RIFS STUDY

Research Institute for Sustainability (RIFS)

Green Hydrogen Development in South Africa and Namibia

Opportunities and Challenges for International Cooperation

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Executive Summary

South Africa and Namibia are seeking to become leaders in green hydrogen production. Leveraging world-class renewable energy resources, both nations are working to scale their green hydrogen production capabilities. However, given their very different starting points, they also face different opportunities and challenges. In particular, South Africa hopes to develop its green hydrogen industry through green ammonia exports and applications in hard-to-abate industries, namely steel, chemicals, and aviation fuel. It also seeks to leverage its reserves of so-called platinum grade metals to position the country as a produce of protone-exchange membrane (PEM) electrolyzers, which rely on this rare metal. Namibia has mainly focused on the development of green ammonia exports, though policy documents have also identified potential opportunities for the production of green steel and aviation fuels. Given green hydrogen's technological complexity and the countries' export-oriented ambitions, both countries must cooperate with foreign actors to facilitate technology sharing, financial flows, and technical assistance. To this end, international partnerships are playing a pivotal role in the development of both countries' green hydrogen industries.

Opportunities and challenges of green hydrogen in South Africa's transition away from coal

South Africa has a large industrial sector that has historically relied on coal as a low-cost energy source. This low-cost path-dependent infrastructure is a major factor prohibiting the country from implementing costly green hydrogen technologies in industrial processes. At the same time, South Africa has a number of important industrial capacities that it can build on in the development of a domestic hydrogen economy. In this vein, multiple provinces, including the Northern, Western, and Eastern Capes, have sought to establish special economic zones (SEZ) and industrial development zones (IDZ) to leverage synergies between hydrogen developers, heavy industry, and port infrastructure. Moreover, Sasol-–South Africa's largest private-sector company—is a world leader in hydrogen technology. A vertically integrated energy and chemical business, Sasol has utilized gray hydrogen since the 1970s as a feedstock for its Fischer-Tropsch coal-to-liquids synfuel production process. Able to translate its technical expertise to green hydrogen and ammonia, Sasol has taken steps to develop its own hydrogen projects as well as form technology-sharing partnerships with companies from hard-to-abate sectors.

Seeking to capitalize on these assets, the South Africa has published a Hydrogen Society Roadmap and a Green Hydrogen Commercialisation Strategy, and it has launched major initiatives, both with a focus on exports and on domestic application and manufacturing of hydrogen technologies. While the proposed Boegoebaai project aims to produce 400,000 tons of green hydrogen per year and ship green ammonia via tankers to export destinations such as Europe and East Asia, the Platinum Valley Initiative aspires to scale domestic green hydrogen to advance its application in transport and industry while promoting the manufacturing of PEM electrolyzers. Notably, the government has also launched Hydrogen South Africa, a dedicated R&D initiative. Yet, despite high-level political support for South Africa's hydrogen development, many investments remain at the planning stages, and Sasol and other stakeholders have been slow to develop the country's largest planned green ammonia export project at Boegoebaai.

To help realize South Africa's green hydrogen development goals, European donors have provided the country with public finance to decarbonize its electricity supply while kickstarting the nation's green hydrogen industry, primarily through the funding of common-use infrastructure, feasibility studies, and demonstration projects. These efforts have been complemented by technical assistance programs, notably by Germany's GIZ, which have sought to develop local government capacity, foster opportunities for local value creation, and provide strategic guidance for South African

policymakers. The US and Asian donors have not played a significant role in South Africa's hydrogen sector. A notable exception is a Memorandum of Understanding signed with Saudi Arabia to promote cooperation on hydrogen-related investments, involving Saudi Arabia's ACWA Power. Private sector partnerships, especially between Sasol and foreign firms, are critical as companies seek to share technologies and develop synergies between industries. Given the importance of foreign firms in driving many green hydrogen projects, particularly in industrial green hydrogen applications, it remains to be seen how much local value will be created as a result of these projects.

The creation of local benefits from green hydrogen is a critical question, as South Africa must reconcile its green hydrogen and just transition goals. While the government has prioritized the inclusion of workers and communities in its just transition policies, it is unclear how green hydrogen will improve the everyday lives of the general population, especially those in communities which will be affected by the closure of coal plants. Many proposed green hydrogen projects have export-exclave elements and could be perceived as diverting renewable energy that could help relieve the nation's electricity crisis, not to mention the technology's sizable water and land use requirements. More broadly, hydrogen development in South Africa is embedded in the country's challenging political economy landscape, which is still dominated by powerful fossil fuel actors. These are likely to complicate any efforts to promote a transition to a climate-friendly energy and industrial system. That said, green hydrogen and its related opportunities for new sources of value creation may also provide entry-points for stimulating broader efforts towards decarbonization. In this vein, if successful, green hydrogen development in South Africa could well generate positive spillover effects for its broader transition process.

The promise and pitfalls of export-led green hydrogen development in Namibia

Meanwhile, Namibia's green hydrogen developments depart from a very different starting point. It does not have legacy industries that must overcome reliance on coal or other path-dependent infrastructure, and it currently imports a large share of its electricity from South Africa. The country possesses vast swaths of land available for greenfield renewable energy development, and Namibia's government views the emerging hydrogen economy as an important export-oriented development opportunity for the country. Within Southern Africa, Namibia views green hydrogen as a way to become a net exporter of electricity and increase its economic and political influence in the region.

Against this background, the country has taken significant steps towards developing a domestic green hydrogen industry. Since the beginning of the nation's hydrogen journey, the Namibian government has played an active role in courting project developers and crafting a forward-thinking hydrogen environment. This is evident from the publication of the detailed GHDS and the creation of a Green Hydrogen Council to streamline the green hydrogen decision-making process. These conditions have enticed several foreign companies to initiate the development of large-scale projects in various regions throughout the country. Notably, the $10 billion Hyphen project stands out for its signing of three non-binding offtake agreements to sell over 1 million tonnes annually of green ammonia to foreign offtakers. The government has also articulated ambitions to further value creation via the production and export of e-methanol, synthetic kerosene (sustainable aviation fuel), and hot-briquetted. It is unclear, however, whether the country has sufficient human and technological capacities as well as raw materials, such as iron and carbon feedstock, to support these industries. The government also recognizes that Namibia could suffer from a labor shortage of 55,000-60,000 workers by 2030 as it attempts to scale green hydrogen resources. To remedy this issue, the government's hydrogen strategy recommends retraining and vocational training programs to educate low-skilled workers and specialized university programs for skilled workers and engineers

The EU, Germany and the Netherlands stand out as its main counterparts in this context. The European Commission concluded a strategic partnership that includes an EIB loan worth up to €500 million. Similarly, Germany has provided significant technical assistance to develop Namibia's government capacity, while the Netherlands has demonstrated considerable interest in establishing the new SDG Namibia One sovereign wealth fund. Through the fund Namibia hopes to take an equity stake

in domestic green hydrogen projects, so that it can partake in future revenues. While these plans have the potential to significantly benefit the local population in areas such as education, healthcare, infrastructure, and access to electricity, the government has yet to announce how it will reallocate funds through revenue-sharing plans. Whether these benefits can be realized, however, will strongly depend on the design and implementation of the revenue sharing instrument. Indeed, there is a growing concern that the country will be unable to raise enough money to take the planned 24 percent equity stake in the $10 billion Hyphen project. Since green hydrogen is a relatively unproven technology, it necessitates a high hurdle rate (15 percent or higher) to attract funds from institutional investors. If the Namibian government cannot maximize its equity stake in the Hyphen project, it will collect less public revenue, lowering the amount of money it can redistribute to the general public.

This is particularly salient as Namibia's Hyphen project represents one of the most prominent ventures for the promotion green hydrogen exports with visible support from the EU and Germany. If successful, it has the potential to become an important international reference case. For this, it will have to show that the development of a green hydrogen industry in a low-income country can deliver tangible benefits to the general population, while putting in place appropriate strategies for avoiding and mitigating potential negative impacts on the environment and local livelihoods. Another key challenge lies in managing associated infrastructure and urban development. To ensure these goals are realized, the government needs a steady income stream and a well-developed revenue-sharing model to ensure that it can deliver tangible benefits. Moreover, it will have to ensure that local populations and civil society are involved in decision-making processes. The international donor community can play an important role in supporting these efforts with both technical and financial assistance.

Common challenges of green hydrogen development

A common challenge for green hydrogen development in both Namibia and South Africa has been a lack of pre-existing infrastructure. Not only the Hyphen project in Namibia, but also the Boegoebaai project, the largest planned hydrogen production site in South Africa, is an entirely greenfield venture that will require tremendous amounts of capital to build roads, transmission lines, a desalination plant, and a new deepwater port. Similarly, the brownfield industrial development zone in Saldanha, South Africa will require new infrastructure to attract private-sector green hydrogen investment. Public finance from organizations like EIB, KfW, and the World Bank is helping to fund these projects, but it is increasingly apparent that it may be unrealistic to develop the needed infrastructure with an exclusive focus on green hydrogen. As such, especially in the case of Boegoebaai, planners are seeking to identify additional economic activity to attract public sector finance, both in the green hydrogen space and elsewhere.

Another important condition for successful development of the green hydrogen sector in both countries is linked to regulatory developments in the EU. As a major import market, exports will hinge on compliance with requirements for the production of green hydrogen as set forth in two Delegated Acts to the EU's Renewable Energy Directive. This is a particular concern in South Africa, where initial green hydrogen projects are unlikely to be developed as greenfield projects. Sasol in particular is concerned that its hydrogen production may not qualify as a renewable under EU rules. EU rules on carbon feedstocks for the production of low-carbon synthetic fuels are another concern for Sasol. Currently, carbon sources needed for the production of synthetic fuels may still be derived from industrial CO2 emissions. However, from the 2040s on, EU carbon accounting will no longer permit these carbon sources in the production of low-carbon fuels. For the time being, South African synthetic fuel production is being developed for the domestic market, however, in the future, this may pose a barrier to export development. In Namibia, meanwhile, green hydrogen producers are relatively less concerned about complying with EU rules because their hydrogen products will be produced using exclusively renewable power on greenfield sites.

Regional competition and cooperation

Regarding South African-Namibian cooperation on green hydrogen, engagement has been limited. Despite their proximity and shared goals, stakeholders in both countries have opted to pursue their own hydrogen projects. While officials have floated the idea of a shared hydrogen pipeline from Namibia to South Africa, it is too early to tell whether there will be adequate demand to warrant such an investment. Despite this, South Africa and Namibia are not openly competing in green hydrogen development. This is because both nations have very different starting points in their green hydrogen journeys: The South African government has plans to use green hydrogen to transform its fossil-fuel-dependent domestic industry and produce green ammonia exports, while Namibia is almost entirely focused on greenfield green ammonia export projects. Although Namibia is further along in developing assets and securing green ammonia offtake agreements, it is premature to say that Namibia is out-competing South Africa in green hydrogen development as announced projects in both countries comprise only a fraction of expected world green hydrogen demand and the actual production of green hydrogen is years away. Both countries are currently facing similarly high capital costs for project development and will have to contend with midstream transportation costs as a significant factor in future green ammonia exports.

Together, developments in both countries are contributing to the rise of green hydrogen as a globally traded commodity. The technology has the potential to elevate new players in the global energy arena and allow existing fossil fuel players with sizable renewable energy potential. While South Africa and Namibia will inevitably compete with other green hydrogen exporters, some of which are closer to expected demand centers in Europe and East Asia, Southern African producers can count on low electricity prices to compensate for relatively higher transport costs. Furthermore, especially in the early years of green hydrogen trade, key importing nations will likely elect to diversify imports from a variety of countries, including South Africa and Namibia. Of course, as in the case of South Africa, green hydrogen producers will also provide valuable inputs to help domestic heavy industry transition to less carbon-intensive manufacturing processes, especially in the steel, chemicals, and aviation sectors.

Acknowledgements

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Contents

1 Introduction

Nations are struggling to decarbonize heavy industry. Accounting for nearly 40 percent of global emissions, industries such as steel and chemicals rely on carbon-intensive processes that are difficult to electrify and often endure adverse economic factors, such as low profit margins, high capital intensity, long asset life, and high trade exposure (Gross 2021). Also known as "hard-to-abate," these industries face the most arduous paths to reaching net-zero emissions by 2050.

Recognizing the need to take urgent action, public and private sector stakeholders are increasingly turning to green hydrogen as a technological solution to decarbonize heavy industry. Hydrogen is an energy carrier that can store, move, and deliver energy from a variety of sources (U.S. Department of Energy n.d.). In the case of heavy industry, hydrogen can serve many functions, providing a heat source (as in the case of steel) or serving as a feedstock for chemical processes (as in the case of ammonia and sustainable aviation fuel), among other applications. While hydrogen can be produced using fossil fuels through thermal processes, recent attention has primarily focused on the production of hydrogen using renewable energy through electrolysis, also known as "green hydrogen." If implemented properly, green hydrogen has the potential to significantly reduce or wholly eliminate emissions in several key hard-to-abate sectors, including steel manufacturing, chemical processing, and aviation.

Nonetheless, several factors limit the development of green hydrogen technologies. First, green hydrogen production requires significant amounts of renewable energy. For example, Germany's national hydrogen strategy expects total 2030 hydrogen demand to be 95-130 terawatt hours (TWh), including derivatives like ammonia, methanol, and synthetic fuels (Clean Energy Wire 2023). This will necessitate more than 20 GW of electrolyzer capacity and upwards of 50 GW of renewable power. Furthermore, related to the first point, there is a geographic incongruence between the best locations for green hydrogen production and the largest expected centers of green hydrogen offtake. For example, nations such as Germany, the Netherlands, Japan, and South Korea have robust industrialized economies but lack the natural resources (wind, sunlight, land, etc.) needed to produce sufficient amounts of low-cost renewable energy. To this end, actors are looking to nations with favorable resource endowments to produce and export green hydrogen products.

South Africa and Namibia, both endowed with world-class renewable energy resources, hope to produce low-cost green hydrogen to serve this emerging market. South Africa hopes to develop its green hydrogen industry through green ammonia exports and applications in hard-to-abate industries, namely steel, chemicals, and aviation. Meanwhile, Namibia has mainly focused on the development of green ammonia exports. Given green hydrogen's technological complexity and the countries' export-oriented ambitions, stakeholders in both countries must cooperate with foreign actors to facilitate technology sharing, financial flows, and technical assistance. As such, international partnerships are playing a pivotal role in the development of both countries' green hydrogen industries.

This paper examines the interplay between domestic green hydrogen developments and the emerging engagement by international actors to support these developments. Analyzing South Africa and Namibia individually, the paper begins by contextualizing each country's hydrogen aspirations within its natural resources, energy policy, industrial capacity, and international relations. From this, the paper reviews the current state of each country's hydrogen economies with a focus on strategy, domestic stakeholders, proposed projects, and socio-economic challenges. Then, the paper explores how international actors are shaping both countries' hydrogen development through the lens of public finance, technical assistance, commercial diplomacy, and private sector engagement. Next, the paper explores

the regional dimensions of green hydrogen development and assesses cooperation and competition in the Southern African region. Lastly, the paper evaluates both countries' progress in the green hydrogen space, examines points of tension with international actors, and discusses the potential role of both countries in the rising global green hydrogen export industry.

2 South Africa

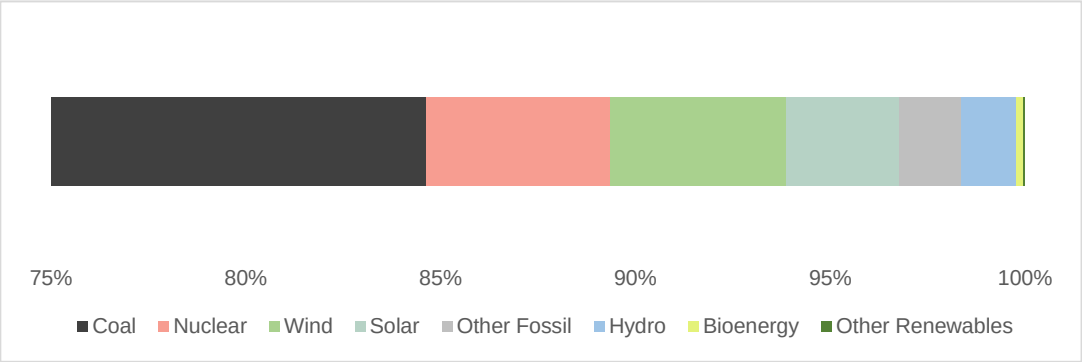
2.1 Background

2.1.1 Energy Sector and Resources

South Africa possesses considerable solar and wind power potential. With clear skies and consistent solar radiation, the country boasts the fifteenth-highest practical photovoltaic potential in the world (Global Solar Atlas 2023). Although much of this potential is located in the Northern Cape, the Eastern and Western Cape also contain sizable solar resources. Similarly, South Africa's land and coastal waters offer significant potential for onshore and offshore wind development, respectively, providing much opportunity for solar and wind colocation.

Despite its solar and wind endowments, South Africa primarily relies on coal to meet its energy needs (see Figure 1). Originally constructed due to abundant natural supply and Apartheid-era energy security concerns, South Africa's coal-fired power plants now comprise 70 percent of the country's total energy supply and more than 85 percent of the country's electricity generation (see Figure 1; Chitonge 2017). Nonetheless, while South Africa has a nominal coal-fired capacity of over 38 gigawatts (GW), its aging and poorly maintained fleet struggles to keep pace with the country's growing electricity demand, leading to as much as 20 GW in lost generation capacity and six to eleven hours of load shedding per day (Eskom n.d.; Mkhize 2022; Omarjee 2021). Simultaneously, Eskom, South Africa's state-owned power utility, cannot develop new power generation due to severe debt, and South Africa's current regulatory system has historically discouraged independent power producers from investing in wide-scale clean energy development (Reuters 2022). Indeed, from 2015 to 2020, South Africa only increased its percentage of renewable energy penetration from 1.9 percent to 4.58 percent. While South Africa has taken steps to liberalize its electricity market in recent years, increasing the threshold under which companies can produce their electricity without a license from 1 megawatt (MW) to 100 MW, the country's longstanding energy policies have exacerbated its electricity crisis and hindered the growth of its renewable energy sector (Kuhudzai 2021).

Figure 1: Electricity generation by source for South Africa, 2022

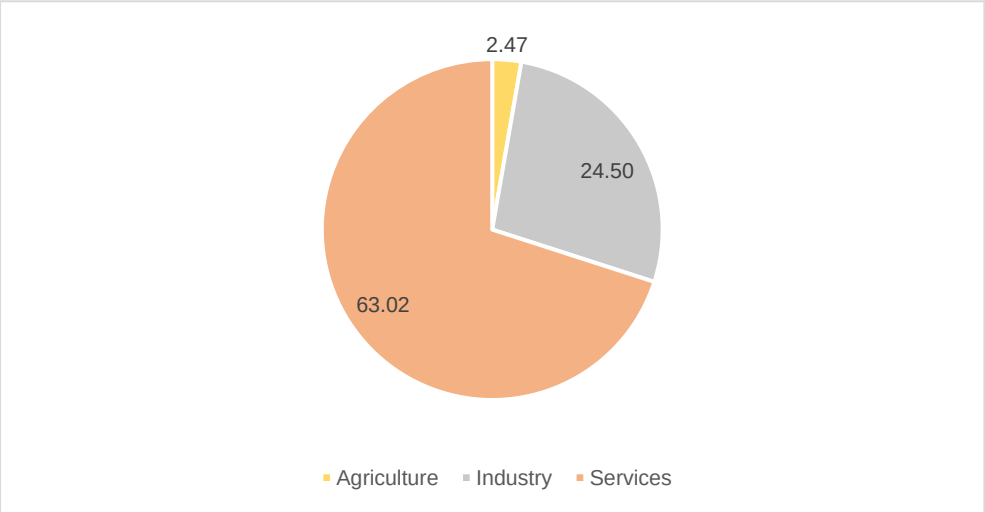


Source: Ember. Retrieved October 15, 2023, from https://ember-climate.org/data/data-tools/data-explorer/

2.1.2 Economy

Accounting for nearly 25 percent of GDP, South Africa has a large industrial sector (see Figure 2). Spearheaded by its mining industry, South Africa is the world's largest producer of platinum-grade minerals (PGMs), namely platinum and iridium (Government of Canada n.d.). Since PGMs are critical to the production of polymer electrolyte membrane (PEM) electrolyzers (a key technology in hydrogen production), some commentators have raised the possibility of South Africa developing a domestic PEM industry (South Africa Department of Trade, Industry, and Competition 2022a).

Figure 2: Distribution of GDP across economic sectors, South Africa, 2021



Source: Statista. Retrieved October 15, 2023, from https://www.statista.com/statistics/371233/south-africa-gdp-distribution-across-economic-sectors/

Aside from mining, South Africa also hosts sizable automotive, metals, agriculture, and chemicals sectors. Often referred to as "hard-to-abate," many of these industries use carbon-intensive industrial processes that are difficult to electrify. In the case of South Africa, these sectors have also traditionally relied on inexpensive coal as a primary energy source. While green hydrogen has the potential to replace coal in these sectors, this requires large volumes of investment in new technologies and production processes that are yet to become cost-competitive with fossil fuel. Given the vested interests in the existing economic model, this also faces substantial political obstacles, particularly from corporate stakeholders and trade unionists in legacy industries (see International Trade Concerns).

2.1.3 International Relations

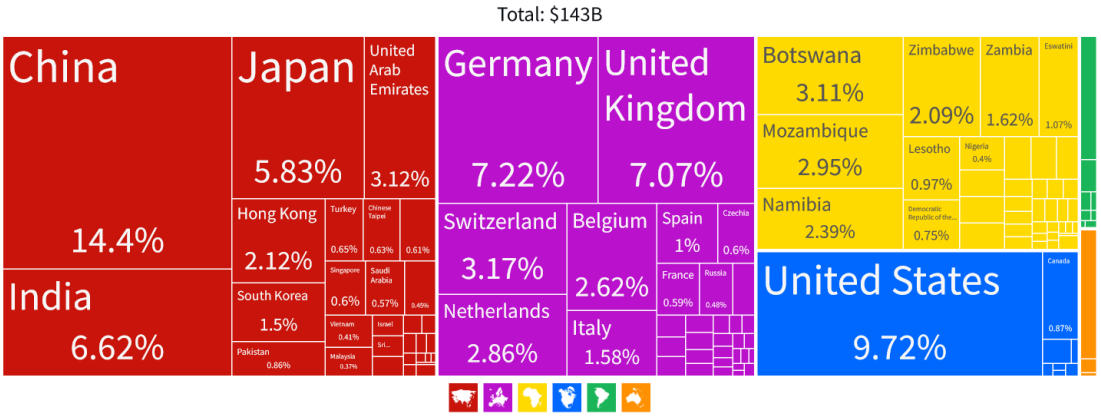
Since the end of Apartheid, South Africa has maintained a de facto leadership role among other African states. As the second-largest economy on the continent (after Nigeria), the country often represents African interests in international fora and wields considerable economic and political influence, especially in Southern Africa. This is exemplified by South Africa's leading role in the Southern African Development Community (SADC), a 16-member intergovernmental organization aimed at advancing regional peace, security, and economic integration. A major producer of automobiles and industrial goods, South Africa is the largest exporter to Namibia, Botswana, Zambia, Zimbabwe, Eswatini, Lesotho, and Mozambique (see Figure 3). Notably, despite suffering from a domestic electricity shortage, South Africa is also a significant supplier of electricity to neighboring countries via the Southern Africa Power Pool (SAPP), exporting over 13-gigawatt hours (GWh) of electricity to SAPP in 2020 (Global Data n.d.). Nonetheless, these exports may change in coming years as South

Africa's power shortage worsens and other SAPP nations, such as Namibia, seek to export excess renewable electricity (see Inter-African Relations).

Outside Africa, South Africa maintains a robust economic relationship with China, the country's largest trading partner (see Figure 3). Despite being much smaller than other members, South Africa is part of BRICS (Brazil, Russia, India, China, South Africa), which has elevated the country's international standing by providing an alternative to traditional development finance and political forums (Prange 2023). China is South Africa's largest export destination for iron ore, crude petroleum, gold, diamonds, and manganese and a major export destination for coal briquettes. Furthermore, at the BRICS summit in August 2023, China made a series of agreements pledging to help extend the lifespan of South African coal plants and upgrade South Africa's nuclear power plant (Mukherjee 2023). Nonetheless, while Chinese firms are involved in the export of solar panels—and potentially alkaline electrolyzers—to South Africa, neither Chinese energy developers nor Chinese government agencies have taken concrete steps to develop South Africa's green hydrogen sector.

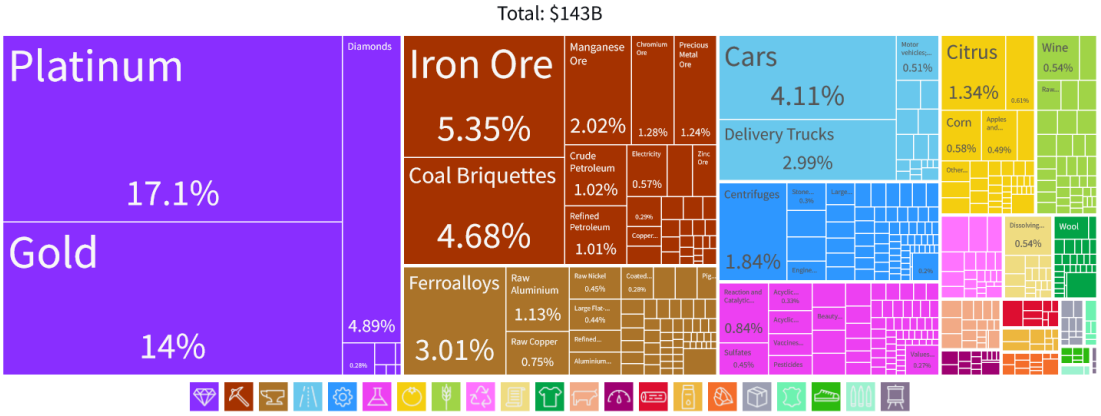
Lastly, South Africa enjoys strong political and economic relationships with Western democracies, namely the United Kingdom (UK), the United States, France, Germany, Japan, and the European Union (EU). Many Western companies, such as German automobile manufacturers and UK mining companies, have subsidiaries in South Africa, capitalizing on the country's relatively large market and access to the rest of the region. Following the start of the war in Ukraine, South African coal exports to Europe increased eight-fold as European buyers sought to replace banned Russian coal (Banya 2022). Nonetheless, despite this increase, Europe still comprises a relatively small export destination for coal (see Figure 3). The United States and Japan are South Africa's largest export destinations for platinum, which are critical to the production of PEM electrolyzers. Lastly, there has been considerable engagement between both parties on climate finance, such as through the Just Energy Transition Partnership (JETP), as Western nations recognize the need to assist decarbonization efforts in emerging economies (see also International Actors).

Figure 3: Export destinations by trade value for South Africa, 2021



Source: OEC. Retrieved October 17, 2023, from https://oec.world/en/profile/country/zaf?yearlyTradeFlowSelector=flow0

Figure 4: Export products by trade value for South Africa, 2021



Source: OEC. Retrieved October 17, 2023, from https://oec.world/en/profile/country/zaf?yearlyTradeFlowSelector=flow0

2.2 South Africa's Green Hydrogen Economy

South Africa faces dual challenges with regard to sustainable development and climate mitigation. Indeed, with the highest income inequality in the world (alongside Namibia) and most carbon-intensive energy sector in the G20, South Africa has sought to merge its development and climate goals through overarching policy strategies such as the National Development Plan, Economic Reconstruction and Recovery Plan, and a series of master plans for select industries (automotive, steel, renewable energy, etc.) (Engineering News 2021; Government of South Africa 2012, 2020; Statista 2022). To this end, green hydrogen presents an opportunity to decarbonize hard-to-abate sectors while creating climate-aligned jobs and boosting carbon trade competitiveness.

2.2.1 Hydrogen Policy

Recognizing the country's green hydrogen potential, the South African Department of Science and Innovation (DSI) published the country's Hydrogen Society Roadmap (HSR) in October 2021 (South Africa Department of Science and Innovation 2022). Providing a broad vision for the future of hydrogen development, the HSR is not a policy framework in that it does not correspond to binding government action. Rather, the HSR outlines desired hydrogen outcomes and provides policy recommendations that, if implemented, could facilitate the development of hydrogen resources. With this in mind, the HSR identifies 70 priority actions for the creation of a domestic hydrogen industry across six focus areas:

1. The creation of an export market for South African hydrogen
2. The decarbonization of energy-intensive industry
3. The decarbonization of transport
4. R&D for hydrogen products and fuel cells
5. A green and enhanced power sector
6. The transition from grey to blue to green hydrogen

Notably, the HSR mentions that international partnerships are critical to achieving certain hydrogen goals, such as establishing a hydrogen export market, as well as accomplishing other objectives, such as scaling up training for hydrogen-economy workers and funding R&D programs. Additionally, the HSR notes that South Africa's participation in international forums is critical to ensuring that national hydrogen production meets international market standards.

Building on the HSR, in December 2022, the Department of Trade, Industry and Competition (DTIC) published the Green Hydrogen Commercialisation Strategy (GHCS) to outline a path to scaling South Africa's green hydrogen industry (South Africa Department of Trade, Industry, and Competition 2022a). Anticipating a global green hydrogen export trade of 27 million tons per annum (mtpa) by 2050, the GHCS recommends that South Africa develop a green hydrogen export capacity of 2 to 7 mtpa by midcentury (Interview 5; South Africa Department of Trade, Industry, and Competition 2022b). Furthermore, given efforts to decarbonize South Africa's economy through green hydrogen applications, the GHCS recommends the country develop 2 to 3 mtpa of green hydrogen production for domestic consumption. Nonetheless, the GHCS acknowledges that South Africa is lagging behind other nations in kick-starting its green hydrogen economy, especially concerning the development of an export industry. As such, to help South Africa reach its green hydrogen ambitions, the GHCS recommends two primary policy actions: 1) fast-track the development of priority hydrogen hubs and; 2) create an enabling ecosystem for long-term hydrogen investment. The first action involves prioritizing key early-stage green hydrogen projects in relevant permitting processes (see Green Hydrogen National Programme). The second involves developing and introducing detailed regulatory measures to support the country's domestic and export markets. To date, however, the government has yet to publish a robust hydrogen regulatory framework. Furthermore, the GHCS reaffirms South Africa's potential to become a global leader in PGM-based component manufacturing for hydrogen technologies. Hoping to claim 15 to 30 percent of the global market in the coming decades, the GHCS recommends that the government assist domestic manufacturers by scaling up capabilities and supporting the development of demonstration projects.

Announced during South Africa's inaugural Green Hydrogen Summit in November 2022, South Africa's **Green Hydrogen National Programme (GHNP)** is a government initiative that aims to fast-track green hydrogen development (T. Creamer 2022; Infrastructure South Africa n.d.-a). As part of the program, green hydrogen projects identified as Strategic Infrastructure Projects (SIPs) receive specialized assistance from the Office of the Presidency (via Infrastructure South Africa) and can qualify for expedited approvals for permits (Infrastructure South Africa n.d.-b). Ideally, this process can help projects attract additional financing and, consequently, accelerate the construction of green hydrogen facilities. Nonetheless, the SIP hydrogen program remains in the early stages of implementation and may require additional technical assistance, such as from GIZ, to increase program capacity (Interview 5). Currently, nineteen projects are part of the GHNP and nine projects have received SIP status, although more are expected to obtain status as they finalize development plans (South Africa Department of Public Works and Infrastructure 2022).

2.2.2 Hydrogen Stakeholders

The South African Presidency, led by President Cyril Ramaphosa, has taken primary responsibility over the country's green hydrogen decision-making (Interview 7). Viewing green hydrogen as a strategic priority for South Africa's future economic security, the Presidency has taken a hands-on leading role in advancing green hydrogen advancement initiatives, such as the GHNP. Nonetheless, at least nine other government departments and two state-owned enterprises have some jurisdiction over hydrogen strategy and development. For example, the Department of Trade, Industry and Competition (DTIC) identifies strategies to accelerate hydrogen commercialization, while DSI researches novel applications for hydrogen technologies. The Department of Mineral Resources and Energy (DMRE), meanwhile, manages long-term renewable energy planning but has relatively little influence over green hydrogen development. This varied distribution of authority, along with divergent political interests among ministries, has led some public and private sector stakeholders to describe South Africa's hydrogen regulatory environment as confusing, complex, and inefficient (Interview 2). Notably, a Green Hydrogen Commercialisation panel, led by Industrial Development (IDC) Corporation Chief Operations Officer Joanne Bate, regularly convenes to discuss policy interventions to promote green hydrogen development (T. Creamer 2021a).

In addition to national departments, sub-national governments play an active role in South Africa's hydrogen development. For example, in November 2022, the Northern and Western Cape governments signed a Memorandum of Understanding (MoU) to develop a joint green hydrogen corridor (Democratic Alliance 2022). Both provinces had previously adopted their own hydrogen strategies and hope to capitalize on regional synergies to scale hydrogen capabilities, especially green steel.

Furthermore, multiple provinces, including the Northern, Western, and Eastern Capes, have sought to establish special economic zones (SEZ) and industrial development zones (IDZ) to leverage synergies between hydrogen developers, heavy industry, and port infrastructure. One such zone, the Freeport Saldanha IDZ, has attracted much attention for its efforts to construct a green hydrogen derivatives hub with a focus on green steel, shipping fuels, and e-chemicals (Saldanha Bay Industrial Development Zone 2022). Indeed, Saldanha is a particularly attractive site for green steel production due to its pre-existing steel manufacturing facilities, railway access, and nearby iron ore reserves. To this end, the Saldanha IDZ has sought to scale infrastructure through funding from multilateral development banks (MBDs) and development finance institutions (DFIs), namely the World Bank (WB), European Investment Bank (EIB), KfW, and the Development Bank of South Africa (DBSA).

Financially, the South African government and international partners have set up the H2-SA Fund to help mobilize $1 billion in blended finance for large-scale green hydrogen infrastructure projects (Invest International 2023). Announced during the state visits of Dutch Prime Minister Mark Rutte and Danish Prime Minister Mette Fredriksen, the fund consists of IDC, DBSA, Sanlam Limited (South Africa), Invest International (Netherlands), and Climate Fund Managers (Netherlands). While it remains to be seen how H2-SA will attract future capital, potential tools will likely include financial de-risking instruments, such as export credit guarantees, first-loss equity, low-cost loans, and political risk insurance.

Importantly, Sasol—South Africa's largest private-sector company—is a world leader in hydrogen technology. A vertically integrated energy and chemical business, Sasol has utilized gray hydrogen since the 1970s as a feedstock for its Fischer-Tropsch coal-to-liquids synfuel production process (National Energy Technology Laboratory n.d.). Able to translate its technical expertise to green hydrogen and ammonia, Sasol has taken steps to develop its own hydrogen projects as well as form technology-sharing partnerships with companies from hard-to-abate sectors (see Domestic Hydrogen Stakeholders). Indeed, due to its deep hydrogen knowledge and extensive industry connections, it is fair to say that the success of South Africa's green hydrogen sector will rely on Sasol's active involvement in the space. Sasol's technical capabilities thus represent a competitive edge for South Africa's hydrogen industry and, if leveraged, could offer a "first-mover advantage" for certain decarbonization sectors, such as sustainable aviation fuel (SAF) (T. Creamer 2019).

Building on its existing hydrogen capacity, private sector partnerships are poised to play a major role in South Africa's green hydrogen development due to their vital role in facilitating technology sharing. For example, Sasol has partnered with Arcelor-Mittal (Luxembourg) to produce green steel and explore opportunities for e-fuels and chemicals production (Sasol 2022). Likewise, Sasol has partnered with Enertrag (Germany), Linde (Germany), and Hydregen (UK) through the HyShiFT Consortium to produce sustainable aviation fuels (HyshiFT n.d.). These technology transfer agreements comprise a fundamental aspect of South Africa's green hydrogen sector as companies seek to access proprietary knowledge and capitalize on synergies between industrial processes. Notably, other key private sector actors include Anglo-American (a UK mining company), Toyota (a Japanese automotive manufacturer), Maersk (a Danish shipping company), Topsoe (a Danish carbon emissions reduction company), and Transnet (South Africa's national rail company), which are each prepared to supply technological knowledge from their respective industries.

Last but not least, Hydrogen South Africa (HySA), an R&D initiative, is playing a key role in the development of South Africa's green hydrogen sector. Since 2007, DSI has funded HySa to advance

South Africa's intellectual property and human capital in hydrogen fuel cell technology. Within HySa, three centers of competence focus on various hydrogen-related technical issues: HySa Systems, HySa Infrastructure, and HySa Catalysis. Together, these centers of competence comprise a significant technological advantage for South Africa and have helped South Africa's hydrogen workforce.

2.2.3 Hydrogen Projects

As of February 2023, there are at least 24 green hydrogen projects in South Africa at various stages of development. Generally speaking, these projects can be classified into two tracks: 1) green ammonia production and export and; 2) industrial decarbonization in hard-to-abate sectors. Within these respective tracks, the Boegoebaai green ammonia project and Platinum Valley Initiative stand out for their size and ambition.

Table 1: South African Green Hydrogen Projects

Project name	Product	Province	Primary stakeholders
Boegoebaai*	Green ammonia export	Northern Cape	Sasol (South Africa), Northern Cape Government
Coega & Little Chelsea*	Green ammonia export	Eastern Cape	Hive Energy (UK)
Prieska Power Reserve*	Green ammonia	Northern Cape	Prieska Power (South Africa)
Secunda HySHiFT*	Sustainable aviation fuel	Mpumalanga	Sasol (South Africa), Linde (Germany), Enertrag (Germany), Hydregen (UK)
Saldanha	Green steel	Western Cape	Arcelor-Mittal (Luxembourg)
Saldanha	Green hydrogen	Western Cape	Sasol (South Africa)
Vaal*	E-fuels, chemicals	Gauteng	Sasol (South Africa), Arcelor-Mittal (Luxembourg)
Sasolburg*	Green hydrogen	Free State	Sasol (South Africa)
Mogalakwena*	Hydrogen-powered mining trucks	Limpopo	Anglo-American (UK)
Platinum Valley Initiative Mobility*	Green hydrogen mobility	Gauteng, Kwazulu-Natal	Sasol (South Africa), Toyota (Japan)
Richards Bay*	Green hydrogen, green ammonia, shipping fuel	Kwazulu-Natal	African Renewable Development (South Africa)

Ubuntu Green Hydrogen*	Green hydrogen	Northern Cape	Ubuntu Green Hydrogen (South Africa)
Air Products	Green hydrogen	Unknown	Air Products (USA), ThyssenKrupp (Germany)
Enertrag Indigen	E-methanol	Eastern Cape	Enertrag (Germany), Earth and Wire (South Africa), 24Solutions (South Africa)
Enertrag Postmasburg	Green ammonia	Northern Cape	Enertrag (Germany)
Mainstream	Green hydrogen	Western Cape	Mainstream Renewable Power Development (Ireland)
HDF	Green hydrogen power plant	Mpumalanga	HDF Energy (France)
Isondo Fuel Cells	Hydrogen fuel cells, PEM technology	Gauteng	Isondo Precious Metals (South Africa)
Isondo NCP Vehicles	NCP Vehicles	Gauteng	Isondo Precious Metals (South Africa)
Phoenix	Hydrogen fuel cells	Free State	Mitochondria Energy (South Africa)
Cape Stack	Hydrogen fuel cells	Western Cape	Cape Stack (South Africa)
Bambili Hyplat	Hydrogen fuel cells, PEM technology	Gauteng	Bambili (South Africa)
Upilanga*	Solar & Green Hydrogen Park	Northern Cape	Upilanga (South Africa)
Atlanthia Green Hydrogen*	Unknown	Western Cape	Atlanthia (South Africa)
*Strategic Infrastructure Project			

Boegoebaai aspires to be South Africa's flagship green ammonia export project. Located in the Northern Cape province, the project entails the development of 9 GW of renewable energy and 5 GW of electrolyser capacity as well as the expansion of a deep-water port (M. Creamer 2022a). Ultimately, the project hopes to produce 400,000 tons of green hydrogen per year and ship green ammonia via tankers to export destinations such as Europe and East Asia.

Sasol, the project's primary developer, signed a Memorandum of Agreement (MoA) with the Northern Cape government in October 2021 and has since undertaken feasibility studies to determine the project's economic viability (Sasol 2021). Possible additions include constructing green hydrogen pipelines to the Western Cape and Gauteng. Notably, the Northern Cape government and Sasol have

also engaged in extensive consultations with the Port of Rotterdam to explore ways of "cracking" green ammonia back to hydrogen in a cost-effective manner (M. Creamer 2022a).

Nonetheless, despite much public attention, there has been relatively little progress on the implementation of the Boegoebaai project. Some commenters have noted that Sasol's company-wide carbon emissions may prohibit the company from securing financing from banks with high environmental standards, such as those in the European Union (Interview 5). Other commenters have expressed concerns about the lack of infrastructure at the Boegoebaai site (ibid.). Indeed, as things currently stand, there is no port, road, electricity, or water infrastructure at Boegoebaai. Furthermore, according to current plans, the development of a deepwater port would primarily benefit Sasol in its green ammonia export ambitions. Since public sector financiers hope to stimulate wide-scale economic activity through their investment and advance the interests of more than one private company, South African policymakers are currently exploring ways to attract additional green hydrogen derivative industries, such as electrolyzer manufacturing and hydrogen trucking. Together, these factors have postponed Boegoebaai's commissioning date to at least 2025 and turned public attention to other green ammonia export projects, namely Hive Energy's project in Eastern Cape, which can utilize existing port infrastructure.

The **Platinum Valley Initiative (PVI)** aspires to scale South Africa's domestic green hydrogen industry by leveraging co-benefits between different sectors. Building on the concept of a hydrogen valley, the PVI plans to connect three green hydrogen hubs to produce an integrated hydrogen region (EU Clean Hydrogen Partnership n.d.). Through shared infrastructure investments, these efforts aspire to build and grow green hydrogen value chains, thereby lowering the levelized cost of green hydrogen production and delivering job growth in participating areas. Currently, PVI consists of green hydrogen hubs in three regions:

- *Limpopo*: Anglo-American has deployed hydrogen-powered mining trucks in its PGM mining operations in Mogalakwena.
- *Gauteng*: Arcelor-Mittal and Sasol plan to use green hydrogen as an industrial substitute in iron and steel production in Vanderbijlpark. HyShiFT partners hope to use green hydrogen to produce sustainable aviation fuel. South African firms hope to manufacture PEM electrolyzer technologies.
- *KwaZulu-Natal*: Toyota plans to use green hydrogen in heavy- and medium-duty trucking. Transnet aims to use green hydrogen to develop a green hydrogen railroad to Richards Bay. Maersk plans to use green hydrogen to decarbonize shipping.

Conceived as a mega-project, many aspects of the PVI are contingent upon private-sector investments. Anglo-American, for example, has already implemented hydrogen-powered mining trucks in its facilities in Limpopo. Nonetheless, the vast majority of PVI projects remain in preliminary stages of development due to ongoing feasibility studies and outstanding financing needs. As such, many PVI projects will likely not witness commissioning until 2025 or later.

2.2.4 Socio-economic Challenges and Just Transition

While the growth of a domestic green hydrogen may positively impact South Africa's economy, it is unclear how it would benefit South African citizens. As a reaction to its dual sustainable development and climate mitigation goals, South Africa has been a forerunner in developing the modern concept of a "just energy transition," which generally describes the incorporation of social considerations in energy transition decision-making. While various governments and entities have differing interpretations of a just energy transition in their domestic contexts, South Africa tends to view just transition issues through the lenses of distributive justice (i.e., who reaps the benefits and bears the costs of the country's green hydrogen revenue) and procedural justice (i.e., who is involved in the decision-making process) (Cassidy 2022). While the government has prioritized the inclusion of

workers and communities in its just transition policies, it remains to be seen how green hydrogen will improve the everyday lives of the general population, especially those in communities that will be affected by the closure of coal plants. Many proposed green hydrogen projects have export-exclave elements and, in the public eye, would theoretically divert renewable energy that could relieve the nation's electricity crisis. It will be important to observe how the South African government attempts to link its green hydrogen and just transition goals in the coming years.

2.3 International Actors

2.3.1 Public Finance

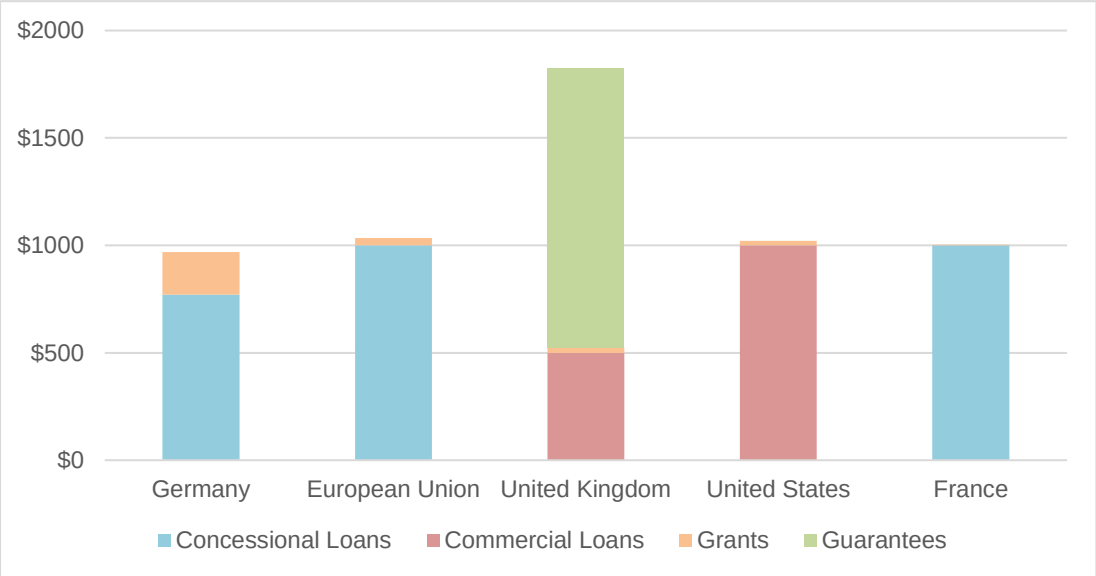
South Africa is in the early stages of developing a green hydrogen economy. Indeed, many green hydrogen projects remain in preliminary stages as policymakers take steps to incentivize green hydrogen investment. To this end, international actors seek to provide public finance to aid these processes.

To date, the largest public finance commitment to South Africa's green hydrogen sector is the Just Energy Transition Partnership (JETP). Conceived as an $8.5 billion multi-donor agreement between France, Germany, the United States, the United Kingdom, and the EU, the JETP is a novel climate finance program with three overlapping goals: 1) facilitate the early decommissioning of coal-fired power plants; 2) mobilize private sector capital to finance decarbonization efforts; and 3) deliver a "just transition" for affected groups (ibid.). Furthering the JETP's second goal, in November 2022, the South African government released the JETP Investment Plan, detailing $700 million in concessional loans and guarantees for green hydrogen infrastructure and implementation (South Africa Presidential Climate Commission 2022). Notably, since the JETP Investment Plan entails a line-item budget that attributes specific energy transition projects to individual donors, certain countries have demonstrated outsized interest in supporting South African green hydrogen. Germany, for example, has earmarked $198 million in grants and $350 million in concessional loans (primarily through KfW) for the "financing of South African grid infrastructure, renewable energy generation, and green hydrogen development" (South Africa Presidential Climate Commission 2022). Some JETP donors, meanwhile, have earmarked funds for related decarbonization activities, while others, namely the United States, have explicitly stated that none of their JETP funds shall go towards green hydrogen investments. The full extent of the JETP's green hydrogen investment will be revealed upon the release of the JETP Implementation Plan.

Some JETP donors have already channeled funds to boost South African green hydrogen. In November 2022, for example, KfW announced it would deliver €23 million in grant funding to the South Africa IDC to accelerate the development of early-stage green hydrogen projects (KfW Development Bank 2022a, 2022b). The same month, the UK pledged an undisclosed amount of grant-funded technical assistance to South Africa as part of its JETP commitment (Omarjee 2022).

One area in which MDBs and DFIs are particularly active in the expansion of South African IDZs, namely the Freeport Saldanha IDZ. Through the announcement of sixteen new projects (many of which have SIP status), the Saldanha IDZ aims to stimulate wide-scale economic activity across a range of industries, including green steel, shipping fuel bunkering, and solar panel manufacturing. Nonetheless, to incentivize and cement investment from private sector actors, the Saldanha IDZ requires the construction of several publicly-oriented infrastructure projects, such as a desalination plant and transmission lines. As such, the WB, EIB, KfW, and DBSA are currently exploring ways to finance these infrastructure projects, thereby decreasing risk for private sector investors and, hopefully, increasing the likelihood of green hydrogen offtake agreements (Interview 3). Additional areas of MDB and DFI activity regarding IDZs include the financing of environmental impact assessments (particularly concerning water- and land-use requirements) and feasibility studies.

Figure 5: JETP Contributions by Country and Type



Source: The Presidency of South Africa. Retrieved October 17, 2023, from https://www.thepresidency.gov.za/content/south-africa%27s-just-energy-transition-investment-plan-jet-ip-2023-2027

Notably, no Asian DFIs, including the Japan Bank for International Cooperation (JBIC), Development Bank of Japan (DBJ), China Development Bank (CDB), or Export-Import Bank of China (CHEXIM), have announced investments to support South African green hydrogen development. Furthermore, the United States Development Finance Corporation (DFC) has not announced investments in the South African green hydrogen sector.

Lastly, as stated previously, the Dutch-owned Climate Fund Managers and Invest International are deeply involved in the development of the H2-SA fund. Like its Namibian counterpart, SDG Namibia One (see Namibia: Domestic Stakeholders), Climate Fund Managers will likely assume day-to-day operating responsibilities, working with IDC and DBSA to manage assets and investments. Together, parties hope to raise up to $1 billion to help finance large-scale green hydrogen projects across South Africa.

2.3.2 Technical Assistance

Germany is the largest provider of technical assistance to South Africa regarding green hydrogen development. Implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), several German federal ministries have commissioned technical assistance programs to help South Africa develop its green hydrogen capabilities.

For example, one of the most well-known GIZ programs is the International PtX Hub (International Ptx Hub n.d.-b). Commissioned by the German Federal Ministry for Economic Affairs and Climate Action (BMWK), PtX Hub works with South African government stakeholders to drive green hydrogen development across four areas: 1) developing political frameworks for hydrogen adoption; 2) identifying opportunities for local value added (e.g. developing domestic hydrogen industries); 3) maximizing green hydrogen's macro-economic potential (e.g. developing green ammonia export markets) and; 4) supporting South Africa's efforts to address climate change through PtX substitutions in energy systems. In addition to training local staff, PtX Hub also assists South African policymakers by offering economic analysis on international and domestic markets, technical advice on hydrogen technologies, and strategic guidance for policy decisions.

Related to the PtX Hub, GIZ's also operates the H2.SA project (GIZ n.d.-b). Commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ) with $28.4 million of grant funding, the project aims to strengthen the country's strategic and regulatory frameworks by collaborating with a range of South African stakeholders across various ministries (Energy Capital & Power 2022). Ultimately, H2.SA hopes to improve green hydrogen investment conditions and, like PtX Hub, provides training to local policymakers in technical and economic fields to improve the capacity of South African institutions.

Additionally, GIZ oversees the South African German Energy Partnership (GIZ n.d.-a). As one of Germany's many energy partnerships with carbon-intensive emerging economies, the BMWK-funded program seeks to facilitate dialogue between high-level government officials—usually at the ministerial level and above—to promote cooperation on strategic decarbonization objectives, namely green hydrogen development (Interview 7). While primarily focused on political dialogue, the Energy Partnership nonetheless plays a vital role in aligning green hydrogen priorities between German and South African leaders. Notably, the Energy Partnership also frequently involves German industry in its exchange activities, arranging South African delegations to network with German business leaders and partake in site visits.

Aside from Germany, the UK has provided technical assistance to South Africa for green hydrogen development. The UK first provided technical assistance to South Africa in 2021 through the UK Partnering for Accelerated Climate Transitions (UK PACT) program to help South Africa develop its HSR (Omarjee 2022). Since then, the UK has funded academic collaboration between Stellenbosch University and Teesside University to research employment opportunities and skills needed to grow South Africa's domestic green hydrogen economy (SAIIA Futures n.d.). While the UK pledged an undisclosed amount of grant-funded technical assistance to South Africa green hydrogen in November 2022, it remains to be seen how these funds will be spent (Omarjee 2022).

Lastly, the EU has provided small-scale technical assistance to South Africa regarding the planning of the PVI and development of the JETP Investment Plan (Interview 6). While the EU does not have an official cooperation framework on green hydrogen with South Africa, EU officials have not ruled out a future agreement.

2.3.3 Commercial Diplomacy

In addition to providing traditional technical assistance, Germany has also taken strides to directly assist green hydrogen companies, most notably through its promotion of the H2Global program (H2Global Stiftung n.d.). With an initial endowment of €900 million from the BMWK, H2Global is a funding instrument that aims to purchase hydrogen products cheaply on the world market and sell them to the highest bidders in the EU. Through its hydrogen brokerage firm, HINT.CO, the program lowers risk for hydrogen exporters, such as companies in South Africa, as they can engage in long-term offtake agreements (HINT.CO n.d.). This, consequently, helps hydrogen projects acquire financing. BMZ has committed an extra $14.2 million in grant funding to promote and develop the H2Global program in South Africa (Energy Capital & Power 2022). While no South African firms have yet to utilize the H2Global instrument, several companies have signaled their intention to submit bids.

Furthermore, Germany has approved grants to directly support South African green hydrogen projects, namely the HySHiFT consortium project in Secunda, Mpumalanga. In December 2022, Vice Chancellor Robert Habeck announced that BMWK would provide Linde (a German chemicals company) a €15 million grant to assist its efforts to produce SAF as part of the HySHiFT consortium (M. Creamer 2022b). The grant will support the first phase of the project in which HySHiFT partners

hope to construct 40 (megawatts) MW of electrolyzer capacity. Notably, HySHiFT partners have also indicated their willingness to apply for offtake agreements through the H2Global program.

Aside from Germany, Saudi Arabia has taken steps to strengthen commercial ties with South Africa regarding green hydrogen production. For example, in October 2022, the South African and Saudi Arabian governments signed 17 MoUs worth $15 billion to improve cooperation in various industries, including clean energy and green hydrogen, although the details of these MoUs have not yet been released (Business Tech 2022). The same month, IDC and ACWA, a Saudi energy company, signed an MoU to explore developing green hydrogen and its derivatives in South Africa (ACWA Power 2022). ACWA would act as a project developer while IDC would act as a co-developer and equity partner in proposed projects. The MoU has a potential value of $10 billion if projects come to fruition, although no details have been released since the deal's signing.

2.3.4 Private Sector

Private sector partnerships are poised to play a prominent role in South Africa's green hydrogen development, particularly in technology transfer. Importantly, nearly all of these partnerships involve agreements between foreign and domestic companies. For example, Sasol has partnered with Enertrag (Germany), Linde (Germany), and Hydregen (UK) to produce SAF through the HyShiFT Consortium. As part of the consortium, partners hope to develop a green hydrogen project in Mpumalanga featuring 200 MW of electrolyzers and 450 MW of renewable energy capacity. For their parts, Enertrag is responsible for developing the project's renewable energy generation, Linde is responsible for the production of green hydrogen, and Sasol is responsible for converting inputs into SAF through the Fischer-Tropsch chemical process (Green Building Africa 2022). In this way, as with Arcelor-Mittal and Sasol's green steel partnership, HyShiFT partners hope to use each other's technological expertise to manufacture a green hydrogen derivative product.

On an economy-wide level, it is evident that international private sector actors are a primary vehicle through which domestic industrial transformation will occur. In the case of the PVI, for example, many of the major actors involved–Anglo-American (UK), Toyota (Japan), Maesrk (Denmark)–are foreign companies acting through South African subsidiaries. Taken together, these companies' applications of green hydrogen technologies will be the engine through which South Africa decarbonizes key industries and, consequently, scales its green hydrogen sector.

2.3.5 Key Challenges for International Cooperation

The outsized influence of international firms raises questions about long-term value creation for the South African economy. Indeed, as pointed out by the German Institute of Development and Sustainability (IDOS), with the exception of Sasol, many of South Africa's green hydrogen projects are driven by foreign tenders and rely on technologies owned by foreign corporations. Because of this, projects may include less local suppliers and local experts (Stamm 2022). While the GHCS prioritizes local value creation, it remains to be seen how South Africa will take steps to ensure that private-sector green hydrogen development benefits the domestic economy.

Other concerns about South Africa's emerging hydrogen economy relate to EU regulatory rules. Published in February 2023, two Delegated Acts to the EU's Renewable Energy Directive define the conditions under which hydrogen produced and consumed in the EU can be considered "renewable and hence count toward fulfilling the EU's ambitions hydrogen policy goals" (European Commission 2023b). Because these definitions apply to third parties hoping to export to the EU, South African companies are currently communicating with European officials to ensure that their hydrogen exports comply with EU regulations. However, this has led to some complications. For example, Sasol has argued that, since many of its hydrogen products rely on coal value chains that employ thousands of

workers, the EU should give the company regulatory leeway as it transitions to fully green hydrogen production (Interview 4). Nonetheless, the EU Commission has not demonstrated a willingness to bend its rules and maintains that companies like Sasol can export hydrogen as long as it is labeled properly (Interivew 6). Furthermore, Sasol is particularly interested in the EU's rules on carbon feedstocks for synthetic fuels. After 2041, EU regulations dictate that carbon feedstock from industrial sources—as opposed to direct air capture or biological sources—have to be account-ed for in the production of low-carbon synthetic fuels (European Commission 2023a). This of particular interest to Sasol as the company currently plans to use carbon feedstock from industrial processes to produce aviation fuel at its Secunda plant. Additional areas of interest pertain to the forthcoming EU CBAM regime since non-green hydrogen products will be significantly more expensive to trade in the EU than green hydrogen products. To ensure maximal export share, South African firms are trying to plan their future manu-facturing processes to comply with CBAM rules.

In terms of international engagement, cooperation on South African green hydrogen is strongly driven by those countries with an anticipated demand for hydrogen imports. In the context of the JETP, for instance, only Germany has designated funds to support green hydrogen commercializa-tion because it will be the only JETP donor dependent on the export of green hydrogen derivatives to Europe. Other JETP donors, such as the United States, United Kingdom, and France, do not plan to import South African hydrogen and, accordingly, have refrained from earmarking public funds to develop South Africa's green hydrogen capabilities. Similarly, the Netherlands has taken an active role in developing the H2-SA fund because it stands to benefit from the import of South African green hydrogen deriva-tives, mainly via the Port of Rotterdam. The European Union has indicated some interest in supporting South Africa's green hydrogen sector, but this support would occur out-side the JETP framework and involve commercial loans from the EIB, similar to EU green hydrogen engagement in Namibia. These trends indicate that green hydrogen is viewed differently than other public investments in South Af-rica's energy sector, such as the expansion of transmission infrastruc-ture, which aim to improve the system as a whole and contribute to the decarbonization of the pow-er sector.

3 Namibia

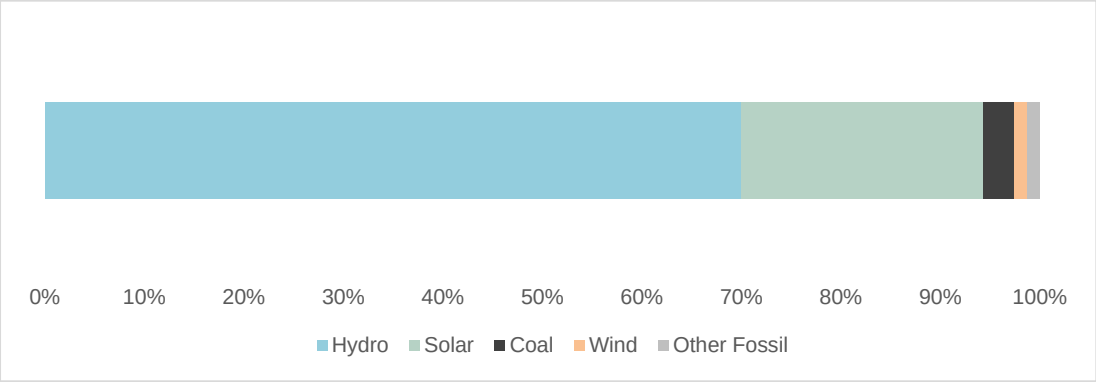
3.1 Background

3.1.1 Energy Sector and Resources

Namibia heavily depends on imports to meet its electricity needs. Despite having a relatively small peak load demand of 630 MW and low electrification rate of 56 percent, only about 40 percent of Namibia's electricity demand can be met by domestic generation (GIZ 2022; USAID 2023; World Bank 2023). Namibia's domestic electricity generation is mostly clean, relying on hydropower and solar to provide 75 percent and 18 percent of capacity, respectively (see Figure 6). Nonetheless, Namibia is typically forced to import up to 60 percent of its electricity from South Africa, which uses coal to produce almost 90 percent of its power generation (USAID 2023).

Despite this, Namibia has great potential to expand its solar and wind capacity, including for green hydrogen production. Enjoying over 300 sunny days per year, the country boasts the highest practical photovoltaic potential in the world (GIZ 2022; Global Solar Atlas 2023). For comparison, PV systems in Namibia can generate twice as much electricity per year as similar PV systems in Germany (GIZ 2022). Since electricity costs are the most crucial factor in the price of green hydrogen production, Namibia's cheap solar power makes the country a highly attractive location for green hydrogen development (Agora Energiewende 2021). While Namibia's wind resources are relatively more limited, the country still offers attractive conditions for wind power, particularly along the southern coast near Lüderitz and northern border with Angola. Indeed, experts believe that the southern coast can achieve a load factor above 90 percent through the co-location of solar, wind, and battery infrastructure.

Figure 6: Electricity generation by source for Namibia, 2021



Source: Ember. Retrieved October 15, 2023, from https://ember-climate.org/data/data-tools/data-explorer/

Namibia is also an attractive destination for green hydrogen production due to its abundance of undeveloped land. A result of naturally arid conditions and colonial-era relocation policies, Namibia features vast swaths of sparsely populated desert lands, particularly in the southern and northern regions along the coast. These conditions make Namibia the second least densely populated country in the world (after Mongolia) (Ritchie & Mathieu 2019). Because concerns about human displacement

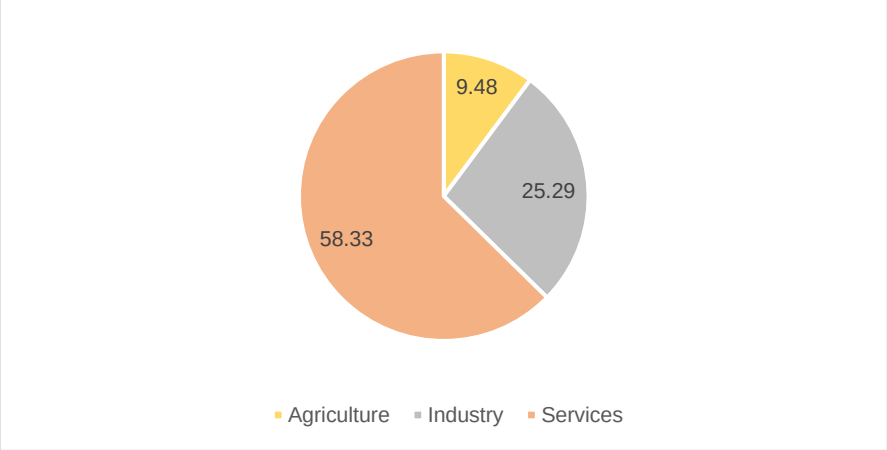
are often a major roadblock for infrastructure projects in Africa, Namibia's abundance of sparsely populated land makes the country a highly desirable location for green hydrogen development, especially compared to countries like South Africa (Interview 8). It should be noted, however, that much of this uninhabited land, including almost the entirety of Namibia's coast, falls within 22 national parks, namely Namib-Naukluft National Park in the central coast and Tsau //Khaeb National Park in the south. While these areas are protected under national law, the government has taken steps to lease land to prospective green hydrogen developers (Shipena 2023). Nonetheless, environmental concerns remain as greenfield hydrogen projects will require significant infrastructure build-up, including roads, housing, and transmission lines.

Furthermore, due to its arid climate, Namibia frequently suffers from water shortages. Since 2015, the country has experienced persistent drought conditions, causing 750,000 people to experience food insecurity in 2022 (IFRC 2022). As such, to avoid supply crunches and provide electrolyzers with constant fresh water supplies, prospective hydrogen developers must construct desalination plants. If constructed, these desalination plants could relieve local water scarcity, but official plans to produce and sell surplus water have yet to be released. Nonetheless, these plants also have notable environmental concerns, notably the discharge of brine and other chemicals at the end of the desalination process (Patel 2018).

3.1.2 Economy

Regarding its domestic economy, Namibia is the fourth largest producer of uranium in the world, providing 10 percent of world mining output (World Nuclear 2022) and making it its second largest export product (see figure 8 below)). However, aside from other mining products, such as diamonds, copper, and recently discovered fossil fuel reserves, Namibia has limited natural resources. Industry-wise, the country has little heavy industry, instead possessing small-scale steel, concrete, and chemicals facilities (see figure 7 below). Namibian strategy documents frequently state the country's goal of leveraging a green ammonia export industry to develop parallel green hydrogen derivative industries, such as e-methanol and sustainable aviation fuel, as well as green steel and hot briquetted iron industries (Namibian Ministry of Mines and Energy 2022). Nonetheless, it remains to be seen whether the country has sufficient human and technological capacities as well as raw materials, such as iron and carbon feedstock, to support these industries. Furthermore, some of the country's green hydrogen plans are contingent on the commercialization of fledgling technologies to provide industrial inputs. For example, the country's long-term e-methanol and green steel plans envision the use of direct air capture to provide sustainably sourced carbon feedstock. While optimistic, there is significant uncertainty regarding the future of this untested technology.

Figure 7: Distribution of GDP across economic sectors, Namibia, 2021



Source: Statista. Retrieved October 15, 2023, from https://www.statista.com/statistics/510204/share-of-economic-sectors-in-the-gdp-in-namibia/

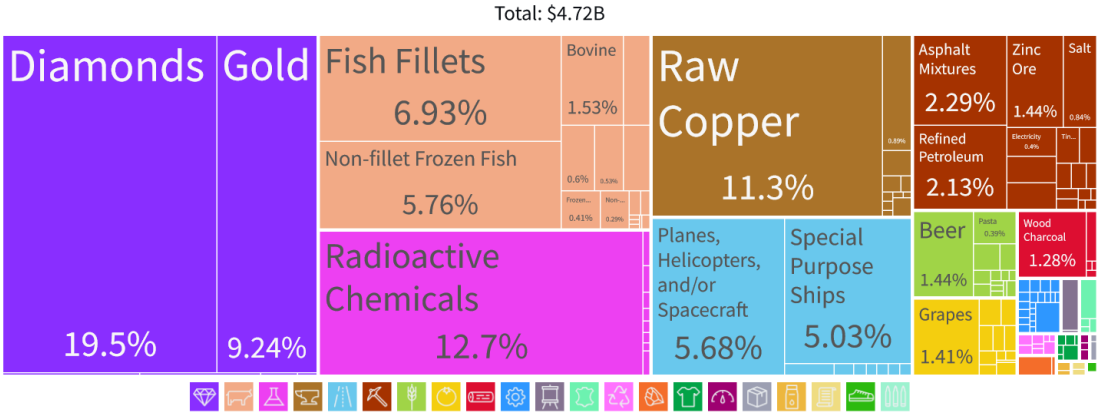
3.1.3 International Relations

Historically, Namibia has maintained close ties with South Africa. A former part of South Africa, Namibia today maintains tight trade relations with its former colonial ruler, making it the country's largest export destination and relying on South Africa for 57.6 percent of total imports, including electricity, automobiles, and petroleum products (see Figures 8 and 9). The Namibia economy is heavily dependent on South African foreign direct investment, especially in the mining and retail sectors, and the Namibian dollar is pegged to the South African rand. As will be discussed later, Namibian policymakers see green hydrogen development as a way to export renewable energy generation to South Africa, thereby earning extra state revenue and gaining increased regional influence (see section on Regional Competition and Cooperation).

Namibia also maintains a special relationship with China. Providing military and political support for Namibia during its struggle for independence, China is now a major economic partner, controlling majority stakes in Namibia's uranium sector and investing heavily in Namibia's shipping industry, namely the Walvis Bay port (France24 2019; Further Africa 2019). Nonetheless, despite these historical and economic ties, China has expressed limited interest in developing Namibia's green hydrogen economy (see Technical Assistance).

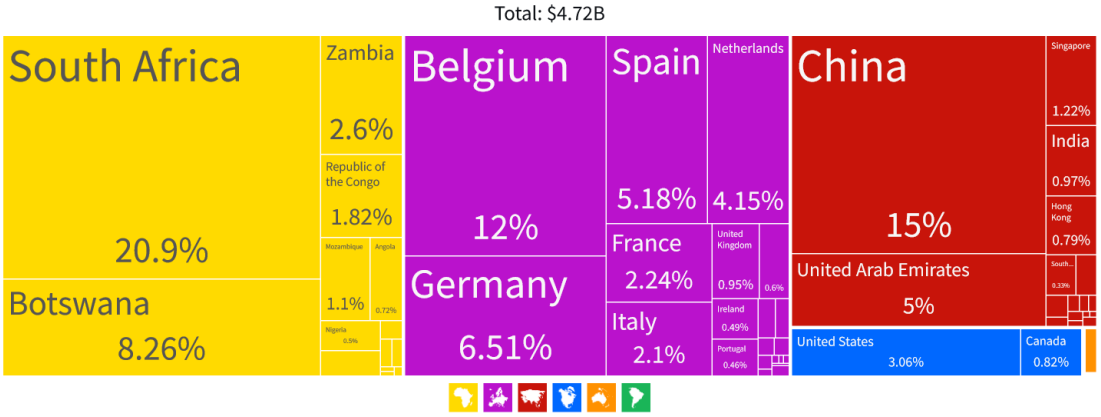
Notably, Namibia has recently tightened relations with Germany. The colonial power in Namibia before South Africa, Germany has come under intense scrutiny for its genocide against Namibia's Herero and Namaqua people between 1904 and 1908. Nonetheless, despite poor relations for much of the twentieth century, today there is much affinity between the two countries as a minority of Namibians continue to speak German, particularly in urban environments. As will be discussed later, Namibia and Germany have recently intensified cooperation to achieve common aims of developing a green hydrogen economy (see International Actors). Additional nations with noteworthy relations include Belgium, which receives 6 percent of Namibian exports, as well as other members of the Southern African Development Community (SADC), namely Botswana and Zambia (see Figure 9).

Figure 8: Export products by trade value for Namibia, 2021



Source: OEC. (2023). Retrieved October 18, 2023, from https://oec.world/en/visualize/tree_map/hs92/export/nam/all/show/2021/

Figure 9: Export destinations by trade value for Namibia, 2021



Source: OEC. (2023). Retrieved October 18, 2023, from https://oec.world/en/visualize/tree_map/hs92/export/nam/show/all/2021/

3.2 Namibia's Green Hydrogen Economy

First and foremost, Namibia views green hydrogen as a chance to merge its industrialization and sustainable development goals. Through overarching national planning documents such as Vision 2030, the country has long sought to promote resource-based industrialization as a means of diversifying its economy, upskilling its labor force, and improving public services (Namibia National Planning Commission 2004). To this end, green hydrogen presents an opportunity for Namibia to develop a future-oriented industry that can generate trickle-down benefits for its domestic economy.

Furthermore, Namibia views green hydrogen as a way of assisting the global fight against climate change. Contributing 0.04 percent of global carbon emissions and housing 0.03 percent of the world's population, Namibia emits slightly more emissions than its share of the global population (UNDP n.d.; Worldometer n.d.). Nonetheless, given that most of Namibia's emissions come from internal combustion engines in the transport sector, the country's green hydrogen development will primarily benefit countries using Namibian green ammonia in their decarbonization efforts. As such, the Namibian government sees its fledgling green hydrogen industry as a critical contribution to decarbonization worldwide.

3.2.1 Hydrogen Policy

Recognizing the country's green hydrogen potential, the Namibian Ministry of Mines and Energy published the country's **Green Hydrogen and Derivatives Strategy (GHDS)** in November 2022. Partially funded by the German Ministry of Education and Research (BMBF), the GHDS provides an in-depth outline of Namibia's green hydrogen ambitions.

Beginning with an overview of Namibia's renewable energy endowment, the GHDS first states Namibia's goal of focusing on the production and export of green hydrogen derivatives, namely green ammonia, e-methanol, synthetic kerosene (sustainable aviation fuel), and hot-briquetted iron (Namibian Ministry of Mines and Energy 2022). Rather than exporting pure green hydrogen, Namibia will likely export hydrogen derivatives, namely green ammonia, due to the technical challenges of transporting hydrogen over long distances. In the case of green ammonia, this transport will likely take place through the use of modified liquid natural gas (LNG) tankers. Notably, the GHDS states that Namibian green ammonia production could become cheaper than gray ammonia by 2030. Nonetheless, the GHDS recognizes that low shipping costs will be crucial for Namibia to become a cost-competitive exporter. To this end, the GHDS recommends that the government foster supplier relations with Europe, Japan, South Korea, and China, whose high expected demand for green hydrogen products could lead to low-cost bulk shipping agreements.

Regarding export destinations, the GHDS anticipates that Germany will be Namibia's largest green ammonia export destination, where the ammonia could be used to decarbonize sectors such as fertilizer production and chemicals. This is primarily due to Namibia's relative proximity to Europe compared to East Asia. While the GHDS notes that Namibia will likely not be the lowest-cost green ammonia export to East Asia, it mentions that Namibia could nonetheless be an attractive trade partner if Asian nations decide to diversify their ammonia suppliers. Notably, the GHDS mentions that Namibia could export green ammonia to China if Chinese buyers cannot procure sufficient hydrogen from domestic and Australian producers.

Following this, the GHDS outlines Namibia's vision of developing three parallel hydrogen valleys. In the southern valley, also known as the Southern Corridor Development Initiative (SCDI), the government envisions an integrated hydrogen hub featuring green ammonia production facilities (with wind, solar, electrolyzer, and desalination assets), an enhanced deep-water port in Lüderitz, and a green steel plant with corresponding iron mine. Spearheaded by the gigawatt-scale Hyphen project (see Hyphen), the government has prioritized this SCDI's development, believing it can kickstart the nation's hydrogen industry and produce up to 5 million tons per annum (mtpa) of green hydrogen by 2050. Notably, the HyIron/Oshivela demonstration project for the production of direct-reduced iron is already underway near Namibia's Shiyela Mine. A consortium of German and Namibian firms aim to begin the production of 0,5 tonnes of direct-reduced iron per hour by 2024 (see details below). In the central hydrogen valley, meanwhile, the government hopes to take advantage of existing infrastructure to develop a bunkering hub for green ammonia shipping fuel at the Walvis Bay Port as well as facilities for green hydrogen locomotives and mining equipment. There are currently four confirmed pilot projects in the central valley in various stages of development (see below), and the government believes that this region can produce 3 mtpa of green hydrogen by 2050. Lastly, in the northern valley, the government thinks it can develop another 5 mtpa green hydrogen hub capitalizing on the area's significant renewable energy potential. Nonetheless, because this region lacks basic infrastructure, the government does not foresee development in this space until the late 2020s.

The GHDS mentions several ways in which Namibian green hydrogen development could strengthen ties with neighboring countries. The document states Namibia's intention to export excess renewable energy-based electricity to South Africa, Botswana, and Zambia via the Southern Africa Power Pool. This has the potential to be a highly profitable proposition for all parties as these nations, especially South Africa, suffer from severe electricity shortages. Furthermore, the GHDS notes

the potential of hydrogen-powered transport routes between Namibia, Botswana, and Zambia to facilitate the trade and export of raw materials from the African interior to the coast.

Regarding implementation, the GHDS identifies several domestic measures that the government should take to create an enabling environment for green hydrogen development. First, the strategy recognizes that Namibia could suffer from a labor shortage of 55,000-60,000 workers by 2030 as it attempts to scale green hydrogen resources. To remedy this issue, the GHDS recommends retraining and vocational training programs to educate low-skilled workers and specialized university programs for skilled workers and engineers. Indeed, partnerships between Namibian and German universities are already playing a role in this area (BAM 2022). Nonetheless, the GHDS acknowledges that immigration will play a major role in meeting the country's skills needs. Second, the strategy outlines a novel regulatory and institutional framework for green hydrogen development. Called the Synthetic Fuels Act, this piece of legislation would set the governance of all aspects of green hydrogen, including permitting processes, tax structures, and guidelines for pilot projects. The Namibian government states that the details of the Synthetic Fuels Act will be finalized by the end of 2023 (Biogradlija 2023b). Last, the GHDS foresees the creation of a novel delivery support system under the government's Implementation Authority Office to facilitate all aspects of green hydrogen development, including land auctions, permitting approvals, and stakeholder management. This effort hopes to create a "one-stop shop" for information on green hydrogen regulation, thereby simplifying and accelerating the green hydrogen development process.

Finally, the GHDS mentions the critical role of international partnerships in helping Namibia meet its green hydrogen ambitions. As will be further detailed later (see International Actors), the document outlines Namibia's green hydrogen cooperation with Germany and its memoranda of understanding (MoUs) with Belgium, the Netherlands, and several Japanese companies. Additionally, the GHDS notes Namibia's role as a founding member of the Africa Green Hydrogen Alliance (along with South Africa, Egypt, Morocco, Kenya, and international development partners). The GHDS emphasizes Namibia's commitment to international partnerships and openness to future arrangements, including deals with private sector actors.

3.2.2 Hydrogen Stakeholders

Namibia's Green Hydrogen Council is the primary government body responsible for the country's green hydrogen strategy (Namibian Ministry of Mines and Energy 2022). Led by James Mnyupe, who serves as Green Hydrogen Commissioner and Economic Advisor to the President, the Council comprises the heads of various government agencies with interests in green hydrogen development, including the National Planning Commission, Central Bank, and Ministries of Finance, Agriculture, and Energy. Bringing together the leaders of relevant public sector entities, the Council seeks to promote interagency coordination on green hydrogen development, thereby streamlining and accelerating the processes through which strategic decisions are made and implemented. For this reason, while the ministries ultimately carry out regulatory functions such as land auctions and permitting, the national government acts more or less as one unit. Other significant government entities include Namport, Namibia's national port authority, and Nampower, the country's national electric power utility, which controls power generation, transmission, and distribution. Notably, Commissioner James Mnyupe plays a de-facto role as Namibia's emissary for green hydrogen matters, frequently traveling to international conferences and serving as a primary representative in negotiations with foreign governments and companies. In this way, albeit primarily focused on hydrogen, Mnyupe occupies a multifunctional position similar to United States Special Envoy for Climate John Kerry and German Minister for Economic Affairs and Climate Action Robert Habeck.

On the finance side, the Namibian government has set up the SDG Namibia One Fund to help mobilize capital for green hydrogen infrastructure. Recognizing that it will need to raise upwards of $1 billion to develop the SCDI, the Namibian government established SDG Namibia One in November

2022 to attract blended concessionary and commercial capital for green hydrogen and common-use infrastructure projects (Invest International 2022). Composed of the Namibian-owned Environmental Investment Fund and Dutch-owned Climate Fund Managers and Invest International, the fund has already received €40 million in initial grant funding from Invest International and is slated to obtain additional financing as part of a €500 million agreement between the European Investment Bank (EIB) and Namibian government (Namibian Sun 2022). SDG Namibia One plans to attract future capital by working with development partners to implement financial de-risking instruments, such as export credit guarantees, first-loss equity, low-cost loans, and political risk insurance (Namibian Ministry of Mines and Energy 2022). Importantly, acting as a sovereign wealth fund, SDG Namibia One is also the financial vehicle through which the Namibian government is expected to take an equity stake in green hydrogen projects, namely the Hyphen project. Nonetheless, some commentators have expressed concern that the government will be unable to raise enough capital to take the 24 percent equity stake in Hyphen project as agreed upon in the project's Feasibility and Implementation Agreement (Interview 1).

On the subnational level, regional governments wield little influence in Namibia's green hydrogen development. Instead, green hydrogen decision-making rests mainly with the national government. Furthermore, while the Namibian government has floated the idea of creating special economic zones to promote synergies between prospective industries and create favorable conditions for foreign investment, it has yet to officially announce such plans (Namibian Ministry of Industrialisation and Trade 2022).

Concerning the private sector, several companies are poised to play an important role in Namibia's green hydrogen economy. For example, Hyphen Hydrogen, a joint venture between Enertrag (Germany) and Nicolas Holdings (United Kingdom), has emerged as Namibia's most promising green ammonia export project and is slated to spearhead the development of the SCDI (see Hyphen). In the central hydrogen valley, meanwhile, Hydrogène de France (HDF Energy) (France) has obtained permits to construct an 85 MW solar park and green hydrogen production unit near Swakopmund (Beyer 2022). Other notable stakeholders include CMB.TECH (Belgium) and the Ohlthaver & List Group (Namibia), which want to decarbonize port activities at Walvis Bay and develop a hydrogen-diesel locomotive project, and the Daures Green Hydrogen Village, a local constituency which wants to produce green ammonia for carbon-neutral agricultural production (CMB.TECH 2022; Daures n.d.). Notably, the Daures Village project is supported by a partnership between the BMBF, University of Namibia, the University of Stuttgart, Enersense (Namibia), and Windwise GmbH (Germany). Interestingly, Mizuho Bank, a major Japanese commercial bank, signed an MoU with the Namibian Investment Promotion and Development Board (NIPDB) in August 2022 to promote increased investment in Namibia's green hydrogen and sustainability space (Mizuho 2022). Nonetheless, Mizuho and NIPDB have yet to announce any updates since.

Lastly, educational institutions are poised to play a small but important role in the development of Namibia's green hydrogen industry. Founded in October 2021, the University of Namibia's Green Hydrogen Research Institute (NGHRI) serves a multifaceted role in generating domestic green hydrogen research and training a skilled green hydrogen labor force. NGHRI comprises six centers, including Centers on Clean Hydrogen Production and Storage and Hydrogen Fuel Cell Technology. Notably, in October 2022, NGHRI formed a partnership with the German Bundesanstalt für Materialforschung und -prüfung (BAM) to provide postdoctoral positions for Namibian scientists working in the field of renewable energy and green hydrogen technology (BAM 2022). Additionally, in November 2022, NGHRI partnered with RWTH Aachen University to promote research collaboration in green hydrogen technology (RWTH Aachen 2022).

3.2.3 Hydrogen Projects

As of July 2023, there are six confirmed green hydrogen projects in Namibia in various stages of development. Many of these projects are focused directly or indirectly on the export of green ammonia, although some are focused exclusively on domestic consumption. Nonetheless, among Namibia's confirmed green hydrogen projects, the Hyphen project stands out for its ambition and progress.

Table 2: Confirmed Namibian Green Hydrogen Projects

Project name(s)	Product	Region & closest city	Primary stakeholders
Hyphen Hydrogen	Green ammonia for export	Southern Region: Lüderitz	Hyphen: Enertrag (Germany), Nicolas Holdings (UK); Government of Namibia
HyIron/Oshivela project	Direct-reduced iron	Southern Region, Shiyela Mine	Elino/TS Group, CO2GRAB, LSF Energy (all Germany), HyIron (Namibia)
Renewstable Swakopmund	Green hydrogen power plant	Central Region: Swakopmund	HDF Energy (France)
Hydrogen-Diesel Dual Fuel Locomotive	Green hydrogen- diesel locomotive	Central Region: Walvis Bay to Kranzberg	CMB.TECH (Belgium), Hyphen Technical (South Africa), TransNamib (Namibia), NGHRI (Namibia), Nicholas Holding (UK)
Walvis Bay Port Infrastructure	Green hydrogen port infrastructure (tugboats, cranes)	Central Region: Walvis Bay	Cleanergy Solutions Namibia: CMB.Tech (Belgium), Ohlthaver & List Group (Namibia), CMB (Belgium), Namport (Namibia), NGHRI (Namibia)
Walvis Bay Refueling Station	Green ammonia	Central Region: Walvis Bay	Cleanergy Solutions Namibia: CMB.Tech (Belgium), Ohlthaver & List Group (Namibia)
Daures Green Village	Green ammonia for agriculture	Central Region: Daures	BMBF (Germany), Enersense Energy (Namibia), Windwise (Germany), University of Stuttgart (Germany), NGHRI (Namibia)

The **Hyphen** project is slated to kickstart Namibia's green ammonia export industry. A venture between Enertrag (Germany) and Nicolas Holdings (United Kingdom), the $10 billion project envisions the development of approximately 7 gigawatts GW of renewable energy generation and 3 GW

of electrolyzer capacity (Hyhen 2023). For context, Namibia's current gross domestic product (GDP) is approximately $12.61 billion. Furthermore, the proposed facility requires the construction of a desalination plant and expanded deepwater port in Lüderitz, a town of less than 13,000 people with little existing infrastructure. Ultimately, once both phases of the project are complete, Hyphen aims to produce 350,000 metric tons of green hydrogen per year and export green ammonia from Lüderitz via modified LNG tankers.

Hyphen first rose to public attention in November 2021 when the company was awarded preferred bidder status to develop a vertically integrated green hydrogen project on 4,000 km2 of land in Tsau // Khaeb National Park (T. Creamer 2021b). The largest public procurement auction in Namibia's history, the tentative deal would give Hyphen the right to construct and manage the project for 40 years. Notably, the government committee that selected the preferred bidder was supported by both the United States (US) National Renewable Energy Laboratory, a national laboratory of the US Department of Energy, and technical experts appointed by the European Union (EU) Global Technical Assistance Facility on Sustainable Energy (Hyphen 2023b). In the following 18 months, Hyphen and the Namibian government entered into negotiations to determine the governance model of the proposed project as well as plan the construction of complementary common-use infrastructure projects. Finally, in May 2023, Hyphen and the Namibian government signed a joint Feasibility and Implementation Agreement, announcing the development process and roles and responsibilities of both parties (ibid.). Broadly speaking, the government is responsible for approving the project and ensuring it enjoys a favorable legal, fiscal, and regulatory environment. Meanwhile, Hyphen is responsible for the technical, financial, environmental, social, and commercial delivery of the project. Importantly, under the agreement, the government of Namibian can take up to a 24 percent equity stake in the project, making it a key minority stakeholder and business partner.

Hyphen must raise funds to finance its green hydrogen development through project financing. To this end, long-term offtake agreements, such as those offered by the H2Global mechanism (see Commercial Diplomacy), are critical to reducing investment uncertainty and attracting new investors. Nonetheless, the company still faces an uphill climb as it hopes to raise approximately $4 billion from equity investors (interview 1).

As of July 2023, the Hyphen project has signed three non-binding MoUs with prospective offtakers totaling over 1 million tonnes annually of green ammonia exports from 2027 onwards (Hyphen 2023a). Offtakers include Approtium, a South Korean hydrogen producer (250,000 tonnes), RWE, a German multinational utility (300,000 tonnes), and an unnamed chemical company (500,000 tonnes). Additionally, Hyphen has signed an MoU with Itochu Corporation (Japan) to explore potential areas of green hydrogen investment.

Another notable project is the HyIron/Oshivela demonstration project for the production of 15,000 direct-reduced iron per year. The project will utilize iron ore from the Shiyela Mine in the South of Namibia and green hydrogen from a 20 MW solar energy installation. The project is located approximately 30 km from Namibia's largest port in Walvis Bay, from where the direct-reduced iron could be exported. The consortium consists of three German technology providers and a Namibian project management firm and has received €13,8 million grant from the German government. The consortium envisages scaling-up production at a later stage from 0,5 tonnes to 100 tonnes per hour with a solar energy installation of 60 MW (HyIron, 2023; BMWK, 2023).

3.2.4 Socio-economic Challenges and Just Transition

Despite much progress in realizing green hydrogen projects, many questions remain concerning the benefits and costs of Namibian green hydrogen development to the broader population. As previously mentioned, the government of Namibia has chosen to act as a business partner in hydrogen projects, taking an equity stake of 24 percent in the case of Hyphen. In addition to collecting

royalties from leases on public land, the government is could potentially earn significant revenue from these equity stakes. However, it remains uncertain how the government will secure its envisioned equity stake, and the government has yet to announce how it will reallocate funds through revenue-sharing models. Acting through SDG Namibia One, it is unclear whether the government will elect to pursue direct dividend payments, a national budget allocation, national resource fund, or another mechanism as a means of reinvesting in the economy (Systematic IQ 2022). Potential investments include education, healthcare, infrastructure, and access to electricity. Indeed, given Namibia's electrification rate of 56 percent, revenue could be used to establish a rural electrification fund. This would be economically and politically advantageous as many green hydrogen projects do not entail the expansion of Namibia's grid to previously unconnected locations. Similarly, the government has yet to detail how excess desalinated water will be distributed among citizens. This is a particularly salient issue as some communities are more connected to national transportation systems than others.

Moreover, many open questions remain regarding the environmental impacts of large-scale hydrogen projects and how these will be managed. The Hyphen project is located in the Tsau Khaeb National Park, which includes areas that have raised concerns over biodiversity. Water is another concern. In the interior where water desalination is not an immediate option, hydrogen production risks adding to pre-existing water stress. On the coast, water desalination and the related brine could have impacts on local eco-systems and related livelihoods, such as fishery (Grobler & Civillini, 2023).

More broadly, these issues tie into conversations about the justice dimensions of Namibia's green hydrogen development aspirations. Indeed, revenue sharing is strongly associated with distributive justice (i.e. who reaps the benefits and bears the costs of the country's green hydrogen revenue), while the planning of projects is strongly associated with procedural justice (i.e. who is involved in the decision-making process). Regarding the latter, local civil society organizations have voiced concerns regarding the lack of transparency in the context of the tendering process for the Hyphen project (Matthys, 2023). While the government has articulated its intention to ensure broader benefits to the Namibian population, it has not yet clarified how they hope to accommodate and include citizen voices in the green hydrogen development process.

3.3 International Actors

3.3.1 Public Finance

Namibia has taken concrete steps to develop a green hydrogen economy. Indeed, spearheaded by the Hyphen project, the government has made considerable progress in creating an enabling environment to grow its green hydrogen industry. To this end, public finance has played a critical role allowing the government to plan common-use infrastructure projects and attract private sector investment.

To date, the largest public finance contribution to Namibia's green hydrogen sector is a €500 million loan from the European Investment Bank (EIB) (EIB 2022). Announced at COP27 in November 2023, the loan was unveiled in conjunction with a new strategic partnership between the European Union (EU) and Namibia on renewable hydrogen and critical minerals. For its part, the agreement primarily consists of concessional finance intended to assist the development of common-use infrastructure projects, namely transmission lines and desalination plants (European Commission 2022). By aiding the development of these projects, such as through the financing of feasibility and environmental studies, the Namibian government can de-risk private sector investment and facilitate infrastructure that can benefit the general population. Notably, part of the EIB's loan will be channeled to SDG Namibia One, the country's sovereign wealth fund tasked with attracting private sector

capital and taking an equity stake in green hydrogen projects. It remains to be seen how much of the EIB's loan will be directed to SDG Namibia One.

In addition to providing a loan to the Namibian government, the EIB has also formed a strategic partnership with French HDF Energy to aid the company's development of its green hydrogen power plant near Swakopmund (ESI Africa 2022). In the pipeline since 2021, the HDF project, also known as Renewstable Swakopmund, envisions the development of 36 MW of solar capacity and 235 MW of combined battery storage and hydrogen fuel cell capacity to provide baseload power supply to the Erongo region (Hartman 2023; HDF Energy n.d.). Seeking to promote Namibian electricity security, the project also includes the construction of a common-use desalination plant and green hydrogen refueling station. Indeed, if successful, Renewstable Swakopmund would be Africa's first green hydrogen power plant. While announced in conjunction with EIB's €500 million sovereign loan facility, it is unclear how much money EIB will direct to HDF. Nonetheless, the EIB believes the Renewstable Swakopmund project has the potential to significantly benefit the security of the Namibian power grid (Renew Africa 2022). As such, EIB funds will help accelerate project development, lower the price of electricity to consumers, and foster the broader Namibian green hydrogen economy.

As previously stated, the Dutch-owned Climate Fund Managers and Invest International are deeply involved in the growth of SDG Namibia One. The Dutch government has expressed interest in Namibian green hydrogen since November 2021, when it first signed a letter of intent on collaboration with Namibia in the field of energy, especially green hydrogen (Government of the Netherlands 2021). Acting as an anchor donor, in November 2022, Invest International awarded SDG Namibia One a €40 million grant to attract additional donors and investors to the fund (Invest International 2022). For its part, Climate Fund Managers has assumed day-to-day responsibilities operating SDG Namibia One, working with the Namibian Environmental Investment Fund to manage assets and investments. Together, parties hope to raise up to $1 billion to help finance green hydrogen projects across Namibia.

Lastly, Germany has given Namibia public finance to develop a green hydrogen industry. Announced in August 2021, the BMBF and Namibian National Planning Commission have formed a novel German-Namibian hydrogen partnership which entails a €40 million grant to help finance feasibility studies for three green hydrogen projects near Walvis Bay, namely the Daures Green Village, the Walvis Bay Port Decarbonization Project, and the Walvis Bay Hydrogen-Diesel Dual Fuel Locomotive (BMBF 2021). Moreover, the BMWK has provided a €13,8 million grant for the HyIron/Oshivela project (see Hydrogen Projects). Additionally, German funds will be used to fund research on desalination technologies and fund exchange opportunities for Namibian students.

Notably, no Asian DFIs, including the Japan Bank for International Cooperation (JBIC), Development Bank of Japan (DBJ), China Development Bank (CDB), or Export-Import Bank of China (CHEXIM), have announced investments to support Namibia's green hydrogen industry. Furthermore, the United States Development Finance Corporation (DFC) has not announced investments in Namibia's green hydrogen sector.

3.3.2 Technical Assistance

Germany is a major provider of technical assistance to Namibia regarding green hydrogen development. Implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Germany's primary avenue of engagement is International PtX Hub, a far-reaching technical assistance platform that operates in 13 partner countries. Commissioned by the German BMWK, PtX Hub works with Namibian government stakeholders to drive green hydrogen development across four areas: 1) building capacities on green hydrogen and power-to-x (PtX); 2) supporting national dialogue on green hydrogen and PtX; 3) advising political partners on sustainability; and 4) analyzing

Namibia's potential for green hydrogen and PtX growth (International PtX Hub n.d.-a). In addition to providing training to local staff, PtX Hub also assists Namibian policymakers by offering economic analysis on international and domestic markets, technical advice on hydrogen technologies, and strategic guidance for policy decisions. In addition the BMBF is funding capacity building and scientific exchange, involving Germany's Bundesanstalt für Materialforschung und -prüfung (BAM) and the Namibia Green Hydrogen Institute (NGHRI) at the University of Namibia (UNam). Among other things, the two organization are cooperating on research centered on a hydrogen pilot plant and refueling station, aimed at generating scientific insights for upscaling green hydrogen technologies and to ensure a high safety level for the hydrogen economy in both countries (BAM, 2023).

The EU is also an active provider of green hydrogen technical assistance. In November 2022, EU Commission President Ursula von der Leyen and Namibian President Hage Geingob signed an MoU establishing a strategic partnership between both entities on sustainable raw materials and renewable hydrogen. As part of the partnership, the EU and Namibia agreed to coordinate on six main pillars (European Commission 2022):

- Integration, where feasible, of raw materials and renewable hydrogen value chains, including networking, new business models and promotion and facilitation of trade and investment linkages;
- Cooperation to leverage Environmental, Social, and Governance (ESG) Criteria and align with international standards;
- Mobilization of funding for the development of soft and hard infrastructure required for projects development and for leveraging private sector funding through cooperation to address trade matters, including inclusiveness, and improving investments on climate action;
- Capacity building, training and skills development along raw materials and renewable hydrogen value chains;
- Co-operation on research and innovation along the raw materials value chain, including on mineral knowledge and circularity, hydrogen technologies and skills;
- Regulatory alignment, standards and certification.

EU-Namibian cooperation in these areas is key as Namibian green ammonia exporters hope to comply with new EU import standards, such as the 2023 EU Delegated Acts on Renewable Hydrogen (European Commission 2023b). These standards define the conditions under which hydrogen produced and consumed in the EU can be considered "renewable" and impose penalties on producers and consumers who do not meet sustainability requirements. Since Namibian green ammonia products will be likely produced using greenfield renewable power, the country's exports will almost certainly comply with EU rules. Nonetheless, the Namibian government and green hydrogen producers have been working closely with the EU to understand its regulatory requirements, lest they risk losing a large share of the EU green ammonia market and falling behind international competitors.

The US National Renewable Energy Laboratory and EU Global Technical Assistance Facility on Sustainable Energy provided small-scale technical assistance to Namibia by helping administer the bidding process through which Hyphen was selected as the country's preferred green hydrogen developer. The United States has not provided additional technical assistance to Namibia in the green hydrogen space.

Lastly, China has expressed limited interest in Namibia's green hydrogen sector. In April 2023, the head of the Chinese National Energy Administration visited Namibia to discuss collaboration on green hydrogen issues (Biogradlija 2023a). Nonetheless, parties have not announced the creation of any formal green hydrogen partnership.

3.3.3 Commercial Diplomacy

In addition to traditional technical assistance, Germany has also taken steps to directly support green hydrogen companies, most notably through its promotion of the H2Global program (H2 Global Stiftung n.d.). With an initial endowment of €900 million from the BMWK, H2Global is a funding mechanism that strives to purchase hydrogen products cheaply on the world market and sell them to the highest bidders in the EU. Through its hydrogen brokerage arm, HINT.CO, the program lowers risk for hydrogen exporters, such as companies in Namibia, as they are able to engage in long-term offtake agreements. This, consequently, helps hydrogen projects acquire financing. While no Namibian firms have yet to utilize the H2Global instrument, several companies, including Hyphen, have signaled their intention to submit bids. H2Global thus represents another avenue through which Namibian green ammonia exporters can receive sovereign support to grow their companies.

Namport is actively cooperating with the ports of Antwerp-Bruges and Rotterdam to create green hydrogen supply chains. In February 2023, the Port of Antwerp-Bruges and Namport announced a partnership to develop a green hydrogen supply chain between Walvis Bay and Antwerp (NBC n.d.). Publicized in conjunction with a visit to Walvis Bay by EU Commissioner for the Internal Market Thierry Breton, both parties agreed to cooperate on feasibility studies and development roadmaps. Then, in June 2023, the Port of Rotterdam, Invest International, Gasunie (Netherlands), Hyphen, the Namibian Implementation Authority Office, Namport, and Nampower signed an MoU to collaborate on green hydrogen-related infrastructure with the goal of developing a novel hydrogen supply chain between the Namibian port of Lüderitz and Rotterdam (Port of Rotterdam 2023). This agreement was announced during an official state visit by Dutch Prime Minister Mark Rutte. While it remains to be seen how this partnership will work in practice, this agreement advances the development of the SCDI and creates a platform for technical engagement between relevant parties. For its part, Namport has already set aside 350 hectares of land at the Walvis Bay North Port for the development of green hydrogen related industries and made plans to expand the deepwater port at Lüderitz (The Brief 2021).

3.3.4 Private Sector

Foreign companies are slated to play a key role in the growth of Namibia's hydrogen industry. This is because Namibia does not possess any major energy companies and, consequently, must rely on foreign expertise to develop its hydrogen resources. For example, Hyphen Hydrogen is a joint venture between Enertrag (Germany) and Nicolas Holdings (United Kingdom), while HDF Energy (France) plans to develop its green hydrogen power plant alone. These companies bring knowledge and experience to Namibia that domestic firms generally lack. In this way, Namibia differs from South Africa, whose national chemicals champion, Sasol, possesses in-depth knowledge of hydrogen technology and is expected to play a major role in the country's green hydrogen development. While CBM.TECH (Belgium) plans to cooperate with Namport, TransNamib, and the Ohlthaver & List Group to introduce green hydrogen applications, the Belgian company possesses the vast majority of hydrogen technical knowledge.

For these reasons, some commentators have questioned the prospects for long-term value creation that green hydrogen could bring to the Namibia economy, particularly in local technology and skills development. Indeed, almost all projects are managed by foreign companies, rely on foreign technologies, and will employ foreign workers to complete high-skill jobs. This is even more concerning as it is unclear whether Namibia has sufficient natural resources to develop additional green hydrogen derivative industries, such as green steel and sustainable aviation fuel. While the Namibian government and international actors have taken steps to intervene, founding the NGHRI and paying for Namibian scientists to cooperate with foreign universities, it appears that international actors will remain highly influential over Namibia's green hydrogen sector for the foreseeable future.

3.3.5 Key Challenges for International Cooperation

Similar to South Africa, the outsized influence of international firms raises questions about value creation for the Namibian economy. Like South Africa, many of Namibia's green hydrogen projects are driven by foreign tenders and rely on technologies owned by foreign corporations. Because of this, projects may involve fewer local suppliers and local workers. Despite efforts to create a Namibian green hydrogen innovation ecosystem, it appears that Namibia will continue to depend on foreign entities for technology and expertise for the foreseeable future. Similarly, Namibian officials have already predicted that the country will require a greater quantity of skilled and unskilled labor than currently present in the country. While Namibia's GHCS prioritizes local job creation, it is unclear how the government will take steps to train workers to meet the demands of the nation's fledgling green hydrogen sector. Unlike South Africa, Namibian green hydrogen stakeholders are generally less concerned by the introduction of the EU Delegated Acts (European Commission 2023b). Since Namibian green ammonia products will be likely produced using greenfield renewable power, the country's exports will almost assuredly comply with EU rules.

While the EU and Germany are individually devoting significant public finance and technical assistance to develop Namibia's green hydrogen sector, there has been no coordination between parties. Rather, each entity has chosen to provide funds to different green hydrogen ventures, with the EU—through the EIB—supporting HDF's Renewstable Swakopmund facility and Germany supporting three projects near Walvis Bay. Like South Africa, green hydrogen investments in Namibia are strongly tied to national interest as European donors are more inclined to invest if they believe they will import Namibian green hydrogen products or their nation's corporations are involved in Namibian projects. To this end, since Germany and the EU are expected to be the primary export destinations for Namibian green hydrogen products, they are the most active in developing Namibia's green hydrogen sector. Nonetheless, despite national interest being a primary driver, parties have also taken action without specific projects in mind. For example, Germany has taken a leading role in delivering technical assistance via its International PtX Hub platform, while the EU has taken a leading role in the delivery of public finance for system-wide energy infrastructure projects. These actions have aimed to improve Namibia's general green hydrogen ecosystem as a whole and do not stand to benefit specific projects.

4 Regional Competition and Cooperation

South Africa and Namibia maintain close political and economic relations. A former part of South Africa, Namibia today relies on its former colonial ruler for 57.6 percent of total imports, including electricity, automobiles, and petroleum products (see Figure 9). Furthermore, the Namibian economy is heavily dependent on South Africa foreign direct investment, especially in the mining and retail sectors, and the Namibian dollar is pegged to the South African rand. As members of SADC, both nations also frequently cooperate on regional economic integration, security, and development. Additionally, as members of SAPP, both nations frequently trade electricity, with Namibia serving as a major destination for South African power exports.

Regarding South African-Namibian cooperation on green hydrogen development, engagement has been limited. Parallel to Namibia's green hydrogen aspirations, South African actors hope to develop green hydrogen assets over the coming decade, pursuing both green ammonia export projects and green hydrogen applications in industrial processes. Nonetheless, despite both nations' proximity, stakeholders in neither country have taken meaningful steps toward collaborating on green hydrogen projects. For example, at one point, commentators raised the possibility of Namibia and South Africa developing a joint green hydrogen port near their border on the Atlantic Coast. However, hydrogen stakeholders in both nations have since decided to develop their own hydrogen ports, with Namibia expanding the ports of Lüderitz and Walvis Bay and South Africa hoping to develop a deepwater port at Boegoebaai. Furthermore, while Namibian Green Hydrogen Commissioner James Mnyupe has mentioned a proposal to construct a green hydrogen pipeline between Southern Namibia and the Western Cape in South Africa (presumably to support South African domestic industry), it is too early to tell whether South Africa will have adequate green hydrogen demand to warrant such an investment (Mnyupe 2022).

Despite this lack of cooperation, South Africa and Namibia are not openly competing in green hydrogen development. This is because both nations have very different starting points in their green hydrogen journeys. South Africa, for example, has a large industrial sector that has historically relied on coal as a cheap power source. This low-cost path-dependent infrastructure has delayed the country from scaling up more expensive green hydrogen technologies in industrial processes. Additionally, South Africa has a shortage of renewable power and lacks common-use infrastructure for wide-scale hydrogen development. While the country has taken steps to develop its green hydrogen assets, projects are nonetheless moving at a slow pace.

Namibia, meanwhile, is a small, un-industrialized nation with a relatively cohesive political environment. The country can rapidly develop green hydrogen assets because it does not have existing industries that must overcome a reliance on coal and other path-dependent factors. Furthermore, the country possesses vast swaths of empty land that can accommodate renewable energy development. Of course, the Namibian government has also taken an active role in propelling the country's green hydrogen aspirations by working closely with prospective developers and taking steps to streamline green hydrogen decision-making. Nonetheless, unlike South Africa, Namibia does not have the skills, technological expertise, and infrastructure that it can readily build on to grow its green hydrogen capabilities.

Because of these differences, both nations have engaged differently with international actors. On the public sector side, foreign governments and development banks have tailor-made public finance commitments and technical assistance programs for each country's needs. For example, South Africa and international partners developed the Just Energy Transition Partnership in large part to help the country overcome its dependence on coal power. Meanwhile, recognizing that the country was further along in its hydrogen journey, the EU and Namibia announced a strategic partnership to ensure that green hydrogen value chains comply with EU trade rules. In this sense, South Africa and Namibia are not competing for public sector resources but rather engaging with foreign governments based on their respective needs.

Furthermore, on the private sector side, both countries have taken different routes in engaging with private firms. Because South Africa has a large industrial base, many green hydrogen projects are being developed by companies already operating there. Meanwhile, in Namibia, the government has had to actively court foreign companies to develop green hydrogen assets. Neither country is competing for private sector engagement.

All things considered, Namibia is further along in developing green hydrogen projects and securing green ammonia offtake agreements. The country is also in the process of developing landmark green hydrogen legislation that will benefit project developers and attract future financiers. Nonetheless, it is too early to tell whether Namibia is out-competing South Africa in green hydrogen development as the announced projects in both countries comprise only a fraction of the expected global green hydrogen demand by 2050 and the actual production of green hydrogen is years away. Both countries are currently facing similarly high capital costs for project development, and both nations will have to contend with midstream transportation costs as a significant cost factor in future green ammonia exports.

If successful, however, green hydrogen would significantly improve Namibia's economic and political standing among African countries. As stated in the GHDS, Namibia hopes to export excess renewable generation from green hydrogen projects to neighboring countries, namely South Africa, Botswana, and Zambia. For context, the Hyphen project alone has the potential to generate between 700 MW to 2 GW of power for export to neighboring countries (Namibia has a current peak load demand of 630 MW). Furthermore, Namibian hydrogen stakeholders could elect to oversize renewable capacity, generating upwards of 4-12 GW of surplus electricity for export (Systematic IQ 2022). These power exports could significantly impact balancing and decarbonizing the Southern African Power Pool, particularly in South Africa, which loses up to 20 GW of electricity generation per day due to load shedding (Omarjee 2021).

If successful, these plans would transform Namibia from a net electricity importer to a net exporter, thereby generating significant state revenue for the Namibian government and increasing Namibia's political power relative to neighboring nations. This is particularly salient in the context of Namibia-South African relations, as Namibia has historically relied on South Africa for a variety of imports, including electricity. While South Africa will undoubtedly remain the dominant regional power, green hydrogen and electricity exports nonetheless represent a novel avenue through which Namibia can increase economic independence and exert political influence.

5 Conclusion

Both South Africa and Namibia are beginning to take steps towards promoting a domestic hydrogen economy. However, given their very different starting points, they also face different opportunities and challenges.

Opportunities and challenges of green hydrogen in South Africa's transition away from coal

South Africa has a large industrial sector that has historically relied on coal as a low-cost energy source. This low-cost path-dependent infrastructure is a major factor prohibiting the country from implementing costly green hydrogen technologies in industrial processes. While the South African government has published two major strategy documents outlining the country's needs, it has not yet developed a comprehensive legal framework to regulate the nascent green hydrogen industry. Furthermore, Sasol and other stakeholders have been slow to develop the country's largest planned green ammonia export project at Boegoebaai.

To help realize South Africa's green hydrogen development goals, international actors have provided the country with public finance to decarbonize its electricity supply while kickstarting the nation's green hydrogen industry, primarily through the funding of common-use infrastructure, feasibility studies, and demonstration projects. These efforts have been complemented by technical assistance programs, notably Germany's GIZ, which have sought to develop local government capacity, foster opportunities for local value creation, and provide strategic guidance for South African policymakers. Private sector partnerships, especially between Sasol and foreign firms, are critical as companies seek to share technologies and develop synergies between industries. Given the importance of foreign firms in driving many green hydrogen projects, particularly in industrial green hydrogen applications, it remains to be seen how much local value will be created as a result of these projects.

The creation of local benefits from green hydrogen is a critical question, as South Africa must reconcile its green hydrogen and just transition goals. While the government has prioritized the inclusion of workers and communities in its just transition policies, it is unclear how green hydrogen will improve the everyday lives of the general population, especially those in communities which will be affected by the closure of coal plants. Many proposed green hydrogen projects have export-exclave elements and could be perceived as diverting renewable energy that could help relieve the nation's electricity crisis, not to mention the technology's sizable water and land use requirements.

Finally, hydrogen development in South Africa is embedded in the country's challenging political economy landscape, which is still dominated by powerful fossil fuel actors. These are likely to complicate any efforts to promote a transition to a climate-friendly energy and industrial system. That said, green hydrogen and its related opportunities for new sources of value creation may also provide entry-points for stimulating broader efforts towards decarbonization. In this vein, if successful, green hydrogen development in South Africa could well generate positive spillover effects for its broader transition process.

The promise and pitfalls of export-led green hydrogen development in Namibia

Meanwhile, Namibia's green hydrogen developments depart from a very different starting point. It does not have legacy industries that must overcome reliance on coal or other path-dependent infrastructure, and it currently imports a large share of its electricity from South Africa. The country possesses vast swaths of land available for greenfield renewable energy development, and Namibia's

government views the emerging hydrogen economy as an important export-oriented development opportunity for the country. Within Southern Africa, Namibia views green hydrogen as a way to become a net exporter of electricity and increase its economic and political influence in the region.

Against this background, the country has taken significant steps towards developing a domestic green hydrogen industry. Since the beginning of the nation's hydrogen journey, the Namibian government has played an active role in courting project developers and crafting a forward-thinking hydrogen environment. This is evident from the publication of the detailed GHDS and the creation of a Green Hydrogen Council to streamline the green hydrogen decision-making process. These conditions have enticed several foreign companies to initiate the development of large-scale projects in various regions throughout the country. Notably, the $10 billion Hyphen project stands out for its signing of three non-binding offtake agreements to sell over 1 million tonnes annually of green ammonia to foreign offtakers.

The EU, Germany and the Netherlands stand out as its main counterparts in this context. The European Commission concluded a strategic partnership that includes an EIB loan worth up to €500 million. Similarly, Germany has provided significant technical assistance to develop Namibia's government capacity, while the Netherlands has demonstrated considerable interest in establishing the new SDG Namibia One sovereign wealth fund. Through the fund Namibia hopes to take an equity stake in domestic green hydrogen projects, so that it can partake in future revenues. While these plans have the potential to significantly benefit the local population in areas such as education, healthcare, infrastructure, and access to electricity, the government has yet to announce how it will reallocate funds through revenue-sharing plans. Whether these benefits can be realized, however, will strongly depend on the design and implementation of the revenue sharing instrument. Indeed, there is a growing concern that the country will be unable to raise enough money to take the planned 24 percent equity stake in the $10 billion Hyphen project. Since green hydrogen is a relatively unproven technology, it necessitates a high hurdle rate (15 percent or higher) to attract funds from institutional investors. If the Namibian government cannot maximize its equity stake in the Hyphen project, it will collect less public revenue, lowering the amount of money it can redistribute to the general public.

This is particularly salient as Namibia's Hyphen project represents one of the most prominent ventures for the promotion green hydrogen exports with visible support from the EU and Germany. If successful, it has the potential to become an important international reference case. For this, it will have to show that the development of a green hydrogen industry in a low-income country can deliver tangible benefits to the general population, while putting in place appropriate strategies for avoiding and mitigating potential negative impacts on the environment and local livelihoods. Another key challenge lies in managing associated infrastructure and urban development. To ensure these goals are realized, the government needs a steady income stream and a well-developed revenue-sharing model to ensure that it can deliver tangible benefits. Moreover, it will have to ensure that local populations and civil society are involved in decision-making processes. The international donor community can play an important role in supporting these efforts with both technical and financial assistance.

Common challenges of green hydrogen development

A common challenge for green hydrogen development in both Namibia and South Africa has been a lack of pre-existing infrastructure. Not only the Hyphen project in Namibia, but also the Boegoebaai project, the largest planned hydrogen production site in South Africa, is an entirely greenfield venture that will require tremendous amounts of capital to build roads, transmission lines, a desalination plant, and a new deepwater port. Similarly, the brownfield industrial development zone in Saldanha, South Africa will require new infrastructure to attract private-sector green hydrogen investment. Public finance from organizations like EIB, KfW, and the World Bank is helping to fund these projects, but it is increasingly apparent that it may be unrealistic to develop the needed infrastructure with an exclusive focus on green hydrogen. As such, especially in the case of Boegoebaai, planners

are seeking to identify additional economic activity to attract public sector finance, both in the green hydrogen space and elsewhere.

Another important condition for successful development of the green hydrogen sector in both countries is linked to regulatory developments in the EU. As a major import market, exports will hinge on compliance with requirements for the production of green hydrogen as set forth in two Delegated Acts to the EU's Renewable Energy Directive. This is a particular concern in South Africa, where initial green hydrogen projects are unlikely to be developed as greenfield projects. Sasol in particular is concerned that its hydrogen production may not qualify as a renewable under EU rules. EU rules on carbon feedstocks for the production of low-carbon synthetic fuels are another concern for Sasol. Currently, carbon sources needed for the production of synthetic fuels may still be derived from industrial CO2 emissions. However, from the 2040s on, EU carbon accounting will no longer permit these carbon sources in the production of low-carbon fuels. For the time being, South African synthetic fuel production is being developed for the domestic market, however, in the future, this may pose a barrier to export development. In Namibia, meanwhile, green hydrogen producers are relatively less concerned about complying with EU rules because their hydrogen products will be produced using exclusively renewable power on greenfield sites.

Regional competition and cooperation

Regarding South African-Namibian cooperation on green hydrogen, engagement has been limited. Despite their proximity and shared goals, stakeholders in both countries have opted to pursue their own hydrogen projects. While officials have floated the idea of a shared hydrogen pipeline from Namibia to South Africa, it is too early to tell whether there will be adequate demand to warrant such an investment. Despite this, South Africa and Namibia are not openly competing in green hydrogen development. This is because both nations have very different starting points in their green hydrogen journeys: The South African government has plans to use green hydrogen to transform its fossil-fuel-dependent domestic industry and produce green ammonia exports, while Namibia is almost entirely focused on greenfield green ammonia export projects. Although Namibia is further along in developing assets and securing green ammonia offtake agreements, it is premature to say that Namibia is out-competing South Africa in green hydrogen development as announced projects in both countries comprise only a fraction of expected world green hydrogen demand and the actual production of green hydrogen is years away. Both countries are currently facing similarly high capital costs for project development and will have to contend with midstream transportation costs as a significant factor in future green ammonia exports.

Together, developments in both countries are contributing to the rise of green hydrogen as a globally traded commodity. The technology has the potential to elevate new players in the global energy arena and allow existing fossil fuel players with sizable renewable energy potential. While South Africa and Namibia will inevitably compete with other green hydrogen exporters, some of which are closer to expected demand centers in Europe and East Asia, Southern African producers can count on low electricity prices to compensate for relatively higher transport costs. Furthermore, especially in the early years of green hydrogen trade, key importing nations will likely elect to diversify imports from a variety of countries, including South Africa and Namibia. Of course, as in the case of South Africa, green hydrogen producers will also provide valuable inputs to help domestic heavy industry transition to less carbon-intensive manufacturing processes, especially in the steel, chemicals, and aviation sectors.

6 Annex

Annex - Table: International Green Hydrogen Activity in South Africa

Germany	
Official Partnership	▪ Cooperation Agreement between German BMWK and South African Presidency; signed June 2023
Public Finance	▪ JETP contribution: $968 million ($198 in grants; $770 in concessional loans) ▪ As part of JETP contribution: $198 million in grant funding for studies and technical assistance on policy and regulatory reforms related to energy transition; support to local authorities to prepare for the transition; promotion of renewable energy, including green hydrogen; and the skilling and reskilling of the decarbonised energy workforce. ▪ As part of JETP contribution: $350 million of concessional loans from KfW to support financing of grid infrastructure and renewable energy generation and green hydrogen development ▪ KfW: Demonstrated interest in financing common-use infrastructure projects at the Saldanha IDZ
Technical Assistance	▪ International PtX Hub (GIZ): collaboration on political frameworks, local value addition, macro-economic analysis, technology analysis, capacity building; funded by BMWK ▪ H2.SA (GIZ): $28.4 million in grant funding for collaboration on strategic and regulatory frameworks; funded by BMZ ▪ German-South African Energy Partnership (GIZ): promotion of ministerial-level political exchange on strategic energy issues, including green hydrogen collaboration; funded by BMWK
Commercial Diplomacy	▪ H2Global mechanism: €900 million from the German BMWK to facilitate the sale of hydrogen products to EU purchasers ▪ In addition to Germany's €900 million contribution, BMZ has committed an extra $14.2 million in grant funding to promote and develop the H2Global program in South Africa. ▪ BMWK: €15 million grant to Linde to help it produce SAF as part of the HySHiFT consortium
Private Sector	▪ Enertrag: Member of the HySHiFT consortium (SAF) ▪ Linde: Member of the HyShiFT consortium (SAF) ▪ ThyssenKrupp: Developing an unknown green hydrogen project with Air Products
European Union	
Public Finance	▪ JETP contribution: $1.035 billion ($35 million in grants; $1 billion in concessional loans) ▪ EIB: Demonstrated interest in financing common-use infrastructure projects at the Saldanha IDZ
Technical Assistance	▪ Small-scale technical assistance on the development of the PVI and JETP Investment Plan

United Kingdom	
Public Finance	JETP contribution: $1.824 billion ($24 million in grants; $500 million in commercial loans; $1,300 in guarantees) As part of JETP contribution: undisclosed amount of grant funding to support green hydrogen technical assistance As part of JETP contribution: undisclosed amount of grant funding to support green hydrogen technical assistance
Technical Assistance	UK Partnering for Accelerated Climate Transitions (PACT): collaboration on the development of the HSR
Research & Education	Partnership between Stellenbosch University (South Africa) and Teesside University (UK) to research labor needs for a green hydrogen economy
Private Sector	largest producer of PGMs in South Africa and the world; deploying green hydrogen-powered vehicles at mines in Limpopo; leading member of the PVI Hive Energy: developing a green ammonia export project in Eastern Cape Hydrogen: Member of the HySHiFT consortium (SAF)
United States	
Public Finance	JETP contribution: $1.020 billion ($20.15 million in grants; $1 billion in commercial loans)
Private Sector	Air Products: Developing an unknown green hydrogen project with ThyssenKrupp
France	
Public Finance	JETP contribution: $1.002 billion ($2.5 million in grants; $1 billion in concessional loans)
Private Sector	Hydrogen de France (HDF Energy): developing unknown green hydrogen project in Western Cape
Netherlands	
Public Finance	Invest International: $50 million in grant funding to the SA-H2 fund FMO: founding member of the SA-H2 fund Climate Fund Managers: manager of the SA-H2 fund
Ports & Infrastructure	Port of Rotterdam and Koninklijke Vopak NV have been asked to submit construction and funding plans for a $2.8 billion port and associated rail links at Boegoebaai -Consultations between the Port of Rotterdam, Sasol, and the Northern Cape Government to develop efficient ways of transporting and "cracking" green ammonia
Denmark	
Public Finance	Founding member of the H2-SA fund
Private Sector	Maesrk: developing green hydrogen shipping capabilities in Richards Bay
Saudi Arabia	
Commercial Diplomacy	17 MoUs worth $15 billion to improve cooperation in various industries, including clean energy and green hydrogen
Research & Education	MoU between IDC and ACWA, a Saudi energy company, to explore the development of green hydrogen and its derivatives in South Africa
Luxembourg	
Private Sector	Arcelor-Mittal: exploring the development of a green steel facility at Saldanha Bay with Sasol; exploring CCUS applications at Vanderbijlpark steel plant to produce sustainable fuels and chemicals at Sasol's Vaal facility
Japan	
Private Sector	Toyota: developing green hydrogen-powered trucks to create a green hydrogen transport corridor between Limpopo, Gauteng, and Kwa'Zulu Natal; leading member of the PVI
Ireland	
Private Sector	Mainstream Renewable Power: Developing unknown green hydrogen project in Western Cape
World Bank	
Public Finance	Demonstrated interest in financing common-use infrastructure projects at the Saldanha IDZ

Table 4: International Green Hydrogen Activity in Namibia

European Union	
Official Partnership	▪ EU-Namibian Strategic Partnership on Sustainable Raw Materials and Renewable Hydrogen; MoU signed November 2022
Public Finance	▪ Up to €500 million loan from EIB to assist the development of common use infrastructure projects through the financing of feasibility and environmental studies ▪ As part of €500 million EIB loan: undisclosed loan to the SDG Namibia One sovereign wealth fund ▪ As part of €500 million EIB loan: undisclosed loan to the Hydrogen de France (HDF Energy) Renewstable Swakopmund green hydrogen power plant
Technical Assistance	▪ EU-Namibian Strategic Partnership: collaboration on sustainable value chains, ESG criteria, infrastructure funding, capacity building, research and innovation, and regulatory alignment (especially in the context of the 2023 EU Delegated Acts on Renewable Hydrogen) ▪ EU Global Technical Assistance Facility on Sustainable Energy: Assisting the administration of Namibia's first green hydrogen auction (the Hyphen project)
Netherlands	
Official Partnership	▪ Letter of Intent between Namibia and The Netherlands on Cooperation in the Field of Energy Resources; signed November 2021
Public Finance	▪ Invest International: €40 million in grant funding to the SDG Namibia One sovereign wealth fund ▪ Climate Fund Managers: manager of the SDG Namibia One fund
Ports & Infrastructure	▪ MoU between the Port of Rotterdam, Invest International, Gasunie, Hyphen, the Namibian Implementation Authority Office, Namport, and Nampower to develop a hydrogen supply chain between Lüderitz and Rotterdam
Germany	
Official Partnership	▪ German-Namibian hydrogen partnership between German BMBF and Namibian National Planning Commission; Joint Communiqué of Intent signed August 2021
Public Finance	▪ €40 million in grant funding to help finance feasibility studies for three green hydrogen projects near Walvis Bay, Namibia
Technical Assistance	▪ International PtX Hub (GIZ); collaboration on hydrogen and PtX capacity building, building national dialogue, advising policymakers, technical and economic analysis
Commercial Diplomacy	▪ H2Global mechanism; €900 million from the German BMWK to facilitate the sale of hydrogen products to EU purchasers
Research & Education	▪ Partnership between the German Bundesanstalt für Materialforschung und -prüfung (BAM) and University of Namibia's Green Hydrogen Research Institute (NGHRI); signed November 2021 ▪ Partnership between RWTH Aachen University and NGHRI; signed November 2022
Private Sector	▪ Enertrag: co-developer of the Hyphen project ▪ RWE: will purchase 300,000 tonnes/anum of green ammonia from the Hyphen project starting in 2027
Belgium	
Official Partnership	▪ Belgium-Namibia MoU on Green Hydrogen; signed June 2022
Ports & Infrastructure	▪ Partnership between Port of Antwerp-Bruges and Namport announced to develop a green hydrogen supply chain between Walvis Bay and Antwerp; signed February 2023
Private Sector	▪ CMB.TECH: Three green hydrogen projects in central Namibia

United States	
Technical Assistance	▪ US National Renewable Energy Laboratory: Assisting the administration of Namibia's first green hydrogen auction (the Hyphen project)
South Korea	
Private Sector	▪ Approtium; will import 250,000 tonnes/annum of green ammonia from the Hyphen project starting in 2027
France	
Private Sector	▪ Hydrogène de France (HDF Energy): Developer of the Renewstable Swakopmond project
United Kingdom	
Private Sector	▪ Nicolas Holdings: co-developer of the Hyphen hydrogen project
Japan	
Private Sector	▪ MoU between Itoochu Corp. and Hyphen to collaborate on green hydrogen and ammonia production
Other	▪ Visit by Japanese Ministry of Economy, Trade, and Industry to explore cooperation on rare earth mineral mining
Finland	
Private Sector	▪ MoU between Kaoko Green Energy Solutions (Namibia) and AW Energy (Finland) to produce green hydrogen from wave energy technology
Southern African Power Pool (SAPP) Nations	
Other	▪ Will receive electricity exports from excess power generation at Namibian green hydrogen facilities
China	
Other	▪ Visit by head of the Chinese National Energy Administration to discuss collaboration on green hydrogen issues; no official hydrogen partnership

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The **Research Institute for Sustainability (RIFS)** conducts research with the aim of investigating, identifying, and advancing development pathways for transformation processes towards sustainability in Germany and abroad. The institute was founded in 2009 as the Institute for Advanced Sustainability Studies (IASS) and has been affiliated with the Helmholtz Centre Potsdam - GFZ German Research Centre for Geosciences under its new name since 1 January 2023 and is thus part of the Helmholtz Association. Its research approach is transdisciplinary, transformative, and co-creative. The Institute cooperates with partners in science, political and administrative institutions, the business community, and civil society to develop solutions for sustainability challenges that enjoy broad public support. Its central research topics include the energy transition, climate change and socio-technical transformations, as well as sustainable governance and participation. A strong network of national and international partners and a Fellow Programme supports the work of the Institute.

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