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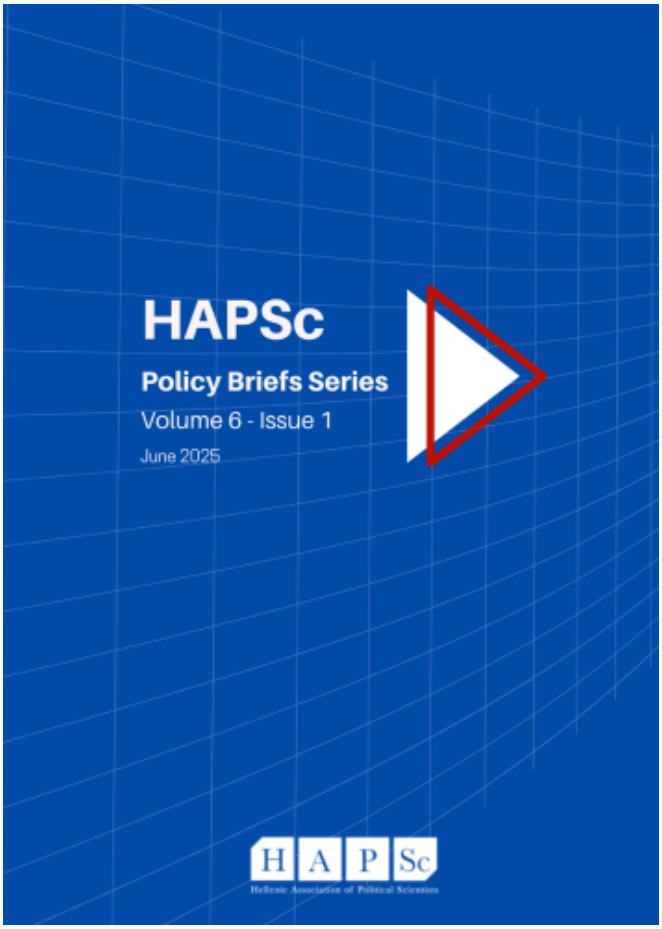

Unlocking Africa's Green Hydrogen Economy

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Unlocking Africa's Green Hydrogen Economy[1]

Brian Kithinji[2], Bolly Echessa[3] & Elijah Bakari[4]

Abstract

Green hydrogen, derived from renewable energy sources through electrolysis, presents a pivotal opportunity in the global shift towards sustainable energy systems. As nations accelerate their decarbonization efforts to combat climate change, the role of green hydrogen has become increasingly crucial. It offers a versatile energy carrier capable of decarbonizing sectors that are challenging to electrify directly, such as the transportation, aviation, and the chemicals industry. However, several barriers hinder its widespread adoption in Africa, including high production costs, inadequate policy frameworks, infrastructure gaps, and technological scalability. Addressing these challenges requires coordinated efforts across governments, private sector, multilateral organizations, and research institutions to drive down costs, scale up production capacities, and establish robust regulatory frameworks. By investing in innovation and skill development, incentivizing private sector participation, and fostering international collaboration, Africa can accelerate a smooth transition to a sustainable hydrogen economy, unlocking its full potential to decarbonize its economies and create sustainable growth pathways.

Keywords: decarbonization, green hydrogen, green transition, renewable energy, sustainable development.

Introduction

Access to affordable and clean energy is vital for poverty eradication. Despite the recent setbacks from the COVID-19 pandemic and ongoing conflicts globally, the shift towards green energy is gaining momentum as governments and private sectors worldwide integrate renewable sources into their electricity grids. However, these efforts have not been sufficient to catalyze economic growth in developing countries. About 733 million people, 9.1 percent of the world's population, lack access to electricity. According to the United Nations Conference on Trade and Development Agency (UNCTAD), over 600 million people in the African continent lack access to electricity, 80 per cent of whom live in the rural areas (UNCTAD, 2023). Additionally, the World Bank estimates that 426 million Africans live in extreme poverty, accounting for about one-third of the continent's 1.4 billion population (World Bank, 2020).

Africa's energy landscape presents a confounding scenario. Despite holding 60 percent of the world's solar resources (IRENA, 2022) and 15 gigawatts (GW) of untapped geothermal energy reserves (Kambanda, 2022), Africa accounts for less than 3 percent of the world's installed renewable energy

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production and less than 2 percent of the renewable energy capacity in the world, according to the International Energy Agency (IEA). Moreover, less than 3 percent of the renewable energy jobs globally are in the continent. Traditional biomass remains the primary source of energy for millions across the continent (Agyekum, 2024).

With its vast renewable energy potential, green hydrogen can be the most effective pathway towards weaning reliance on fossil fuels and reducing energy costs. Africa holds significant potential for green hydrogen production. The United Nations anticipates that about 800 gigawatts (GW) of green hydrogen will be deployed by 2030, helping to potentially meet up to 25 percent of global energy needs by 2050 (Gado et al., 2024). According to the European Investment Bank (EIB), green hydrogen could add more than $120 billion USD to the continent's overall GDP by 2050, while creating 50 million new jobs (Benkhlafa, 2023). This scale of deployment could halve electricity costs in Africa and contribute to decarbonizing critical sectors such as agriculture, transportation, manufacturing, and industrial chemical processing.

Green hydrogen has many applications in sectors such as ammonia production; a key ingredient of fertilizers, oil and gas refinery operations, methanol production used in manufacturing plastics and textiles, transportation, electric energy storage, and other industrial chemical processes. Green hydrogen could also contribute to cold storage and cold chain capacity to boost Africa's food sovereignty. In the long run, excess production can open avenues for export to global markets, particularly in Europe. With projections that Africa could produce green hydrogen at about $1 USD per kilo in the next decade, the continent can establish dominance in international energy markets (UNCTAD, 2023).

To fully exploit Africa's rich green hydrogen potential, worth over $1 trillion in some estimates (UN, 2023), the sector will need massive upfront capital investments to develop infrastructures, industries, and train skilled labor to work in the production process. Due to its nascent nature, traditional investment firms and philanthropies are likely to stay away from injecting large finances, afraid of potential risks and viability of the projects. It is therefore necessary for African governments to set strong policy frameworks that can support the industry through tax breaks and providing formal assurances to investors on their commitment to green energy transition. Currently, the regulatory frameworks are advancing with more than 40 countries formulating policies on green hydrogen, while others like South Africa, Morocco, Egypt, Namibia, Mauritania and Niger are in the process of launching green hydrogen production plants.

The global momentum towards decarbonization underscores the urgency of transitioning to sustainable energy solutions. Green hydrogen presents a compelling opportunity for Africa to catalyze economic development and mitigate climate impacts. As Africa navigates these opportunities, strategic partnerships and targeted investments will be key to realizing a sustainable and prosperous future for the continent and beyond. However, there are significant challenges towards making green hydrogen economically viable. The current costs of green hydrogen are estimated to be four times higher than solar power, presenting a barrier to widespread adoption among end-users. Infrastructure limitations and skill gaps are also rife. Nevertheless, there is still substantial investment interests from the private sector, with more than $200 billion of green hydrogen projects underway globally (IRENA, 2023).

This paper identifies the opportunities and barriers affecting Africa's pursuit of green hydrogen production, highlighting its potential to enhance energy security, stimulate solid economic growth, and contribute to global decarbonization efforts. By leveraging on its abundant natural resources and investment-friendly policy frameworks, Africa is poised to emerge as a major contributor to the global green hydrogen sector, offering substantial socio-economic benefits that will lift millions out of poverty.

Analysis of the Green Hydrogen Sector

State of Green Hydrogen Production

The creation of the Africa Green Hydrogen Alliance (AGHA) consisting of six countries – Egypt, Kenya, Mauritania, Morocco, Namibia and South Africa, in 2022 marked a significant turning point in the adoption of green hydrogen in the continent (AGHA, 2023). Many African countries are formulating national strategies and targets to promote the development of green hydrogen. These strategies typically outline goals for renewable energy deployment, including hydrogen production, and set timelines for achieving these objectives. Governments are also introducing tax incentives to attract investment and support green hydrogen projects, subsidies for research and development, and streamlined permitting processes. These incentives aim to position the continent as the key destination for foreign investors looking for a place with abundant renewable energy resources and land that can be tapped into the production of green hydrogen.

However, the costs of producing and using green hydrogen at scale are still high. The average cost of green hydrogen is $6.40 USD per kilogram, comfortably higher than other energy forms (AbouSeada & Hatem, 2023). Research on the technology currently used shows that the profitability of green hydrogen relies on electrolyzers, which produce hydrogen by splitting water molecules and fuel cells

used to convert hydrogen into usable energy (Dumančić et al., 2024). While there are other ways of producing green hydrogen, electrolysis is more preferred due to its smaller carbon footprint. Renewable energy sources such as solar and wind are utilized in electrolysis and their development can help lower the costs of green hydrogen production.

Across the continent, investments are being driven by multilateral organizations such as the African Development Bank (AfDB), the European Investment Bank (EIB), and the International Finance Corporation (IFC), largely in the form of concessional financing towards research, feasibility studies and pilot projects. International collaboration can facilitate knowledge transfer, technology exchange, and substantial investments that in turn accelerate the continent's capacity for sustainable energy development and infrastructure enhancement.

Domestically, public-private partnerships (PPPs) are being fostered to leverage expertise, share risks, and accelerate innovation in the sector. Partnerships often involve joint ventures, pilot projects, and technology transfer initiatives. The success of these partnerships relies on the presence of robust national regulatory frameworks and budgetary allocations that can encourage long-term investments.

Planned Green Hydrogen Projects

Across Africa, countries are working to tap into the potential of green hydrogen energy through massive infrastructure projects. Egypt has introduced a plan to supply 8 percent of the global hydrogen market by 2050, targeting export markets in Europe and the Asia-Pacific region. Namibia signed a $10 billion USD deal with Hyphen Hydrogen in May 2023 to advance feasibility studies ahead of implementing its green hydrogen strategy, which targets producing 300,000 tonnes of green hydrogen for domestic use and exports, and employing 20,000 persons. To dampen investor concerns, the government placed a 24 percent equity stake in the project (AGHA, 2023).

Next-door neighbor Angola has rolled plans to become the first exporter of green ammonia, the transportable form of green hydrogen, by 2026. The project, which is developed by fossil fuel giant SONANGOL as part of its renewable energy transition plan, will be powered by hydropower electricity thus helping reduce costs. South Africa also targets to produce over five million tonnes of green hydrogen annually by 2040 at a cost of $230 billion USD (United Nations, 2023). Automobile manufacturing giants, Sasol and Toyota, are exploring the feasibility of hydrogen mobility and fuel cell electric vehicles in the country.

Future Prospects

Some African countries are looking to secure investments in green hydrogen by focusing on fertilizer production and the development of existing renewable energy sources such as wind, solar, and

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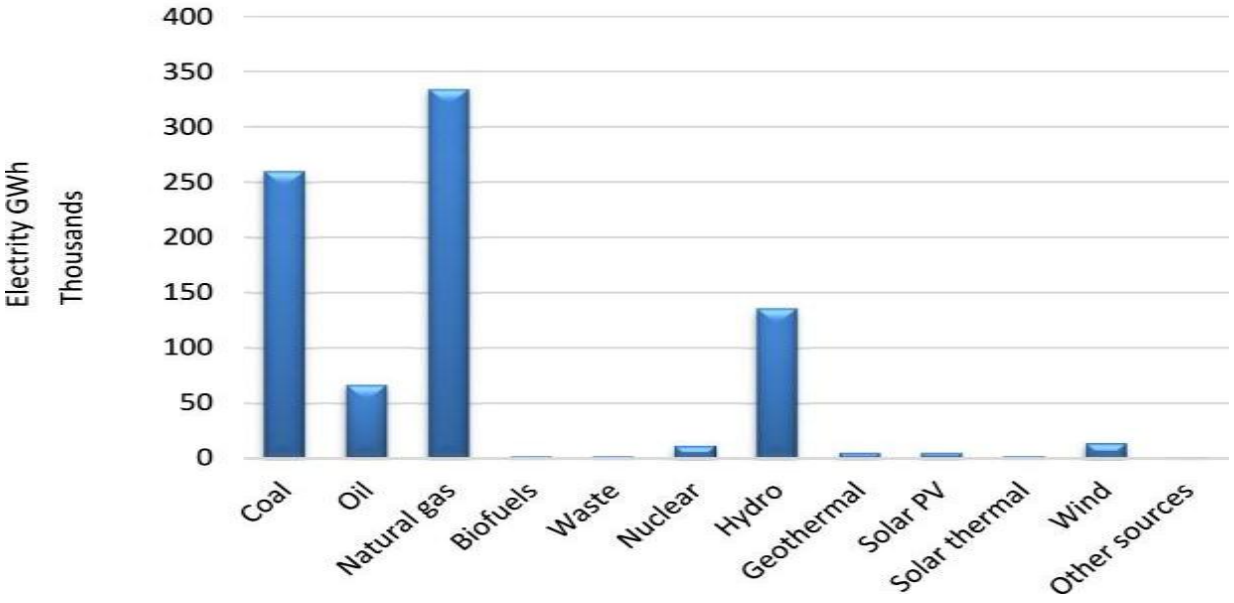
hydropower. In 2022, Morocco, which is Africa's biggest producer and exporter of fertilizers, announced a $7 billion USD investment in a green ammonia plant in the southern region, set to begin operations in 2026 (Ammonia Energy Association, 2023). At its peak capacity, the plant will power the national grid and reduce imports of ammonia that are used to produce fertilizers. Last year, Morocco imported 1.8 million tons of ammonia mostly from Russia and Ukraine.

Fig. 1 The share of electricity generation by fuel source in Africa



IRENA, 2023

To realize the potential of green hydrogen, African countries need to invest in capacity building and skill development programs. There is need to equip local workforces with the expertise needed to design, construct, and operate green hydrogen facilities. Academic institutions should establish training programs, academic partnerships, and vocational training to cultivate a skilled workforce capable of supporting the growing green hydrogen industry. Overall, the outlook for green hydrogen in Africa is optimistic but contingent on overcoming infrastructure challenges, securing adequate funding, and establishing supportive policy frameworks.

Case Studies and Success Stories

Morocco's Power-to-X sector

Morocco has emerged as a leading African nation in the green hydrogen sector thanks to its ambitious Power-to-X (PtX) sector, which converts renewable electricity into various energy carriers, including hydrogen and other synthetic fuels. The country's abundant solar and wind resources provide a solid

foundation for PtX projects to produce green hydrogen at scale. The Moroccan Agency for Sustainable Energy (MASEN) has been at the forefront of this transformation, aiming to produce 4 GW of green hydrogen by 2030. The government's ambitious renewable energy targets and supportive policies have created a favorable environment for the development of this emerging technology. This green hydrogen strategy is part of Morocco's Low Carbon Development Strategy (LCDS), a policy framework that aims to position it as a leading nation in green hydrogen production and all the products that come with it, with the help of PtX in increasing the value of renewable energy in the country (Ministry of Energy, Mines and Environment, 2021).

In the case of Morocco, PtX activities promise to help mitigate climate change issues not only in the country, but also throughout Africa. In the process of producing synthetic fuels such as green hydrogen from excess renewable electricity, the country can increase its storage capacity hence a stable and secure energy supply. In addition, PtX allows the Moroccan green ambition to abate sectors such as heavy industries and transport systems to be achieved. The generation of green fuels via PtX may also lead to new export markets, growth of the economy and income generation (Ministry of Energy, Mines and Environment, 2021).

The factors behind Morocco's confidence to spearhead and scale up PtX projects revolve greatly on the sustained development of renewable energy assets. The country has already accrued great success in the deployment of new solar and wind power plants for large-scale production that has made the manufacture of green hydrogen possible. However, challenges such as water scarcity, lack of storage facilities for energy, high capital investment on PtX innovation, and many others still linger. They are estimated to determine the successful implementation of PtX projects (World Bank, 2022).

It is therefore feasible to compare Morocco's path to PtX with other African nations interested in reaping the opportunities of renewable power. By sharing knowledge and experiences, Morocco can contribute to the continent's green hydrogen ecosystem. As Africa strives to diversify its energy mix, reduce reliance on fossil fuels, and combat climate change, Morocco's leadership in PtX is essential. The country's success story can inspire and motivate other nations to embark on their own PtX journeys, leading to a more sustainable and prosperous Africa.

Table 1. Green Hydrogen Projects in Morocco

Project Name	**Location**	**Estimated Capacity (Annual)**	**Estimated Cost (Euros)**	**Project Status**
Nareva Green Hydrogen	Midelt, Draa-Tafilalet	10,000 tonnes NH3	€1.2 billion	Under development

Phoenix Green Hydrogen	Foum Assaka, Dakhla	1million tonnes NH3	€1.4 billion	Announced
HY 氨 (Hy氨) Green Hydrogen/ Ammonia Project	Jorf Lasfar	350,000 tonnes NH3	Not publicly available	Planning
Hevo Ammonia Morocco	Agadir, Essaouira, or Jorf Lasfar (location not finalized)	183,000 tonnes NH3	$850 million	Announced

Ministry of Energy, Mines and Environment, 2021

Namibia's Hyphen Hydrogen Energy project

Namibia, especially due to its abundant solar and wind energy sources, has the potential to become a major global exporter of green hydrogen in the future. This ambition is demonstrated through the Hyphen Hydrogen Energy project which targets the production of green ammonia for exportation. Once fully operational, the project aims to produce about 300,000 tons of green hydrogen per year by 2030, and will showcase Namibia's capacity for exporting of green hydrogen. Despite hurdles such as infrastructure and insufficient water resources, the country's strategic direction points to a favorable future for green hydrogen production (Zawya, 2022).

Kenya's Geothermal Merger

Kenya on the other hand is looking to blend geothermal energy into green hydrogen generation. This approach is underlined by the recently conducted feasibility study on the production of green hydrogen and ammonia fertilizers at the Olkaria geothermal site. Kenya plans to boost its domestic consumption and the export of geothermal power noting the multiple roles of green hydrogen in diverse African countries (Further Africa, 2023). At the Africa Climate Summit 2023, hosted in the capital Nairobi, Kenya outlined its Green Hydrogen Strategy. With support from the European Investment Bank, the country is gearing to launch green hydrogen production that is going to complement existing renewable energy sources, as well as reduce electricity costs by cutting imports of power from neighboring countries (The Exchange, 2022).

Namibia and Kenya are two examples that illustrate the opportunities and the differentiation of how African countries are approaching green hydrogen production. Namibia, which targets big export-favored projects, differs in its approach from Kenya, which seeks to utilize its abundant geothermal power for green hydrogen generation. The success of the green hydrogen sector in Africa is

conditional on substantial investment, backing policies, and cooperation between countries with divergent approaches.

Challenges and Opportunities

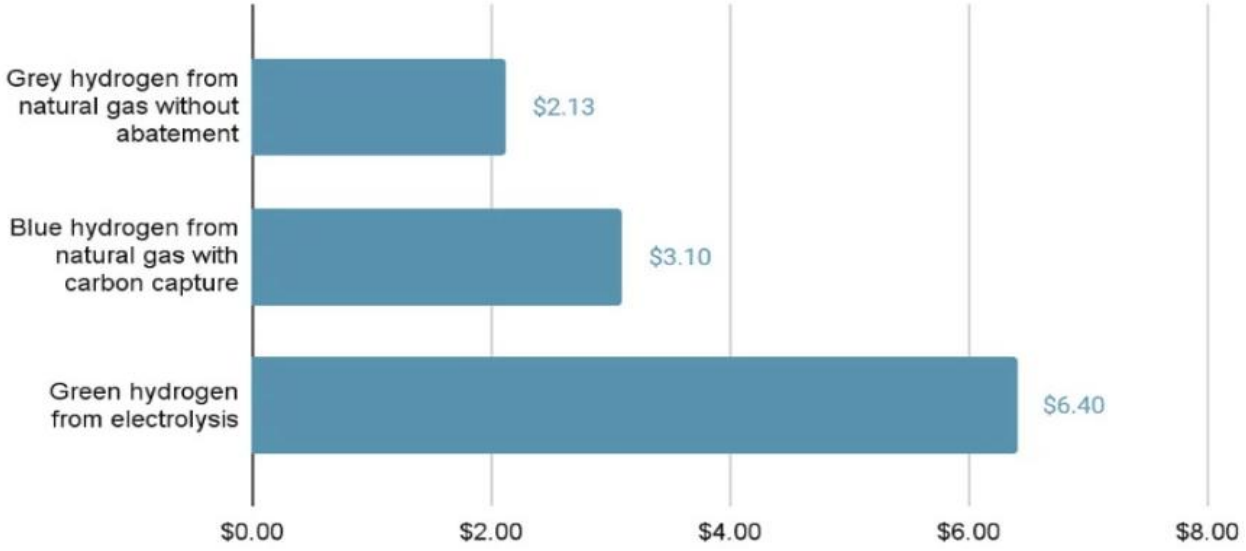
Policy Regulatory Frameworks

Despite the potential of green hydrogen to transform the continent's energy sector, the regulatory and legal frameworks in place are not tailored to support development. The Africa Green Hydrogen Alliance (AGHA) has been pushing its member states to harmonize a continental policy even as governments explore their own strategies. The legal framework should also accompany investment in the necessary infrastructure in remote regions in Africa that are suitable for renewable energy sites but have been marginalized by centralized systems of governance since the colonial era. Unlike in Europe and America where existing natural gas infrastructure supports hydrogen transportation, Africa faces the daunting task of building such infrastructure from scratch (Cardinale, 2023).

Land and Water Resources

Additionally, arid regions in Africa suffer from water scarcity that poses a significant challenge for green hydrogen production. Electrolysis, a key process in green hydrogen production requires substantial water resources. With Africa suffering extreme droughts and famines, and the population growing at rates of 2 percent annually (Economist, 2020), it will be extremely difficult for authorities to justify diverting shrinking water resources towards green hydrogen production.

Fig 2. The average production cost of hydrogen forms



IRENA, 2022

Aside from water, land is also a major concern. According to the International Land Coalition (ILC), only 10 percent of land in rural areas in Africa is documented (Koch, 2020), and indigenous communities whose ancestral lands may be suitable for hosting solar and wind farms crucial for green hydrogen production are at risk of losing their property to private investors or state agencies. Moreover, they may frequently oppose relocation due to historical injustices and unfair treatment in previous development projects. Overcoming community resistance and addressing land rights is essential in advancing green hydrogen projects sustainably in Africa.

Production Costs

Green hydrogen projects worldwide are capital intensive, yet funding for renewable energy in Africa has dwindled in recent years. In 2021, just $10.8 billion USD was allocated to developing countries in the Global South to support solar, wind, and hydropower projects, a large drop from the $26.4 billion provided in 2017. Moreover, the current high costs of green hydrogen production remain a significant challenge (SG H2 Energy, 2023). Green hydrogen is more expensive than alternative hydrogen production methods like grey and blue hydrogen. The cost barriers derail the competitiveness and affordability of green hydrogen is-à-vis fossil fuels and traditional biomass.

Conclusion

In conclusion, this policy brief calls for:

Developing Effective Policy Frameworks

To step up green hydrogen production in the continent, policymakers need to develop long-term strategies that can be embedded by national and local governments to guide future explorations. Some key industrial sectors that can be targeted include the transportation, construction, energy generation, and agricultural sectors. Moreover, increasing documentation of land in rural areas and reforming regulatory frameworks on community land will be crucial in easing investor concerns on the viability of long- term projects.

Stimulating Commercial Demand for Green Hydrogen

Despite the development of green hydrogen technologies, its production costs remain significantly high. This shows there is need for African countries to create sustainable markets for green hydrogen, reduce carbon emissions from fossil fuel-based hydrogen, and strengthen the energy investments by local, private, and public investors. Scaling up the supply chains networks by leveraging on the African Continental Free Trade Area (AfCFTA) could lead to increased energy production and

competitive prices. Collaborations through PPPs can also spur investments in green hydrogen projects where the initial set up costs are extremely high for singular actors.

Investing in Research and Development

It is vital that African governments prioritize research into strategies that can lead to the production of green hydrogen at lower costs, including improving technology performances of electrolyzers, fuel cells, and any other hydrogen-based technologies. Governments should also include desalination in their blue economy policies, as it can play a crucial role in green hydrogen production by providing a cheaper and less controversial alternative to using limited fresh water resources.

Capacity-building and Skill Development

Currently, there is a shortage of skilled manpower that can work in hydrogen plants or value chains, thus increasing the cost of production associated with importing labor from outside the continent. There is need for universities to offer course curriculums that can train the future group of green hydrogen workers.

Developing Innovative Financing Systems

Reliance on concessional funding to develop renewable energy projects is not sustainable, with the financial flows reducing annually and bilateral aid cuts by developed nations. It is therefore crucial that African institutions, including the central banks, increase the roll out of green bonds and infrastructure bonds that can allow local private investors to make secure investments, while bringing much-needed capital injections.

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