)
- Ann Abheiden (International Business Development Manager, Gasunie)
- Representatives from RVO
- Representatives from National Commission on Research, Science and Technology
- Representative from TNO
- Representative from Noorderpoort
- Representative from STC-R
- Representative from Eco-Stream Nederland BV

In addition to the listed interviewees, all members from the Make Hydrogen Work sounding board have been interviewed (refer to p. 4)

Annex 2 – Overview of Green Hydrogen training programs in the EU

This table offers a comprehensive yet not exhaustive overview and analysis of European and cross-country education programs related to hydrogen, based on publicly available resources. Throughout Europe, there are numerous small-scale education initiatives for hydrogen at the country or cross-regional level, making it a diverse and scattered field.

Program	Green Skills for Hydrogen (GreenSkills4H2)	PtX.Academy	Hydrogen Centres of Vocational Excellence (H2CoVE)	European Hydrogen Academy (HyAcademy.EU)	H2Excellence: Fuel Cells and Green Hydrogen Centres of Vocational Excellence towards affordable, secure, and sustainable energy for Europe
Start year	2022 (4 year project)	2019	2024 (4 year project)	2024 (4 year project)	2023 (4 year project)
Summary	In 2022, GreenSkills for Hydrogen released the Hydrogen Skills Strategy to meet the REPowerEU2030 targets by upskilling and reskilling the workforce in Europe. In February 2024, they launched a Hydrogen Skills VET Curriculum tailored to market needs, and created the European Hydrogen Skills Community offering training programs and networking opportunities. Additionally, GreenSkills for Hydrogen plans to establish a European Hydrogen Skills Alliance to foster collaboration between industry and education. The Green Skills for Hydrogen partners comprise six Work Packages (WP): - Hydrogen Skills Alliance Management & Growth - Skills Intelligance, Needs Analysis & Skills Strategy - Core Curriculum, Qualifications and VET training - Rollout of VET Training Programme to meet existing and emerging skills needs - Europe Wide Dissemination, Adoption & European Impact - Long Term Sustainability and Impact	The International PtX Hub is a contribution to the German National Hydrogen Strategy of 2020 and represents one of the four pillars of the BMUV's PtX action programme. The International PtX Hub is a center of expertise and collaboration for green hydrogen and Power-to-X solutions. It establishes and nurtures strong networks with industry, academia, governments, and civil society with hubs in Africa, Asia, Europe, and Latin America. It works on accelerating sustainable aviation and shipping, developing PtX solutions, stakeholder dialogues, policy and regulatory advice, and capacity building. The PtX.Academy offers trainings and workshops for decision-makers on green hydrogen and Power-to-X.	H2CoVE aims to bring together five partner regions, with different expertise and asssets, to enhance Europe's capacity in the hydrogen value chain. The project will connect citizens, educational institutions, and businesses to promote knowledge sharing and innovation throuh a specialised platform. It will also focus on developing courses and programs to address industry needs and improve requires knowledge and skills among students, workers and the potential workforce. Furthermore, it will also ensure sustainability for projects by sharing best practices across regions. Deliverables include training for 150 teachers, upskilling activities for 1000 employees, and participation of 140 students in a project competition. At least 12 theses on sector challenges will also be developed.	The HyAcademy.EU aims to coordinate and support the development of hydrogen education and training across a network of European institutions. It will create over five jointly-used training laboratories for hydrogen technologies and establish networks of universities and schools offering qualifications and integrating hydrogen topics into their science teaching curriculum. Additionally, the Academy will provide free training materials in European languages, develop physical training laboratories, offer a portal for prospective trainees to access information about available educational programs, and prepare for the establishment of the European Net-Zero Hydrogen Academy. Leveraging previous investments made by the European Commission and Member States in education and training activities, the consortium will bring together representatives from various projects to merge and utilise previous results, maximiing the impact and outreach of the Academy.	The H2Excellence project aims to establish the H2Excellence Platform of Vocational Excellence in fuel cells and green hydrogen technologies. The project will create lifelong learning opportunities, including several local clusters, i.e., Centres of Vocational Excellence (CoVEs), fully integrated into the innovation, skills and job ecosystem in green hydrogen and fuel cell technologies in six Erasmus+ countries and two support/associated CoVEs in the other two Erasmus+ countries. It will also facilitate international cooperation in North America, particularly with Canada, for vocational education and training opportunities and exchange programs. H2Excellence aims to create world-class reference points for training in green hydrogen technologies and contribute to the skills development of individuals in the sector. This will involve various activities such as developing joint curricula, lifelong training, collaboration with universities, and partnerships with companies and professionals to integrate into national/regional economic and innovation ecosystems.

Program	Green Skills for Hydrogen (GreenSkills4H2)	PtX.Academy	Hydrogen Centres of Vocational Excellence (H2CoVE)	European Hydrogen Academy (HyAcademy.EU)	H2Excellence: Fuel Cells and Green Hydrogen Centres of Vocational Excellence towards affordable, secure, and sustainable energy for Europe
Countries involved	Europe (15 member states of the European Union are represented)	The program originates from Germany and involves collaboration with international partners and experts. A list of countries involved is accessible on the website: https://ptx-hub.org/countries/	5 regions in Europe (Vestland in Norway, Northern Netherlands, Tyrol in Austria, Estonia and Precarthian region in Ukraine)	Europe (Germany, Belgium, Bulgaria, Spain, Italy, The Netherlands, Czech Republic, Romania and the United Kingdom (England and Northern Ireland).	9 different Erasmus+ EU countries (Finland, Italy, Spain, Portugal, France, Germany, Poland, Greece, Romania) and 1 international partner (Canada)
Main funder	Green Skills for Hydrogen is an ERASMUS+ Project, co-funded by the European Union	The International PtX Hub is implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the German Federal Ministry for Economic Affairs and Climate Action (BMWK) and it is financed by the International Climate Initiative (Internationale Klimaschutzinitiative, IKI)	H2CoVe is an ERASMUS+ Project, co-funded by the European Union.	Clean Hydrogen Partnership and its members. UK Research and Innovation (UKRI) and Swiss Confederation Secretariat for Education, Research and Innovation (SERI). Co-funded by the European Union.	H2Excellence is funded by the European Union.
Collaborators	GreenSkills4H2 is an Alliance of Hydrogen sector partners led by Karlsruher Institut für Technologie (KIT), Hydrogen Europe and Hydrogen Europe Research, bringing together key Industry and Education stakeholders from across the sector. It has a total of 34 partners from 15 Member States of the European Union. Full list of members is available: https://greenskillsforhydrogen.eu/consortium-members/	"The PtX Hub builds and fosters strong networks with industry, academia, administrations, and civil society with hubs in Africa, Asia, Europe, and Latin America." Full list of partners is available: https://ptx-hub.org/wp-content/uploads/2023/11/International-PtX-Hub-flyer-digital_en.pdf	It is a collaboration between 27 partners, consisting of National and regional vocational training centers across Europe and industry partners from the European hydrogen sector. Full list of partners is available: https://peec.org.ua/en/?project=hydrogen-centres-of-vocational-excellence-h2cove	The programme brings together universities, companies and foundations from several European countries. It is led by the University of Birmingham and the University of Chemistry and Technology Prague. The full HyAcademy.EU Consortium is available: https://www.hyacademy.eu/	The project consortium consists of 24 partners from 9 different Erasmus+ countries (Finland, Italy, Spain, Portugal, France, Germany, Poland, Greece, Romania) and 1 international partner (Canada). The full consortium is available: https://h2excellence.eu/consortium/
Target audience	Three different typologies of target audiences: - Non-technical hydrogen workers: professionals in non-engineering roles (decision makers, managers, public administration, legislators, etc.). - Professionals with engineering/technical formation: professionals that start working in the hydrogen sector - Technical operators: workers in the installation, operation, and maintenance. The learners have different specialisations and need training for the installation/operation of hydrogen technologies (safety/maintenance operators).	Different target audiences (both German and international participants): - Primarily decision-makers in energy, environmental, economic, infrastructural ministries - Experts of regulatory authorities and other relevant administrations - Experts in public and private research institutes, energy federations and renewable energy agencies - Journalists and actors of civil society and - Professionals in the private sector	The education program targets different audiences: - Upskilling and reskilling students, workers, and the potential workforce - Upskilling teachers at different VET levels in Train-the-Trainer courses	The Academy has a focus on students and prospective trainees. It also aims to provide the necessary content and training to educational staff to deliver the material.	H2Excellence aims to provide education for: - Educational and training programmes for students and engineers - Upskilling and reskilling of professionals (e.g. Existing energy sector employees)

Program	Green Skills for Hydrogen (GreenSkills4H2)	PtX.Academy	Hydrogen Centres of Vocational Excellence (H2CoVE)	European Hydrogen Academy (HyAcademy.EU)	H2Excellence: Fuel Cells and Green Hydrogen Centres of Vocational Excellence towards affordable, secure, and sustainable energy for Europe
Training Program content	The core curriculum has been separated into 10 modules to address the competences needs identified: - Hydrogen basics - Hydrogen applications - Hydrogen technologies - Electrochemical systems - Hydrogen mobility - Hydrogen use: combustion, components, and detection - Hydrogen safety - Hydrogen economics - Environmental and social impact of hydrogen - Hydrogen initiatives and regulation Three courses have been detailed: (1) Introduction to Hydrogen: A complete introduction to gain a baseline knowledge of the hydrogen value chain (2) Hydrogen for technical profiles: A complete update on state-of-the-art and innovative hydrogen technologies (3) Hydrogen Skills for Safety and Maintenance Operators: An understanding of the innovative hydrogen technologies and the baseline skills for the operation and maintenance of the technologies.	The PtX.Academy has several training categories and formats: - PtX.Training: Basic Training, Add-on and target group-specific modules, and Train-of-Trainers programmes - PtX.e-Academy: web-based trainings and online content - Knowledge Base: The studies, tools, event recordings, videos, and graphics produced by the International PtX Hub are in a searchable repository known as the Knowledge Base. The training programs cover a comprehensive overview of the entire value chain of PtX, It follows a holistic approach to sustainability aspects of the PtX Hub's Environmental, Economic, Social and Governance Framework (EESG). In the additional modues, participants learn to discuss and assess potential application cases of renewable PtX products in their countries. More information about the various modules can be found on the website: https://ptx-hub.org/academy/	Training will be provided on basic and advanced applications for the hydrogen economy, Details on the training curriculum are not provided and will be based on the needs of the industry in the partner regions at different VET levels,	Details on the training curriculum are not provided.	Details on the training curriculum are not provided.

Program	Green Skills for Hydrogen (GreenSkills4H2)	PtX.Academy	Hydrogen Centres of Vocational Excellence (H2CoVE)	European Hydrogen Academy (HyAcademy.EU)	H2Excellence: Fuel Cells and Green Hydrogen Centres of Vocational Excellence towards affordable, secure, and sustainable energy for Europe
Distinct features ** Analysis made based on available online information*	- Tailored programs based on identified target audiences from the Skills Needs and Strategy - Cross-Collaboration between relevant stakeholders: Involves top-tier education and research institutions, industry organisations and employment organisations across Europe - Broad Curriculum: Covers a wide range of topics, from hydrogen production to policy and economics.	- Focus on Power-to-X: Comprehensive coverage of Power-to-X value chain, technologies and their applications. - International Collaboration: Partnerships with universities and institutions in emerging economies, promoting global knowledge exchange and find bottom-up solutions for specific local needs and demands (incl train-to-trainers programmes) - Industry-Relevant Training: Strong emphasis on practical and industry-relevant skills. - Tailored format: training can be adjusted with modules based on audience needs - Holistic sustainability approach and education: education involves the EESG Framework for Sustainable PtX	- Network of Vocational Centers: Establishes a Europe-wide network of vocational training centers. - Industry Integration: Close collaboration with industry to ensure training meets current market needs. - Leveraging regions knowledge and expertise strengths: Combining complementary assets and specialitions across the hydorgon value chain in Europe - Challenge-Based learning for students: specially designed project competition for students	- Student and Trainee Focus: The program aims to integrate hydrogen knowledge into new and existing science programs, create public awareness, and establish a comprehensive academic career. - Innovative Teaching Methods and Multilingual Materials: The goal is to update educational materials from previous projects to meet current educational standards and translate them into different languages to reach a wider audience. This includes translating the necessary technical vocabulary. - Free Access: The program provides free training materials in European languages to lecturers and teachers. This will enable educational staff to effectively deliver the necessary educational measures. - Hands-on Laboratories: A network of laboratories will be established to enhance resource-sharing for hydrogen technologies.	- Support for SMEs: foster international support to companies (SMEs) operating in green hydrogen through technical support, training, upskilling and reskilling employees - Increase the attractiveness of the sector: developing open innovation, competitions and flagship projects towards increase fo the attractiveness of the sector among VET students, teachers, engineers and professionals - Building a holistic network: the project wants to establish a solid collaborative education-business-research network
Potential areas of improvement ** Analysis made based on available online information*	- Limited Practical Training: the program is focused on academic education. Further integration with industry could enhance the practical relevance of the training. - Regional Focus: Predominantly European-focused, it may not fully address the needs of emerging markets or adapt to non-European contexts. - Education materials gaps: whilst the program covers a broad range of topics, there are gaps in the distribution of the education material, in particular: hydrogen mobility, hydrogen economics, E&S impacts, and Hydrogen Initiatives and Regulation (based on figure 4 and 5 in Hydrogen Skills Core VET Curriculum report)	- European knowledge sharing: PtX.Hub partners predominantly with non-European countries. It could be beneficial to faciliate knowledge sharing with European countries. - Narrow Focus: While the focus on Power-to-X technologies is a strength, it may limit exposure to the broader hydrogen economy and its diverse applications.	- Geographic Scope: While extensive in Europe, the program could benefit from expanding its reach to include more non-European countries, addressing global vocational training needs. - Industry Partnership for practical education: Expanding partnerships with industry players to increase practical experience and learning,	- Emerging Markets: The program could benefit from incorporating more content relevant to emerging markets, ensuring global applicability. - Industry Collaboration: Increased direct collaboration with industry partners could provide more practical insights and employment opportunities for graduates.	- Emerging Markets: The program could benefit from incorporating more content relevant to emerging markets, ensuring global applicability. - Industry Partnership for practical education: Expanding partnerships with industry players to increase practical experience and learning,

Program	Green Skills for Hydrogen (GreenSkills4H2)	PtX.Academy	Hydrogen Centres of Vocational Excellence (H2CoVE)	European Hydrogen Academy (HyAcademy.EU)	H2Excellence: Fuel Cells and Green Hydrogen Centres of Vocational Excellence towards affordable, secure, and sustainable energy for Europe
Resources consulted for this table overview	*Green Skills for Hydrogen (https://greenskillsforhydrogen.eu/)* *European Hydrogen Skills Strategy (https://greenskillsforhydrogen.eu/wp-content/uploads/2023/10/Green-Skills-for-Hydrogen-European-Hydrogen-Skills-Strategy-last-update-24102023.pdf)* *Hydrogen Skills Core VET Curriculum: (https://greenskillsforhydrogen.eu/wp-content/uploads/2024/03/D3.1-Green-Skills-for-Hydrogen-Hydrogen-Skills-Core-VET-Curriculum.pdf)*	*International PtX Hub (https://ptx-hub.org/)* *International PtX Hub Flyer (https://ptx-hub.org/wp-content/uploads/2023/11/International-PtX-Hub-flyer-digital_en.pdf)*	*Funding (https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/projects-details/43353764/101143966/ERASMUS2027?programmePeriod=2021-2027&frameworkProgramme=43353764&topicAbbreviation=ERASMUS-EDU-2023-PEX-COVE&order=DESC&pageNumber=1&pageSize=50&sortBy=title)* *European Commission H2CoVe Project sheet (https://hydrogen.ua/images/about/CoVE_projects_2024cor-1-2.pdf)* *Hydrogen Centres of Vocational Excellence (H2CoVe) (https://peec.org.ua/en/?project=hydrogen-centres-of-vocational-excellence-h2cove) (https://www.hvl.no/en/collaboration/erasmus/h2cove/)*	*Hy.Academy website (https://www.hyacademy.eu/)* *HydrogenInsight article on the Academy (https://www.hydrogeninsight.com/innovation/at-least-100-universities-500-schools-and-5-000-experts-eu-unveils-funding-to-help-establish-a-european-hydrogen-academy/2-1-1390013)* *HydrogenToday article on the Academy (https://hydrogentoday.info/en/utbm-european-hydrogen-academy/)* *European Commission Hy.Academy project (https://cordis.europa.eu/project/id/101137988)*	*European Commission H2Excellence Funding (https://www.erasmusplus.nl/sites/default/files/2023-09/CoVE_projects_2023_ver%2006.pdf)* *H2Excellence Project Summary (https://h2excellence.eu/project-summary/)* *H2Excellence website (https://h2excellence.eu)*