FLORENCE SCHOOL OF REGULATION

ROBERT SCHUMAN CENTRE

POLICY BRIEF

Redrawing the EU's energy relations: Getting it right with African renewable hydrogen

Introduction

In Barcelona on May 18, 2022, the 'Africa Green Hydrogen Alliance (AGHA)' was formally launched at the first ever 'Green Hydrogen Global Assembly'. The Alliance brings together Kenya, South Africa, Namibia, Egypt, Morocco, and Mauritania in a shared objective of establishing the African continent as a leading producer of green hydrogen, both for domestic and export purposes. This announcement came the same day as the publication of the EU's 'REPowerEU Plan'[1] outlining the EU's path to energy independence from Russian fossil fuels by 2027 as well as the 'EU External Engagement Strategy'[2], which sets the wider framework for EU international energy policy. Both documents highlight the importance of Africa as a future trading partner for energy commodities with a strong focus on hydrogen, including a share of the massive 10 million tonnes (mt) of imported renewable hydrogen envisaged by 2030.

1 European Commission, (2022h). REPowerEU, Retrieved from https://energy.ec.europa.eu/communication-repowereu-plan-com2022230_en

2 European Commission, (2022b). EU external engagement in a changing world, Retrieved from: https://energy.ec.europa.eu/joint-communication-eu-external-energy-engagement-join202223_en

Issue 2022/50

September 2022

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African renewable hydrogen is also featuring increasingly prominently in the political rhetoric on trade between the EU and Africa. In February 2022 at the 'Europe Africa Business Forum'[3] Executive vice President of the European Commission Frans Timmermans spoke about a 'triple dividend' for African nations engaging in renewable energy partnerships with the EU; (i) local energy access, (ii) revenue from export of green hydrogen and derivative products, as well as (iii) creation of highly skilled jobs for the local youth labour market. More widely speaking, recent International Renewable Energy Agency (IRENA)[4,5,6,7], International Energy Agency (IEA)[8], and Intergovernmental Panel on Climate Change (IPCC)[9] reports highlight the potential advantages of a renewable hydrogen economy in Africa.

Renewable hydrogen seemingly offers a very exciting economic opportunity for African countries to claim a share of the new global energy economy, with meaningful synergies in other priority areas such as local energy access, decarbonisation, as well as social and environmental aims. The IEA envisage that U$D190bn of annual investment in the energy sector will be required in the continent between 2026-2030, roughly double the current level.[10] Exports of hydrogen and derivative products could help with this.

Nevertheless, how credible is the case? Particularly in the context of rising public debt burdens, inflation, as well as policy shifts following the COVID-19 pandemic and the Russian invasion of Ukraine.[11] Moreover, why is hydrogen different from other traded energy commodities? What projects are emerging on the ground? Where is the added value for African countries? Where are the pitfalls in realising ambitions and how might they be avoided?

In this paper we will explore the state of play with renewable hydrogen development in Africa through some case studies from AGHA members, and the scope for growth moving forward. In so doing, we will address some of the prevailing challenges to build out of a clean hydrogen economy that could be foreseen already at this early stage and look for potential solutions, building on what is already in place in other sectors. We make the case that there should be four key areas of focus moving forward on African-EU hydrogen collaboration. Firstly, (i) foreign direct investment (FDI) should be de-risked through offtake mechanisms and public-private partnerships, (ii) flagship projects should lead the way, (iii) large parts of the value chain should remain in Africa, (iv) wider 'democratisation' and accessibility of the sector should be encouraged.

3 European Commission, (2022e). Keynote speech EVP Timmermans at the Europe Africa Business Forum event on Sustainable Energy, Retrieved from: https://ec.europa.eu/commission/presscorner/detail/en/SPEECH_22_1067

4 International Renewable Energy Agency (IRENA), (2021c). The Renewable Energy Transition in Africa, Retrieved from: https://irena.org/-/media/Files/IRENA/Agency/Publication/2021/March/Renewable-Energy-Transition-Africa_Country_Studies_2021.pdf?la=en&hash=46D8ADDF378CD917C90F85F899B3F2B33A787CB8

5 International Renewable Energy Agency (IRENA), Planning and Prospects of Renewable Power in Africa, Retrieved from: https://www.irena.org/energytransition/Energy-System-Models-and-Data/Planning-and-Prospects-of-Renewable-Power-in-Africa

6 International Renewable Energy Agency (IRENA), (2020). Planning and Prospects of Renewable Power in Africa, Retrieved from: https://www.irena.org/publications/2020/Dec/Green-hydrogen-cost-reduction

7 International Renewable Energy Agency (IRENA), (2022a). Geopolitics of the Energy Transformation, Retrieved from: https://irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jan/IRENA_Geopolitics_Hydrogen_2022.pdf

8 International Energy Agency (IEA), (2022). Africa Energy Outlook 2022, Retrieved from: https://iea.blob.core.windows.net/assets/6fa5a6c0-ca73-4a7f-a243-fb5e83ecfb94/AfricaEnergyOutlook2022.pdf

9 International Panel on Climate Change (IPCC), (2022). Climate Change 2022: Mitigation of Climate Change, Retrieved from: https://www.ipcc.ch/report/ar6/wg3/

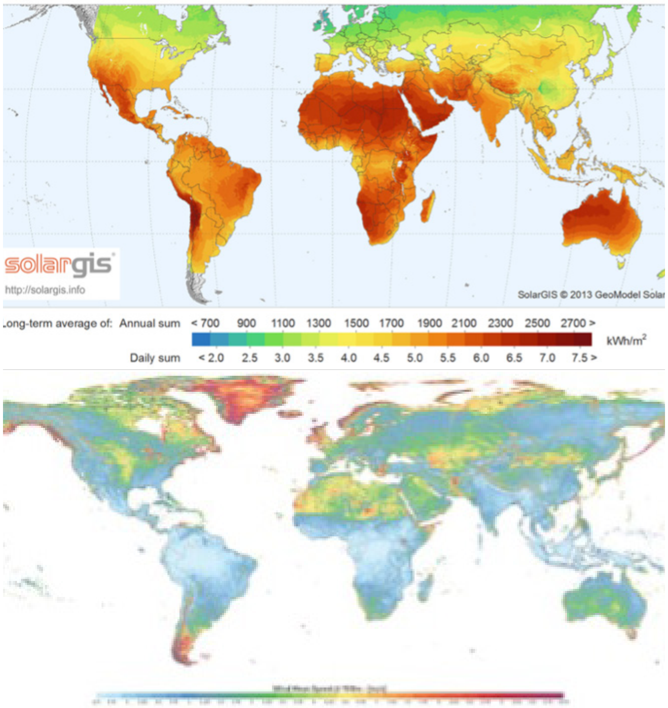
10 International Energy Agency (IEA), (2022). Africa Energy Outlook 2022, Retrieved from: https://iea.blob.core.windows.net/assets/6fa5a6c0-ca73-4a7f-a243-fb5e83ecfb94/AfricaEnergyOutlook2022.pdf

11 International Energy Agency (IEA), (2022). Africa Energy Outlook 2022, Retrieved from: https://iea.blob.core.windows.net/assets/6fa5a6c0-ca73-4a7f-a243-fb5e83ecfb94/AfricaEnergyOutlook2022.pdf

1. The economic and social case for hydrogen in Africa

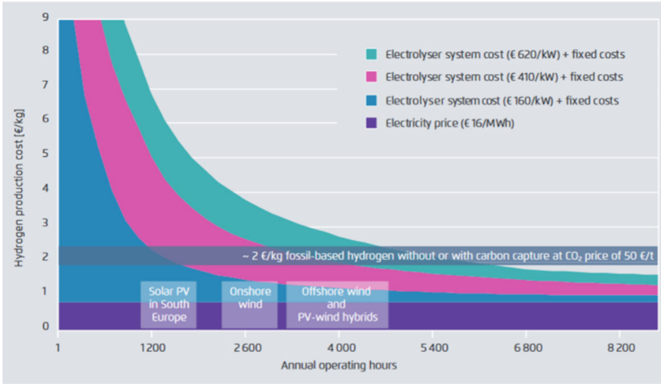
It is well known that Africa has some of the strongest renewable energy conditions on the planet[12], not only in terms of solar across the entire continent, but also wind in the north and at the fringes, as well as hydro on arterial rivers through the centre. The Figure below illustrates the solar and wind conditions globally, highlighting Africa's relative advantage versus virtually all other continents.

Figure 1: Long-term average solar irradiation (kWh/m²) (Solargis, 2013) (TOP), Wind mean speed at 100m above ground (m/s) (Global Wind Atlas, 2017) (BOTTOM)



Access to a combination of solar and wind resources is key for cost-effective renewable hydrogen production, as diversified energy sources mean higher operating hours for electrolysers and a lower marginal cost. Combining wind and solar can increase annual operating hours by roughly 2,000, in turn reducing the price of the resulting hydrogen by more than half, bringing it beyond the threshold of cost-competitiveness with the fossil benchmark.[13] See the Figure below.

Figure 2: Renewable hydrogen production costs depending on operating hours. (Agora Energiewende, 2021).



Agora Energiewende (2021) based on Guidehouse (2021).

The figures are estimates for illustrative purposes and are based on full-load hours that can be reached with renewable energy sources across Europe. The transparent boxes show the full-load hours of corresponding renewable energy sources.

Operating hours are particularly important in the early build-out of the sector whilst electrolyser costs remain high.[14] The EU's draft Delegated Act[15] on additionality is also configured in such a way to encourage operation during times of low electricity prices (and therefore abundant renewables), something that will also be a necessary condition for prospective importers. Most of the African projects presented later in the paper look to make use of dedicated combined wind and solar resources, avoiding common grid capacity and reliability issues.[16] That being said, grid balancing issues in much of Sub-Saharan Africa also create regular

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12 International Renewable Energy Agency (IRENA), (2014). Estimating the Renewable Energy Potential in Africa, Retrieved from: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2014/IRENA_Africa_Resource_Potential_Aug2014.pdf

13 The cost of fossil-based hydrogen has increased considerably in the past year due to high natural gas prices, pushing the threshold for competitive renewable hydrogen closer to 2,500/3,000 hours in many cases.

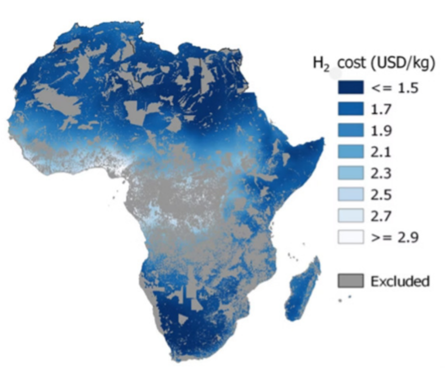
14 Low-cost electrolysers can produce competitive hydrogen at ~1,000 operating hours per year, whilst expensive electrolysers, such as those available from European manufacturers today, typically require 4,000< hours. (Agora Energiewende, 2020)

15 European Commission, (2022f). Production of renewable transport fuels – share of renewable electricity (requirements), Retrieved from: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/7046068-Production-of-renewable-transport-fuels-share-of-renewable-electricity-requirements-_en

16 Roussi, (2021). The pieces still missing in Africa's power puzzle, Retrieved from: https://www.ft.com/content/cd2693c8-67a4-493c-958d-f9f30eac7a2f

periods of 0 and negative prices, ideal conditions for electrolysers to soak up surplus electricity and crucially, to remain compliant with EU additionality requirements.[17] The IEA predict that Africa could produce 5mt[18] of hydrogen at a cost of less than 2U$D/KG by 2030, utilising hybrid wind and solar power from dedicated sources.[19]

Figure 3: Map of hydrogen cost production potential in Africa in 2030 within 200 km of a serviceable coast, ([IEA, 2022](IEA, 2022))



Fresh water is a requirement for renewable hydrogen production, which could be interpreted as a limiting factor in some water scarce regions in Africa. However, the opposite may be true. Recent cost estimates suggest that desalination can be achieved cost-effectively where there are sufficiently high-quality renewable resources, with negligible (~4%) impact on final hydrogen cost, and the opportunity to provide fresh water for local consumption in the process.[20] The correlation between strong renewable energy conditions and available space is also better in large parts of Africa than in most of the rest of the world, owing to it being simultaneously both one of the largest and least populated continents.[21] Furthermore, Africa currently has the lowest energy demand and lowest level of electricity access per capita of any continent on the planet[22], but also the fastest growing population and some of the fastest growing economies.[23]

The combination of rapid growth in population and economic output mean that local African electricity demand is forecasted to more than double by 2040.[24] Considering that solar and wind are now typically the cheapest form of new generation[25], these conditions create the opportunity for “energy leapfrogging”. In this scenario, large parts of the African continent could move from preindustrial fuels (manure, wood, etc.) directly to clean renewable energy, without the fossil fuel steps typically observed in between. This is not necessarily relevant for industrialised regions of Africa where there is already near universal electricity access[26], but rather for much of Sub-Saharan Africa where 77% of the population still do not have access, a proportion which has increased rather than decreased in recent years.

17 Balancing issues in Sub Saharan Africa currently have cumulative costs of roughly $5bn per year. (Financial Times, 2021)

18 Million tonnes.

19 International Energy Agency (IEA), (2022). Africa Energy Outlook 2022, Retrieved from: https://iea.blob.core.windows.net/assets/6fa5a6c0-ca73-4a7f-a243-fb5e83ecfb94/AfricaEnergyOutlook2022.pdf

20 International Renewable Energy Agency (IRENA), (2022b). Global Hydrogen Trade to Meet the 1.5°C Climate Goal: Green Hydrogen Cost and Potential, Retrieved from: https://www.irena.org/publications/2022/May/Global-hydrogen-trade-Cost

21 United Nations (UN), (2022). World Population Prospects 2022, Population Division, Retrieved from: https://population.un.org/wpp/

22 2 out of 3 people in Sub Saharan Africa do not have access to electricity.

23 International Energy Agency (IEA), (2022). Africa Energy Outlook 2022, Retrieved from: https://iea.blob.core.windows.net/assets/6fa5a6c0-ca73-4a7f-a243-fb5e83ecfb94/AfricaEnergyOutlook2022.pdf

24 International Energy Agency (IEA), (2019). Africa Energy Outlook 2019, Retrieved from: https://www.iea.org/reports/africa-energy-outlook-2019

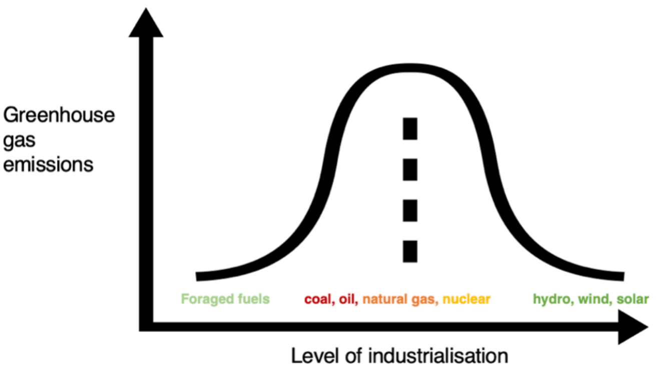
25 International Renewable Energy Agency (IRENA), (2021b). Majority of New Renewables Undercut Cheapest Fossil Fuel on Cost, Retrieved from: https://www.irena.org/newsroom/pressreleases/2021/Jun/Majority-of-New-Renewables-Undercut-Cheapest-Fossil-Fuel-on-Cost

26 For example, in North Africa (IEA, 2022).

[27] In the IEA's 2022 Africa Energy Outlook[28], their Sustainable Africa Scenario (SAS) sees a massive 80% of new power generation capacity added between now and 2030 to come from renewables.

The technology leapfrogging process has taken place in other sectors in Africa such as telecoms[29], as well as in digitalisation more widely.[30] In an environmental context it can be simply explained with an Environmental Kuznets Curve[31] that maps emissions and technological development in a conventional economic transition, as illustrated below.

Figure 4: Kuznets curve adapted to illustrate the traditional correlation between industrialisation and emissions in the context of energy, (Authors own, 2022)



Although simplified here, energy leapfrogging skips as far as possible the 'dirty', high-emission transitionary phase, avoiding enormous emissions in the process. Even in a scenario where energy demand in Africa increases very quickly, the near inexhaustible renewables potential mean it can retain massive export capacity.[32,33] Installing generation capacity for export can also have beneficial synergies with scaling up production capacity and grid infrastructure to meet local demand. For example, technology exchange, economies of scale, and access to external finance.[34]

2. Why renewable hydrogen could be different to fossil fuels

At their root, renewable energy projects in general have predictable OPEX costs due to consistent mid and long-term trends in solar exposure and wind speeds. CAPEX is also diminishing over time due to technology learning and scale-up, notwithstanding short-term fluctuations in cost inputs such as steel or platinum. In this way, project costs and returns can be much more predictable than fossil projects which rely heavily on far more volatile fossil fuel prices, emission pricing trends, as well as political and public attitudes toward fossil fuels in general. McKenzie for example forecast that more than half of African oil and gas production will be uneconomical by 2040, under a 1.5°C scenario.[35] See Figure 5 of historical oil prices on the top versus the cost of solar modules on the bottom, for comparison.

27 International Energy Agency (IEA), (2022). Africa Energy Outlook 2022, Retrieved from: https://iea.blob.core.windows.net/assets/6fa5a6c0-ca73-4a7f-a243-fb5e83ecfb94/AfricaEnergyOutlook2022.pdf

28 International Energy Agency (IEA), (2022). Africa Energy Outlook 2022, Retrieved from: https://iea.blob.core.windows.net/assets/6fa5a6c0-ca73-4a7f-a243-fb5e83ecfb94/AfricaEnergyOutlook2022.pdf

29 Cilliers, (2021). Technological Innovation and the Power of Leapfrogging, Retrieved from: https://link.springer.com/chapter/10.1007/978-3-030-46590-2_10

30 Kattel, Mergel, (2019). Estonia's Digital Transformation: Mission Mystique and the Hiding Hand, Retrieved from: https://oxford.universitypressscholarship.com/view/10.1093/oso/9780198843719.001.0001/oso-9780198843719-chapter-8

31 Stern, (2018). Reference Module in Earth Systems and Environmental Sciences, Retrieved from: https://www.sciencedirect.com/topics/earth-and-planetary-sciences/environmental-kuznets-curve#:~:text=The%20Environmental%20Kuznets%20Curve%20(EKC)%20is%20often%20used%20to%20describe,some%20measures%20of%20environmental%20quality.

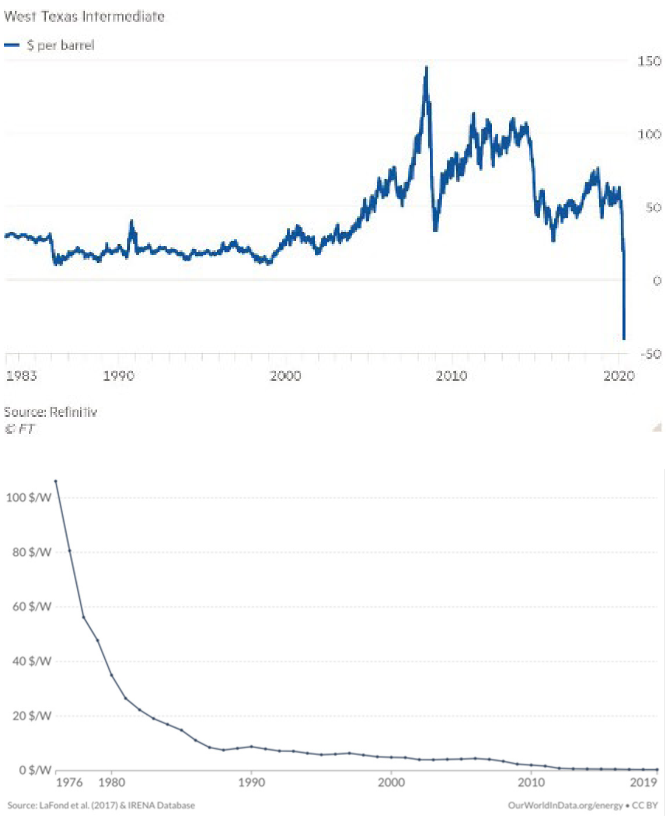
32 International Renewable Energy Agency (IRENA), (2014). Estimating the Renewable Energy Potential in Africa, Retrieved from: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2014/IRENA_Africa_Resource_Potential_Aug2014.pdf

33 Solar power potential in Africa is estimated at more than one million TWh/year, wind potential is estimated at roughly 460,000 TWh/year.

34 For example 'Global Gateway' and the 'Africa-Europe Green Energy Initiative'.

35 Bouchene, et al., (2021). Green Africa: A growth and resilience agenda for the continent, McKinsey & Company, Retrieved from: https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability/our%20insights/green%20africa%20a%20growth%20and%20resilience%20agenda%20for%20the%20continent/green-africa-a-growth-and-resilience-agenda-for-the-continent.pdf

Figure 5: Historical oil prices (U$D per barrel), (TOP) Historical solar module prices (BOTTOM)



These factors help to reduce investor risk in renewable projects, attracting investment and, crucially, facilitating more favourable contractual terms for local parties, two issues which have been major bottlenecks for FDI in Africa in general.[36] Moreover, the majority of negative social and environmental externalities associated with fossil fuel extraction and processing (air and water pollution, etc.) are not associated with renewable projects, mitigating considerable local risk and resistance.[37] Hydrogen specifically is also fundamentally different to most other traded energy commodities in terms of the end-use applications and what that means for the build-up of value chains, particularly in the context of a nascent market.

Whilst hydrocarbons are largely directly used as thermal fuel sources, hydrogen is an 'energy vector'[38] and for the most part used as a feedstock in industrial processes rather than combusted for heat. Within this context, African renewable hydrogen producers may choose to build up further segments of the supply chain locally, exporting finished products (e.g. 'green steel', sustainable fertilisers, etc.) rather than energy products.[39] This may seem like a small detail, but it can have meaningful implications for the profitability and stability of the sector as much of the final value of the finished product as well as employment opportunities are added through secondary processing. Consider for comparison the relatively small revenues earned in West Africa from cocoa bean exports relative to the massive eventual profits made in Europe and North America from chocolate sales.[40]

Localising multiple segments of the hydrogen supply chain is particularly feasible now whilst the market remains nascent, decentralised, and where the other requisite raw materials or inputs are readily available. Many African countries are well positioned in this regard, due to the local availability of iron ore for steel manufacturing or phosphate for fertiliser production, for example. Africa also contains 40% of the global manganese and cobalt reserves.[41] The south of the continent is well endowed with platinum, a key ingredient for electrolysers and fuel cells, whilst the requisite gold, copper, and aluminium are deposited widely across the continent. See Figure 6 below.

36 Wako, (2021). Foreign direct investment in sub-Saharan Africa: Beyond its growth effect, Research in Globalization, Retrieved from: https://www.sciencedirect.com/science/article/pii/S2590051X21000198

37 Schneider, (2021). Indigenous communities in South Africa sue, protest off-shore oil and gas exploration, Mongababy, https://news.mongabay.com/2021/12/indigenous-communities-in-south-africa-sue-protest-off-shore-oil-and-gas-exploration/

38 KBR. What are energy vectors?, Retrieved from: https://www.kbr.com/sites/default/files/2021-01/What-are-Energy-Vectors.pdf

39 This configuration may suit the EU's current receiving infrastructure, as the terminals, pipeline interconnections, and caverns required to receive and store large volumes of hydrogen or derivative carriers will take some time to establish at scale.

40 Nirishkin, et al. (2022). Ghana is a world leader in cocoa production. So why does it see just 2% of the $100 billion chocolate industry's profits?, Business Insider, Retrieved from: https://www.businessinsider.com/ghana-cacao-growing-powerhouse-so-why-no-chocolate-profits-2022-3?r=US&IR=T

41 International Energy Agency (IEA), (2022). Africa Energy Outlook 2022, Retrieved from: https://iea.blob.core.windows.net/assets/6fa5a6c0-ca73-4a7f-a243-fb5e83ecfb94/AfricaEnergyOutlook2022.pdf

Figure 6: Raw materials groups across Africa, (US Geological Survey, via Fissha, et al., 2020)

There is also a fundamental difference in market access. Whilst the economics and geopolitics of hydrocarbon industries are largely defined by the arbitrary and unequal distribution of mineral deposits, in the view of IRENA, a global renewable hydrogen market is likely to be considerably more decentralised and democratised.[42] This is principally because renewable hydrogen can be produced almost anywhere, albeit at varying price points[43] and provided the technology and corresponding materials can be accessed (electrolysers, pipelines, etc.). Moreover, modelling suggests that once transportation scope goes outside of the economic range for new pipelines (~1,500 – 4,000 km) and therefore into shipping, there is a fairly negligible marginal difference in cost for additional difference travelled.[44,45,46] It is therefore unlikely that there will be such a scramble for resources as we have seen with other energy commodities, as importers are free to make value judgements in choosing trading partners based on a range of factors – provided they are willing to be somewhat flexible on cost.[47]

Modelling from IRENA[48], illustrated in Figure 7 below, suggests that even in a pessimistic scenario, there should be more than 2,000 exajoules (EJ) of economic hydrogen (<2U$D/kg) potential globally by 2050, exceeding projected demand at that point by roughly 4,000%.[49] If production does indeed become comparatively diversified, it should reduce the geopolitical influence of energy products versus today, with flexible supply chains fostering improved transparency, optionality, and predictability.

42 International Renewable Energy Agency (IRENA), (2022a). Geopolitics of the Energy Transformation, Retrieved from: https://irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jan/IRENA_Geopolitics_Hydrogen_2022.pdf

43 International Renewable Energy Agency (IRENA), (2022b). Global Hydrogen Trade to Meet the 1.5°C Climate Goal: Green Hydrogen Cost and Potential, Retrieved from: https://www.irena.org/publications/2022/May/Global-hydrogen-trade-Cost g/publications/2022/May/Global-hydrogen-trade-Cost

44 International Renewable Energy Agency (IRENA), (2022a). Geopolitics of the Energy Transformation, Retrieved from: https://irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jan/IRENA_Geopolitics_Hydrogen_2022.pdf

45 Agora Energiewende and AFRY Management Consulting, (2021). No-regret hydrogen: Charting early steps for H□ infrastructure in Europe, Retrieved from: https://static.agora-energiewende.de/fileadmin/Projekte/2021/2021_02_EU_H2Grid/A-EW_203_No-regret-hydrogen_WEB.pdf

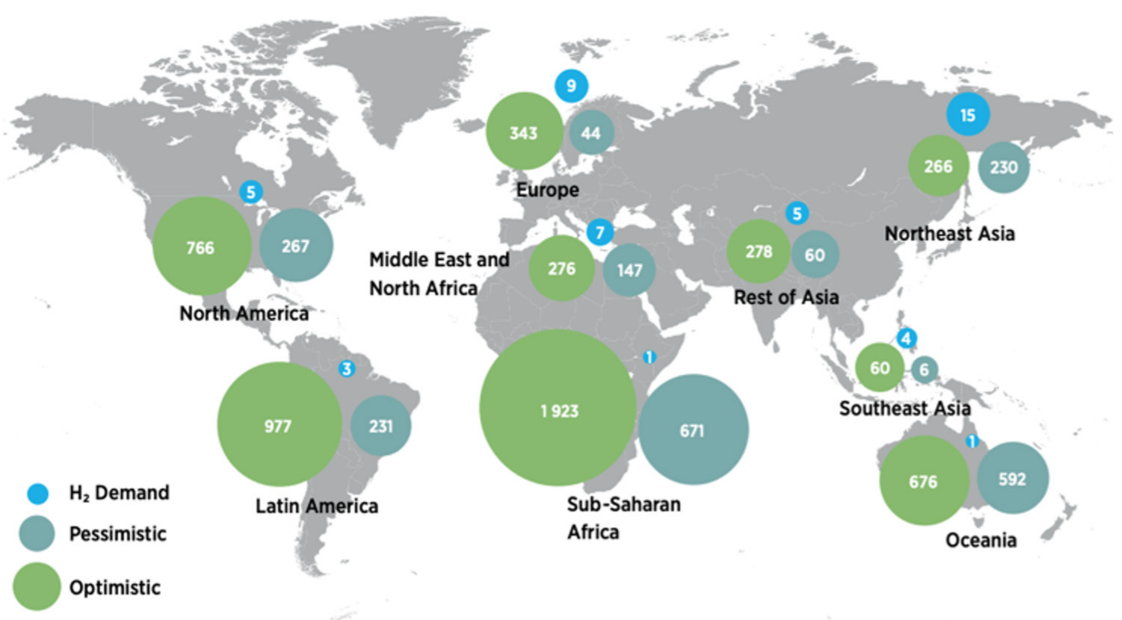
46 Wang, et al., (2021). European Hydrogen Backbone: Analysing future demand, supply, and transport of hydrogen, Retrieved from: https://ehb.eu/files/downloads/EHB-Analysing-the-future-demand-supply-and-transport-of-hydrogen-June-2021-v3.pdf

47 International Renewable Energy Agency (IRENA), (2022a). Geopolitics of the Energy Transformation, Retrieved from: https://irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jan/IRENA_Geopolitics_Hydrogen_2022.pdf

48 International Renewable Energy Agency (IRENA), (2022b). Global Hydrogen Trade to Meet the 1.5°C Climate Goal: Green Hydrogen Cost and Potential, Retrieved from: https://www.irena.org/publications/2022/May/Global-hydrogen-trade-Cost g/publications/2022/May/Global-hydrogen-trade-Cost

49 For reference, the energy content of 1EJ of hydrogen is equivalent to 6.35 million tonnes of hydrogen.

Figure 7: Comparison between economic potential of green hydrogen supply below USD 2/kgH2 and forecasted hydrogen demand, in EJ/year, in 2050, (IRENA, 2022)



As alluded to earlier, the key variable here now shifts from access to hydrocarbon deposits, towards access to harvesting/processing technology and indirectly the scarce materials that are required to produce that technology.[50] Seven of the top ten solar PV manufacturing companies[51] and six of the largest ten wind turbine manufacturers[52] are Chinese, representing a significant concentration of overall market share. The EU[53], US[54], and others have made efforts to claw back shares of these markets through protectionist policies and support for domestic manufacturers, but these value chains are now relatively well settled, at least for now.

The new race is for the electrolyser market, which is currently dominated by European companies[55], but again faces growing competition from the Chinese.[56] The EU has introduced initiatives[57] to protect this domestic manufacturing sector, as well as further initiatives to secure the critical raw materials[58] required to produce them, the majority of which are originate in Africa and China, see the Figure below.

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50 International Renewable Energy Agency (IRENA), (2021a). Critical Materials For The Energy Transition, Retrieved from: https://irena.org/Technical-Papers/Critical-Materials-For-The-Energy-Transition

51 Marsh, (2022). Top solar panel manufacturers, EnergySage, Retrieved from: https://news.energysage.com/best-solar-panel-manufacturers-usa/

52 BizVibe, (2022). Global Wind Turbine Industry Factsheet 2022: Top 10 Largest Wind Turbine Manufacturers, Retrieved from: https://blog.bizvibe.com/blog/energy-and-fuels/top-10-wind-turbine-manufacturers-world

53 Abnett, (2022). EU will do 'whatever it takes' to rebuild solar energy manufacturing in Europe, Reuters, Retrieved from: https://www.reuters.com/business/sustainable-business/eu-will-do-whatever-it-takes-bring-solar-energy-manufacturing-back-europe-2022-03-31/

54 Weissert, (2022). Biden orders emergency steps to boost U.S. solar production, AP News, Retrieved from: https://apnews.com/article/biden-technology-environment-global-trade-ca939bfc5a428c6692beb3e7b4bf715b

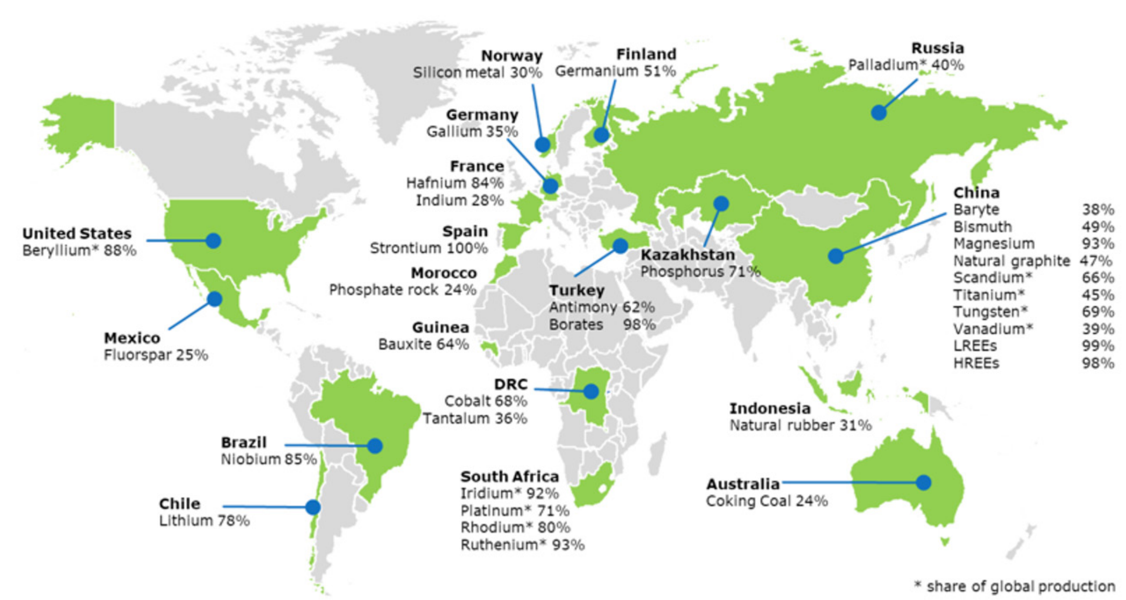
55 Guidehouse, (2022). Guidehouse Insights Leaderboard: Electrolyzer Vendors, https://guidehouseinsights.com/reports/guidehouse-insights-leaderboard-electrolyzer-vendors

56 Yin, (2021). China scaling up electrolyzer manufacturing base for domestic, export markets, SP Global, Retrieved from: https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/120621-china-scaling-up-electrolyzer-manufacturing-base-for-domestic-export-markets

57 European Commission, (2022d). Hydrogen: Commission supports industry commitment to boost by tenfold electrolyser manufacturing capacities in the EU, Retrieved from: https://ec.europa.eu/commission/presscorner/detail/en/IP_22_2829

58 European Commission, (2022a). Critical raw materials, Retrieved from: https://ec.europa.eu/growth/sectors/raw-materials/areas-specific-interest/critical-raw-materials_en

Figure 8: Countries accounting for largest share of EU supply of Critical Raw Materials (CRMs). ([European Commission, 2022](#))



These are the new frontiers of geopolitical dependency in the energy sector and the African continent is well positioned to play a meaningful role in the buildout of value chains.

3. Projects

Despite clear opportunities and potential, how far has this translated into tangible work on the ground so far? In the African context, the countries of the AGHA are broadly leading the way so far. Most of the advanced projects involve public-private collaboration at the local level, as well as foreign investment, either from companies, governments, development organisations, or a combination of the above. The following examples represent a non-exhaustive sample of case studies, chosen for their prominence and relative maturity.

Mauritania – 'Project Nour'

At 10-gigawatt (GW) scale, 'Project Nour' promises to be one of the largest green hydrogen projects in the world. It looks to combine onshore and offshore assets to utilise direct wind and solar connections to produce some of the cheapest green hydrogen on the market, with a targeted levelised cost of hydrogen (LCOH) of <U$D2/kg.

Project Nour is being planned in cooperation between the Mauritanian Ministry of Petroleum, Mines & Energy, and Chariot, a British company with a track record of African energy projects. Chariot intend to sell the hydrogen and derivative products into the EU via the Port of Rotterdam, something they already have an in-principle agreement for. Following a successful preliminary assessment last year, the next step is to carry out an in-depth feasibility study over the following two years. It remains unclear when the first hydrogen molecules would be produced.[59]

South Africa – Hydrogen valleys and mining projects

Building on the publication of its 'Hydrogen Society Roadmap'[60], the South African government are working on a public-private partnership with Angloamerican, Bambili Energy, Sonedi, and ENGIE to develop three renewable hydrogen valleys - one in Johannesburg, one in Durban, and one in Mogalakwena.

These valleys would cover the entire value chain, with hydrogen produced and consumed on site. Whilst the majority of the hydrogen in these projects is envisaged to serve local demand, there is scope for export of finished products as well hydrogen

59 Esau, (2022). Mauritania green hydrogen project takes step forward with Chariot pact, Upstream, Retrieved from: https://www.upstreamonline.com/hydrogen/mauritania-green-hydrogen-project-takes-step-forward-with-chariot-pact/2-1-1224646

60 Department of Science and Innovation: Republic of South Africa, (2021). Hydrogen society roadmap for South Africa 2021, Retrieved from: https://www.dst.gov.za/images/South_African_Hydrogen_Society_RoadmapV1.pdf

itself - through the coastal Durban hub. [61] Japan and Europe are amongst the most widely discussed export destinations for hydrogen if the projects can be effectively scaled[62], with an aim of achieving an LCOH of around U$D4/kg. South African energy company Sasol are also looking to capitalise on Europe's massive appetite for renewable hydrogen[63] by developing a U$D10 billion renewable hydrogen project in Boegoebaai.[64] The project is being aided by the government through a memorandum of understanding (MoU) for the sites operation in a special economic zone (SEZ)[65], as well as co-financing the project through the state Industrial Development Corporation (IDC)[66].

The hydrogen valleys build on somewhat of an established precedent of FDI in renewable hydrogen projects in the country. Angloamerican, a British multinational mining company, established one of the worlds' first up and running renewable hydrogen projects at the world's largest open-pit platinum mine in Mogalakwena. The renewable hydrogen powers massive 'NuGen' mining trucks, in place of conventional diesel fuel.[67]

Namibia – 'Hyphen Hydrogen Energy'

The Namibian government recently opened a largescale hydrogen project for bidding within its wider Southern Corridor Development Initiative (SCDI). The 40-year lease grants the chosen bidder, German consortium 'Hyphen Hydrogen Energy[68]', the right to produce hydrogen on the Tsau Khaeb National Park site. If realised, it could be one of the largest projects of its kind in the world, with operations set to begin in 2026 for production of 120,00 tonnes per annum (t/pa) at 2GW installed capacity, rising to 5GW and 300,000 t/pa in the second phase (or 1.7mt/p.a of ammonia – the intended export product).[69] The final destination of the ammonia is not totally clear, but the consortium mention various domestic applications as well as export. Again, the SCDI project intends to leverage both wind and solar in combination. The project remains at the pre-feasibility study phase, but with an ambitious timeline for development and an expected investment cost of U$D9.4billion.

A local-international private partnership has also emerged between Namibian conglomerate Olthaver & List Group and Belgian company CMB TECH[70]. This joint venture 'Cleanergy Namibia' is developing a U$D18 million demonstration production plant in 2022, with a view to expanding to a larger scale facility after that. Finally, the EU themselves are also believed to be negotiating directly with the Namibian government in anticipation of an MoU for

61 Department of Science and Innovation: Republic of South Africa, (2021). South Africa Hydrogen Valley Final Report, Engie Impact, Retrieved from: https://www.dst.gov.za/images/2021/Hydrogen_Valley_Feasibility_Study_Report_Final_Version.pdf

62 Roos, (2021). The cost of production and storage of renewable hydrogen in South Africa and transport to Japan and EU up to 2050 under different scenarios, International Journal of Hydrogen Energy, Retrieved from: https://www.researchgate.net/publication/354865857_The_cost_of_production_and_storage_of_renewable_hydrogen_in_South_Africa_and_transport_to_Japan_and_EU_up_to_2050_under_different_scenarios

63 Salma, (2022). Namibia Sees Green Bonds as Way to Fund Hydrogen Export Buildout, Bloomberg, Retrieved from: https://www.bloomberg.com/news/articles/2022-05-24/namibia-sees-green-bonds-as-way-to-fund-hydrogen-export-buildout?utm_medium=social&utm_campaign=socialflow-organic&cmpid%3D=socialflow-twitter-markets&utm_source=twitter&utm_content=markets#xj4y7vzkg

64 Sasol, (2021). Sasol announces lead role in feasibility study for the Boegoebaai Green Hydrogen project, Retrieved from: https://www.sasol.com/media-centre/media-releases/sasol-announces-lead-role-feasibility-study-boegoebaai-green-hydrogen-project

65 Sasol, (2021). Sasol announces lead role in feasibility study for the Boegoebaai Green Hydrogen project, Retrieved from: https://www.sasol.com/media-centre/media-releases/sasol-announces-lead-role-feasibility-study-boegoebaai-green-hydrogen-project

66 Industrial Development Corporation (IDC), About us, Retrieved from: https://www.idc.co.za/about-us/

67 Sguazzin, (2022). World's Biggest Hydrogen Trucks Start Work at Anglo American, Bloomberg, Retrieved from: https://www.bloomberg.com/news/articles/2022-05-06/world-s-biggest-hydrogen-trucks-start-work-at-anglo-american#:~:text=Anglo%20American%20Plc%20on%20Friday,the%20fossil%20fuel%20a%20year

68 Hyphen Energy, Home, Retrieved from: https://hyphenafrica.com/

69 Hyphen Energy, Projects, Retrieved from: https://hyphenafrica.com/projects/

70 Compagnie Maritime Belge, Home, Retrieved from: https://www.cmb.be/en/home

the delivery of renewable hydrogen[71], along with potential cooperation on resource imports under the 'Global Gateway Strategy'.[72]

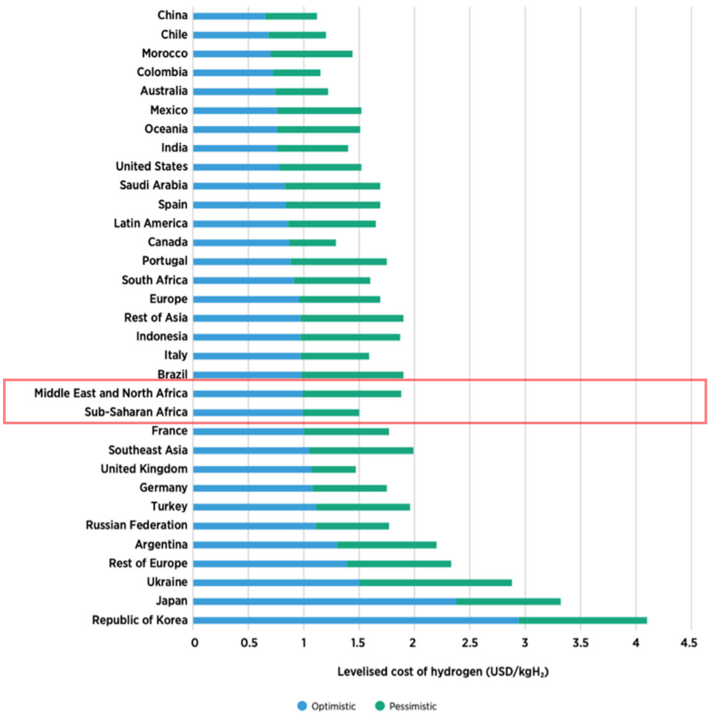
As of June 2022[73,74], 17 African renewable hydrogen projects are at the stage of an MoU or beyond, with a known combined electrolyser capacity of roughly 64GW, corresponding to around 4.8mt[75] renewable hydrogen per year.[76] If realised, this would represent a significant share of the renewable hydrogen on the global market by 2030, and with relatively little local demand forecasted for Africa in the next decade or two, this surplus would likely end up in importing regions like Europe.

Nevertheless, it remains to be seen how much of this capacity makes it to market over the coming years, and even in the most optimistic case where all projects are realised and all of the hydrogen is exported to Europe, it would cover less than half of the EU's targeted hydrogen import aims for 2030. The following section will explore some of the prevailing challenges and offer some tentative suggestions for scale-up.

4. Challenges and mitigation measures

We discussed in the first section the high-quality renewable energy conditions, favourable geological resources, and potential symbiosis with local social and economic aims for the build out of a renewable hydrogen economy in large parts of Africa. These conditions are some of the strongest in the world. However, despite these strong assets, the predicted cost for much of African renewable hydrogen remains considerably higher than in many parts of the world, including regions with relatively weak renewables conditions, such as China or the UK. Figure 9 below illustrates these projections to 2050.

Figure 9: Projected levelised cost of hydrogen (LCOH) (USD/kgH_2) across different countries and regions globally in 2050, (IRENA, 2022)



One key factor in these results is the investment risk associated with large parts of Africa relative to other regions. A 2022 study from IRENA on international hydrogen trade found that the weighted average

71 Guarascio, Nyasha, (2022). EU plans hydrogen deal with Namibia as it pulls away from Russian energy, Reuters, Retrieved from: https://www.reuters.com/business/energy/eu-plans-hydrogen-deal-with-namibia-it-pulls-away-russian-energy-2022-07-04/?taid=62c3459d98fe31000147cad4&utm_campaign=trueAnthem:+Trending+Content&utm_medium=trueAnthem&utm_source=twitter

72 European Commission, Global Gateway, Retrieved from: https://ec.europa.eu/info/strategy/priorities-2019-2024/stronger-europe-world/global-gateway_en

73 Baldessin, et al., (2022). Will Africa become the new green hydrogen "El Dorado"?, IHS Markit, Retrieved from: https://ihsmarkit.com/research-analysis/africa-green-hydrogen.html

74 International Energy Agency (IEA), (2022). Africa Energy Outlook 2022, Retrieved from: https://iea.blob.core.windows.net/assets/6fa5a6c0-ca73-4a7f-a243-fb5e83ecfb94/AfricaEnergyOutlook2022.pdf (Table 2.3, p. 101)

75 Assuming 75% electrolyser efficiency.

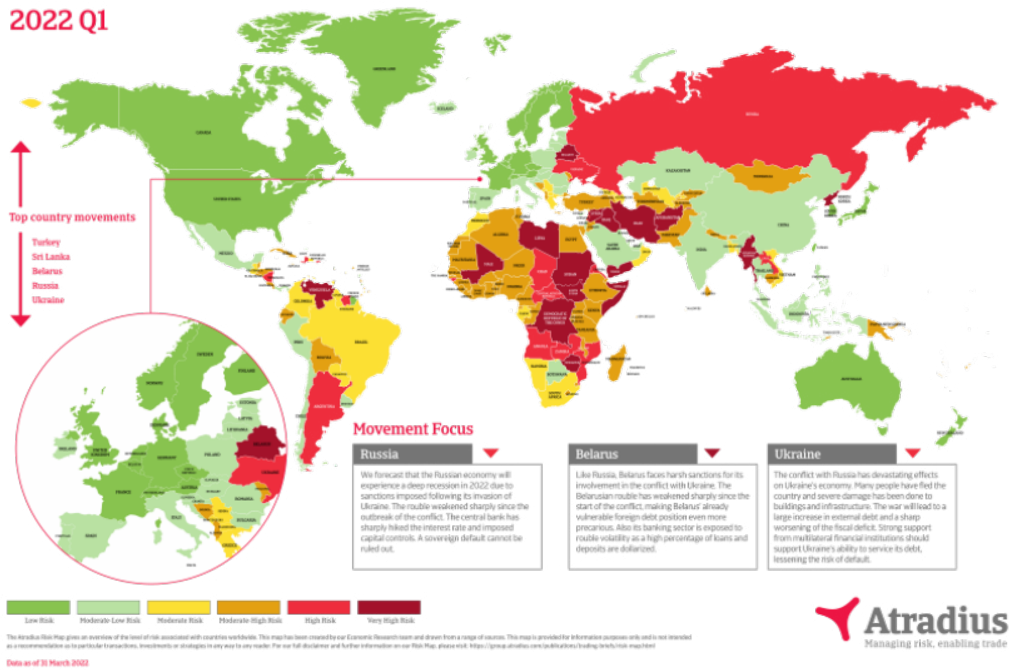
76 Wanner, (2021). Transformation of electrical energy into hydrogen and its storage, Retrieved from: https://link.springer.com/article/10.1140/epjp/s13360-021-01585-8

cost of capital (WACC)[77] had a much stronger impact on the final price of renewable hydrogen produced than the renewable conditions of a given country or region.[78]

> *"Multiple countries in sub-Saharan Africa, the Middle East and Latin America have vast renewable potential and the main uncertainty in their cost levels is how much they will be able to decrease their high WACCs towards 2050. This proved to be* ***more critical in defining the cost differential among countries than the quality of the renewable resource.****"*
> *(IRENA, 2022)*

The map below illustrates geographical distribution of investment risk, with large parts of Africa scoring amongst the highest levels of risk globally.

Figure 10: Country investment risk map for Q1 2022, (Atradius, 2022)



Although there are many benefits to the 'democratisation of the energy sector' as IRENA described it[79], the flip side of this for countries with risky investment climates is that investors can choose *not* to invest. In an extractive (fossil) energy system, project developers must follow the availability of energy deposits[80], even if it incurs high risk. In a renewable energy economy, it is not as black and white as this, with all countries and regions retaining much greater optionality – albeit with trade-offs. Moreover, the high CAPEX low OPEX nature of renewable energy technologies means that their costs increase exponentially with an increase in WACC due to debt and equity expenses. This is inverse to the relationship for fossil energy technologies, whose costs are to the largest extent determined by the cost of fuel inputs (i.e. OPEX) and as such suffer much less from a high WACC.[81] See Figure 11 below for an illustration.

77 Weighted average cost of capital (WACC) can be defined as "The weighted average cost of capital (WACC) is a financial ratio that measures a company's [or country's] financing costs. It weighs equity and debt proportionally to their percentage of the total capital structure. A company's executives use WACC in making decisions about how to fund operations or projects, and it helps investors determine the minimum rate of return they're willing to accept on their money."

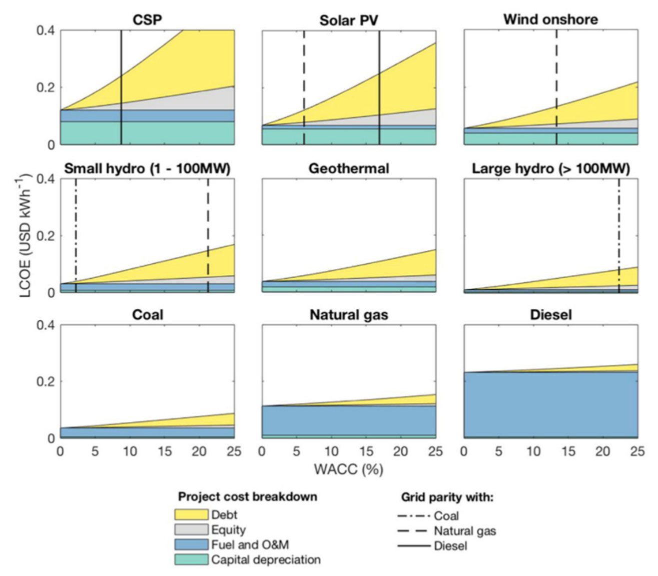
78 International Renewable Energy Agency (IRENA), (2022b). Global Hydrogen Trade to Meet the 1.5°C Climate Goal: Green Hydrogen Cost and Potential, Retrieved from: https://www.irena.org/publications/2022/May/Global-hydrogen-trade-Cost

79 International Renewable Energy Agency (IRENA), (2022a). Geopolitics of the Energy Transformation, Retrieved from: https://irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jan/IRENA_Geopolitics_Hydrogen_2022.pdf

80 Not to say of course that companies are obliged to invest in every country that has fossil energy deposits, but rather that there are a finite fossil resources available for extraction and they are unequally distributed around the world.

81 Sweerts, et al., (2019). Financial de-risking to unlock Africa's renewable energy potential, Renewable and Sustainable Energy Reviews, Retrieved from: https://www.researchgate.net/publication/331442495_Financial_de-risking_to_unlock_Africa's_renewable_energy_potential

Figure 11: The impact of the cost of capital on the cost of power generation, (Sweerts, et al., 2019)



This relationship goes someway to explaining the exceptionally low (and declining) penetration of renewables in the majority of African countries, which continue to struggle to attract up-front investment.[82] This is not a new issue, and some African countries have made progress in reducing WACC in recent years. Nevertheless, if strong theoretical generation potential is to materialise into millions of tonnes of renewable hydrogen and derivatives, there will need to be measures put in place to de-risk investments in the region.

Two of the main contributing factors to a high WACC are regulatory uncertainty and political instability, issues which have often precipitated expensive FDI in Africa for large periods of contemporary history. These are very high-level issues which have historically often not benefitted from or even suffered from external intervention[83], however, there are trade-specific tools which could mitigate risk and channel investment.

One of the main issues to overcome in de-risking investment is to ensure offtake for the product, particularly in a nascent market. 'H2 Global'[84] works as an intermediary by agreeing long-term contracts with producers (supply side) and then auctioning short-term sales contracts (demand side). Any gap in cost between the purchase cost and the supply price is covered by grant funding from the German government agency BMWK.[85] This functions somewhat like a carbon contract for difference (CCfD), de risking both the supply and demand side as well as removing some of the regulatory uncertainty and encouraging CAPEX investment in the process.[86] Both supply and demand are subject to competition, which helps to drive efficiency and minimise the contribution required from the mechanism in-between.

In this configuration, renewable hydrogen producers are not forced to compete directly with incumbent fossil hydrogen, but rather with each other – the mechanism finances the gap. Currently there is a budgetary contribution of €900 million for this project, and it is limited to companies importing into Germany. The major drawback is the contract duration for offtake, where relatively short-term sales agreements are not well suited to long technology cycles in certain industries, like steel.[87]

Nevertheless, the model has the potential to scale and evolve, and could be implemented by other European countries or the EU itself via cooperation mechanisms. One option could be under an extension of the new voluntary joint purchasing 'Energy Platform'[88] established as part

82 International Renewable Energy Agency (IRENA), (2022c). Renewable energy market analysis: Africa and its regions, Retrieved from: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jan/IRENA_Market_Africa_2022_Summary.pdf

83 Simon, (2009). Structural Adjustment Program, International Encyclopedia of Human Geography, Retrieved from: https://www.sciencedirect.com/topics/earth-and-planetary-sciences/structural-adjustment-program

84 H2 Global, Home, Retrieved from https://www.h2-global.de/

85 H2 Global, Home, Retrieved from https://www.h2-global.de/

86 H2 Global, Mechanism, Retrieved from: https://www.h2-global.de/project/h2g-mechanism

87 Florence School of Regulation (FSR), (2022). The EU's Hydrogen Accelerator – what steps should be taken? (VIDEO), Retrieved from https://www.youtube.com/watch?v=zawiYnzQ9as

88 European Commission, EU Energy Platform, Retrieved from: https://energy.ec.europa.eu/topics/energy-security/eu-energy-platform_en#:~:text=The%20platform%20is%20a%20voluntary,%2C%20secure%20and%20sustainable%20energy%E2%80%9D.

of REPowerEU to cover natural gas and hydrogen. As part of REPowerEU, the European Commission already announced plans to roll out an independent CCfD system for renewable hydrogen, utilising revenues from sales of ETS[89] credits as well as Innovation Fund budget.[90] This could be extended to imports via a modular expansion of the H2 Global model, and a reference price for imported fossil hydrogen.

A key benefit of this kind of approach when allocating scarce public funds is that there is only a cost incurred for the guarantor when the product is delivered, there are no sunk costs, and financing can flow incrementally and only where required. Moreover, in the prevailing energy market of high fossil gas prices, renewable hydrogen is already commonly cost-competitive with fossil hydrogen, where electricity supply is arranged under an existing PPA[91] or via dedicated supply.[92] These conditions reduce the guarantor's exposure, potentially to zero, with these market trends set to continue for the foreseeable future as TTF[93] prices forecasts remain above €200eur/MWh until Q2 2024.[94]

Given that there are strong renewable energy conditions across the African continent but significant differences in regulatory frameworks, infrastructure, social and economic conditions, etc., it can be challenging for unfamiliar investors to identify suitable candidates – particularly given the immaturity of the sector. 'H2ATLAS-AFRICA'[95] aims to help in this regard. The project is a joint initiative between the German Federal Ministry of Education and Research (BMBF) and African partners in the Sub-Saharan region (SADC and ECOWAS countries[96]).[97] They aim to physically map the most suitable areas, considering renewable energy conditions, but also technical, economic, and social factors. This tool could then help guide FDI for projects in the region, as well as supporting capacity building domestically for local projects.

As regards access to finance, one limiting factor for public investment in many African countries is national debt and balance of payments constraints, conditions have only worsened in this regard as a result of the COVID-19[98] and rising inflation.[99] These problems are particularly acute for CAPEX intensive sectors, such as for renewable energy. Heavily indebted poor countries (HIPC's)[100] saw on average an increase in national debt of 8.5%

89 EU Emissions Trading System (ETS).

90 European Commission, (2022i). REPowerEU: A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition*, Retrieved from: https://ec.europa.eu/commission/presscorner/detail/en/IP_22_3131

91 Power purchase agreement (PPA).

92 Collins, (2021). 'Green hydrogen now cheaper to produce than grey H2 across Europe due to high fossil gas prices', Retrieved from: https://www.rechargenews.com/energy-transition/green-hydrogen-now-cheaper-to-produce-than-grey-h2-across-europe-due-to-high-fossil-gas-prices/2-1-1098104

93 Title Transfer Facility (TTF).

94 Timera Energy, (2022). Europe's power crisis overtaking gas crisis, Retrieved from: https://timera-energy.com/europes-power-crisis-overtaking-gas-crisis/

95 H2 Atlas, Atlas of potential for green hydrogen in Africa: A study of technological, ecological and socio-economic feasibility, Retrieved from: https://www.h2atlas.de/de/ueber-uns

96 South African Development Community (SADC) and Economic Community of West African States (ECOWAS)

97 H2 Atlas, Atlas of potential for green hydrogen in Africa: A study of technological, ecological and socio-economic feasibility (FLIER), Retrieved from https://www.sasscal.org/wp-content/uploads/2020/04/updated-h2-atlas-project-flier.pdf

98 Heitzig, (2021). Sub-Saharan Africa's debt problem: Mapping the pandemic's effect and the way forward, Brookings, Retrieved from: https://www.brookings.edu/research/sub-saharan-africas-debt-problem-mapping-the-pandemics-effect-and-the-way-forward/

99 International Energy Agency (IEA), (2022). Africa Energy Outlook 2022, Retrieved from: https://iea.blob.core.windows.net/assets/6fa5a6c0-ca73-4a7f-a243-fb5e83ecfb94/AfricaEnergyOutlook2022.pdf

100 Many of which are in Sub Saharan Africa. (World Bank, 2022)

above pre-pandemic projections[101], whilst South Africa's GDP[102] fell 51% from the 1st to 2nd quarter of 2020.[103] As part of recovery efforts, various EU institutions[104,105] and other intergovernmental organisations[106] both inside and outside Africa[107] have allocated funds to support economic development in the worst affected regions. One option for the prospects of the clean hydrogen industry is to tie relief funds to climate-focused investment, including for example the modernisation of energy infrastructure.

As discussed earlier in the paper, there can be meaningful synergies for the scale up of renewable hydrogen for export in parallel with efforts to balance and decarbonise the domestic grid in many African countries, as well as for balance of payments.[108,109] Furthermore, local public authorities are free to place conditions on project promoters to support local aims, even if the final product is intended for export. For example, adding additional dedicated capacity for the grid, or investments in the local transmission network. This is particularly feasible under a common framework with cross-cutting aims, such as the AGHA.

From an EU perspective, the €300bn 'Global Gateway'[110] fund would arguably be the most suitable tool for 'debt for climate swaps', or 3rd country investments targeted at infrastructural development in the field of clean energy. The infrastructural focus of the Global Gateway fund invokes obvious comparisons with the Chinese 'Belt and Road Initiative' (BRI). The BRI has led to massive infrastructural investments in Africa in recent years, indicative of a trend towards project-specific, infrastructure spending in Africa rather than traditional broader development financing loosely bound to health or social causes.[111,112,113,114]

101 Heitzig, (2021). Sub-Saharan Africa's debt problem: Mapping the pandemic's effect and the way forward, Brookings, Retrieved from: https://www.brookings.edu/research/sub-saharan-africas-debt-problem-mapping-the-pandemics-effect-and-the-way-forward/

102 Gross Domestic Product (GDP).

103 German Institute for Global and Area Studies (GIGA), (2020). Africa after the Covid-19 Lockdowns: Economic Impacts and Prospects, Retrieved from: https://www.giga-hamburg.de/en/publications/giga-focus/africa-after-the-covid-19-lockdowns-economic-impacts-and-prospects

104 European Commission, (2022c). Global response to COVID-19 and beyond: Commission steps up funding to vaccination roll-out in Africa, Retrieved from: https://ec.europa.eu/commission/presscorner/detail/en/IP_22_3035

105 European Investment Bank (EIB), (2021). A green recovery strategy for Africa, Retrieved from: https://www.eib.org/en/press/news/op-ed-by-vp-fayolle-a-green-recovery-strategy-for-africa

106 Organization of the Petroleum Exporting Countries (OPEC), (2021). Financing infrastructure for Africa's post-COVID-19 recovery, Retrieved from: https://opecfund.org/news/financing-infrastructure-for-africa-s-post-covid-19-recovery#:~:text=The%20OPEC%20Fund%20and%20Africa,operation%20between%20the%20two%20institutions

107 E.g. the African Development Bank (AfDB).

108 For example, energy leapfrogging, utilisation of negative electricity prices, absorbing excess power that would otherwise be curtailed, local employment, technology sharing, as well as power to gas (PtX) providing for conversion of electrons to gaseous energy vectors which may be better suited to local needs and infrastructure.

109 These are entirely different conditions to the EU in many regards, where additional demand for renewable electricity for hydrogen production risks cannibalising scarce electricity needed for direct electrification and decarbonisation of the grid.

110 European Commission, (2019). The Global Gateway Fund, Retrieved from: https://ec.europa.eu/info/strategy/priorities-2019-2024/stronger-europe-world/global-gateway_en

111 ~$150bn since 2000.

112 Green, (2019). China's Debt Diplomacy, Foreign Policy, Retrieved from: https://foreignpolicy.com/2019/04/25/chinas-debt-diplomacy/

113 Risberg, (2019). The Give-and-Take of BRI in Africa, Center for Strategic and Intnerational Studies (CSIS), Retrieved from: https://www.csis.org/give-and-take-bri-africa

114 Fall, (2022). The Myth of the Chinese 'Debt Trap' in Africa, Retrieved from: https://www.bloomberg.com/news/articles/2022-03-17/the-myth-of-chinese-debt-trap-diplomacy-in-africa

Outside of state and intergovernmental financing, local or foreign, the FDI business case may be sufficiently attractive to draw private investment unsupported – particularly if derisking tools, such as those discussed above, can be applied. One sector that has in some cases proven successful for attracting FDI is mining. Sub-Saharan Africa generates a considerable amount of its revenues from mineral exports[115], roughly 20% on average across the region but much higher in certain countries, such as the Democratic Republic of Congo at 81% or Botswana at 92%.[116] Much of the extractive industries work with foreign companies[117] for technological collaboration, expertise, and investment. It has often proven easier to attract foreign investment in these areas than in non-extractive industries such as agriculture or tech.[118]

There are numerous lessons to be learned in dealings between African countries and foreign companies in the extractive sectors, including issues of corruption, overdependency, exploitative contractual conditions, and so on. However, many of these risks are associated with weak governance and regulatory structures, which may precipitate the same issues regardless of finance origin.

Moreover, in well-managed cases, there are models of FDI in these sectors that exhibit synergies. For example, much of the rail and road infrastructure in modern Zimbabwe was built as a result of investment in the iron ore sector during the countries period of relative stability in the early 2000's.[119] South Africa has also had success in attracting major international mining corporations such as Anglo American, that have gone on to establish significant portfolios and flagship projects with a high-level of transparency and cooperation with local authorities.[120] There could be scope to leverage European 'industry champions' in flagship projects to establish a precedent and model for the hydrogen sector. This process is already evident in the role of ENGIE in the South African case explored above, for example.

As regards hydrogen as a product, there are three key differences compared to many other 'extractive sectors' that may help to insulate against some of the major risks. Firstly, the product is not finite nor excludable. This contrasts with conventional primary industries which rely on the extraction of finite physical materials (lithium, iron, oil, platinum, etc.). The business case is therefore long-term and the costs relatively predictable. Secondly, and as discussed earlier in the paper, hydrogen is both an energy vector that can be sold directly, or the feedstock/input to produce finished products. This overcomes a key weakness in the conventional extractive business model, an overreliance on a single commodity price. Thirdly, as a nascent sector, the trading lines of renewable hydrogen are yet to be established at scale, as such, there is far more scope to establish industrial clusters and hubs or buildout the value chain domestically. In established sectors, such as coffee production or oil refining, the trade lines and clusters have long been established, and only protectionist measures have proven successful in disrupting these conventional and dominant pathways, ultimately weakening competitiveness in a global market.[121]

115 Signé, Johnson, (2021). Africa's Mining Potential: Trends, Opportunities, Challenges and Strategies, Retrieved from: https://www.africaportal.org/publications/africas-mining-potential-trends-opportunities-challenges-and-strategies/

116 UNCTAD. 2020, p. 53, 77

117 Typically, from the USA, Europe, and more recently China.

118 Signé, Johnson, (2021). Africa's Mining Potential: Trends, Opportunities, Challenges and Strategies, Retrieved from: https://www.africaportal.org/publications/africas-mining-potential-trends-opportunities-challenges-and-strategies/

119 Signé, Johnson, (2021). Africa's Mining Potential: Trends, Opportunities, Challenges and Strategies, Retrieved from: https://www.africaportal.org/publications/africas-mining-potential-trends-opportunities-challenges-and-strategies/

120 AngloAmerican, Home, Retrieved from: https://southafrica.angloamerican.com/

121 Narishkin, (2022). Ghana is a world leader in cocoa production. So why does it see just 2% of the $100 billion chocolate industry's profits? (VIDEO), Business Insider, Retrieved from: https://www.businessinsider.com/ghana-cacao-growing-powerhouse-so-why-no-chocolate-profits-2022-3?r=US&IR=T

Conclusions and policy recommendations

Renewable hydrogen is a big opportunity for the EU to cover more of its energy needs domestically, and to diversify its energy imports amongst new partners chosen from a much more democratised global energy economy. Clearly there is huge potential and appetite for cooperation on renewable energy development between the EU and African countries. Renewable hydrogen specifically is emerging as a potential catalyst for a domestic energy transition in Africa, leveraging opportunities to foster an export market for energy products and their derivatives. Nevertheless, there remains little progress on the ground, and significant scepticism that the African renewable hydrogen story will be any different to other hype cycles that have come and passed, such as failed plans to cover the Sahara Desert in solar panels.[122]

Our analysis has attempted to provide reasoned arguments for why renewable hydrogen in Africa could make sense for all parties concerned, and how it might be an opportunity to build trade relations based on equal footed partnerships between African and European stakeholders. Below we offer a few policy recommendations that could help guide efforts in this area moving forward, prescient of the fact that this is a highly complex and nuanced area dependent on numerous and evolving variables.

iv. Foreign direct investment (FDI) should be de-risked through offtake mechanisms and public-private partnerships

We consider investment risk to be the key barrier to leveraging otherwise very attractive environmental, geological, and geographical conditions for renewable hydrogen in Africa. Much of this risk stems from regulatory and political instability, manifesting in a high weighted average cost of capital (WACC) and inflated final hydrogen prices.

It is not the place of the EU or another external actor to exert direct influence for public structural reform. Rather we support the use of mechanisms that directly mitigate existing risk and incentivise destination regimes to foster stable and transparent institutional structures that facilitate added value for local populations and investors alike.

The H2 Global model explored in this paper is a good example of how a simple intermediary guarantor can help to align incentives and send positive signals to the market, without the need for sunk costs. A similar approach could be implemented under the EU's 'Global Gateway', the European joint purchasing 'Energy Platform', or as an extension of the planned carbon contracts for difference (CCfD) scheme.

iv. Flagship projects should lead the way

The economics of the renewable hydrogen sector currently favour large scale projects, as a means of keeping marginal costs low and drawing in multiple stakeholders in a consortium. The examples in this paper illustrate how this pattern is playing out amongst African projects at this early stage, with the majority including a mix of public-private cooperation/ financing, as well as the involvement of a foreign company that has some experience with projects in the destination country.

Strategy and policy on the European side could be well served to follow this model in its external energy planning, supporting domestic industry champions to work with local public authorities for the establishment of flagship projects. Parallels could be drawn here with foreign companies currently working in the extractive sectors in Africa.

iv. Large parts of the value chain should remain in Africa

Whilst there are lessons that can be learned from the extractive industries in terms of organisational models, the renewable energy economy should not follow the same typical supply chain configuration. Specifically, entrenched dependencies on a single traded commodity with a globally established price should be avoided, and the highest 'value added' segments of the supply chain should remain accessible and diversified.

Renewable hydrogen has good credentials for defying historical trends, as it is not only an energy vector but also the feedstock for finished products. Much of these value chains are yet to be established globally at scale, as such there is scope for African countries to establish multiple segments of the value chain domestically, or in cooperation with other African nations, for example building on

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the African Continental Free Trade Area. This can also suit European importers, where infrastructure is currently better suited to importing finished products than pure hydrogen. Such an approach should help to retain large amounts of the 'added value' in secondary steps, fostering complex and resilient local industries.

Nevertheless, these industries are CAPEX intensive and as such will need fertile investment conditions to make possible. The de-risking mechanisms discussed earlier can help with this, but they will likely need support from pull factors associated with a receptive investment climate, such as through local free trade areas, public-private partnerships, etc. The exceptionally high energy prices experienced in Europe at present are also creating incentives for energy intensive industry to relocate outside of the EU and import finished products back into the bloc, this may prove to be an effective push factor.

iv. Democratisation and market access at large should be supported

Central to the urgency and scale of European interest in renewable hydrogen imports is the desire to break from Russian fossil fuel dependency as quickly as possible. The EU hopes that imported hydrogen will directly displace roughly 27 billion cubic metres of Russian natural gas per year by 2030.[123] With this in mind, it is important that the EU does not create new energy dependencies within the renewables sector. This paper covered several aspects of why a diversified and 'democratised' hydrogen market based on abundant and widely available renewable energy could help to avoid entrenched dependencies and support optionality when choosing energy partners. African countries could be key here, due to proximity and links to Europe, strong renewable conditions, and availability of space and raw materials.

However, it is not only the EU that is looking to African countries with a view to establishing energy and raw material supply chains for the new energy economy. The EU will have to compete with Russia, China, India, the US, Turkey, and others for trade in the region. Fortunately, there should be more than enough potential to service trade with multiple partners, and the EU as the largest global importer for energy molecules is well positioned to establish attractive agreements, particularly if they support buildout of multiple segments of the supply chain locally. Nevertheless, the establishment of large flagship projects potentially engenders a risk of centralisation. For example, if large portions of the Global Gateway budget are allocated in only a few countries. This should be kept in mind when planning new partnerships to ensure that Europe is not overexposed.

Furthermore, whilst production resources remain widely distributed (i.e. wind, sun, water), the technology and materials required to produce the relevant harvesting technology (PV panels, electrolysers, wind turbines, etc.) are becoming increasingly centralised in terms of their ownership and control. These are some of the emerging lines of dependence in our global energy economy and diversifying these segments of the value chain should also be prioritised, with Africa likely to play a key role. Moreover, the EU can leverage its expertise and leadership in circular economies to retain and reuse scarce materials when infrastructure reaches the end of its lifecycle.

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Co-funded by the
Erasmus+ Programme
of the European Union

Published by
European University Institute (EUI)
Via dei Roccettini 9, I-50014
San Domenico di Fiesole (FI)
Italy

doi:10.2870/483523
ISBN:978-92-9466-248-4
ISSN:2467-4540
QM-AX-22-050-EN-N