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Natural gas and renewable hydrogen in Africa and cooperation opportunities with the EU

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Abstract

Europe needs to reduce consumption of Russian natural gas by diversifying its suppliers, reducing gas consumption and switching to other energy carriers, including renewable energy. This policy brief presents an overview of current developments in the natural gas and the renewable hydrogen sectors in Africa. It provides some suggestions for possible cooperation between the European Union and the African continent on LNG and green hydrogen markets.

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Introduction

Russia supplies around 40% of EU gas consumption. Europe will need in the short and medium term a reliable supply of non-Russian fossil gas and in the long-term renewable gases. However, Europe does not seem to have the potential to cover all its demand for energy gases and will have to resort to imports. Reducing reliance on Russian gas requires a concerted policy effort across multiple sectors and international cooperation on energy markets.[1]

A case in point is Austria: Due to the limited energy generation potential in relation to consumption and existing coverage gaps in domestic supply, it is necessary for Austria, as a net importer of energy and heavily dependent on Russian gas, to develop a coordinated import strategy for a wide range of renewable energy sources. Such a strategy should focus on the greatest possible diversification of supplier countries, on supplier countries with democratic governments, and on possible diversification of the type of renewable energy sources.

Part of the answer can be for Austria and other European countries to create partnerships to develop the energy sector in Africa. Africa has substantial natural gas production and reserves, and new discoveries are being pursued. Very little of Africa's gas has been exploited so far, either for domestic consumption or export. However, development of new gas fields and infrastructure in Africa requires substantial investments and is exposed to substantial security and political risks as well as environmental risks, including methane leakage, potential ocean fires and use of scarce water resources. If gas fracking is used, environmental risks could be higher.

Africa has also a very large potential for renewable energy. This renewable energy potential must be used to cover development needs in Africa itself and enhance productivity, advance industrialisation, create jobs and improve lives. Part of this potential can be used to produce renewable hydrogen and other renewable gases that can be exported.[2] So far, the renewable energy potential of Africa has been exploited to a very little extent.

Hydrogen, for example, is an energy vector that can facilitate transport of renewable energy over long distances via pipelines and shipping. Hydrogen also serves as energy storage, which is highly important in an energy system based on renewables. Countries with an abundance of low-cost renewable electricity could become producers and exporters of renewable hydrogen. Green hydrogen trade and investment flows can create new patterns of trade interdependence between countries and a new geopolitical landscape.[3] Besides

[1] IEA, 2022: A 10-Point Plan to Reduce the European Union's Reliance on Russian Natural Gas. International Energy Agency. March 2022. https://www.iea.org/reports/a-10-point-plan-to-reduce-the-european-unions-reliance-on-russian-natural-gas

[2] Timmermans, F., 2022: Keynote speech EVP Timmermans at the Europe Africa Business Forum event on Sustainable Energy. 16 February 2022. https://ec.europa.eu/commission/presscorner/detail/en/SPEECH_22_1067

[3] IRENA (2022), Geopolitics of the Energy Transformation: The Hydrogen Factor,

renewable hydrogen, exporting green steel or green fertilisers are additional business opportunities for African countries.

Sourcing more fossil and non-fossil gas from Africa—while at the same time helping African countries to meet their own development goals could be an opportunity for both Africa and Europe. This requires a careful balance between the development of fossil gas infrastructure, if possible with the possibility to be repurposed for a low-carbon future, and development of renewable energy infrastructure in both Africa and Europe. This also means that a careful balance between financial resources used for energy exporting infrastructure and financial resources used for domestic renewable energy development in Africa must be cast.

Renewable energy potentials in Africa remain underdeveloped. According to IRENA, only a small amount (2%) of global investments in renewable energy in the last two decades were made in Africa and less than 3% of global renewables jobs are in Africa. At the end of 2021, Africa had about 56 GW of renewable energy capacity and a 2% share of global installed capacity. [4]

Access to electricity is key to boosting economic activity and social development in Africa. Electrification rate in Sub-Saharan Africa was only 46% in 2019. Significant efforts are required to grant African people access to electricity and clean cooking and renewable energy can play an important role in achieving this goal.[5]

At the same time, many African countries are heavily reliant on inefficient, polluting electricity generation sources, requiring fuel imports. Africa requires cleaner power generation sources to avoid locking their economies into a future of relatively carbon-intensive power generation and mitigate the risk of stranded assets. Here, the development of renewable energy sources in Africa is a key element to supply sufficient electricity to meet the development needs of the continent without exposing African countries to the volatility and security of supply risks posed by fossil fuels. Renewable energy is an important element towards sustainable and peaceful energy systems.

The development of the energy sector in Africa requires reducing inequalities, and a transition towards cleaner, fairer and more peaceful energy systems. Equitable access to domestic and international finance and renewable energy technology while addressing equity and justice is essential for a sustainable development pathway for Africa. The EU can play a catalytic role here.

Another relevant aspect is the industrial development of African countries. Africa needs to industrialise in order to develop and energy is a fundamental foundation of industrial development. Massive investments in infrastructure development, including energy

International Renewable Energy Agency, Abu Dhabi. https://www.irena.org/publications/2022/Jan/Geopolitics-of-the-Energy-Transformation-Hydrogen

[4] IRENA, 2022: Renewable Capacity Statistics 2022. April 2022. https://www.irena.org/publications/2022/Apr/Renewable-Capacity-Statistics-2022

[5] Puliti, R.,(2022). Putting Africa on the path to universal electricity access. World Bank Blogs. 31 January 2022. https://blogs.worldbank.org/energy/putting-africa-path-universal-electricity-access

infrastructures, as well as an open and transparent market are needed for an inclusive and sustainable industrial development in Africa. In the long term, a massive build-up of clean energy will be necessary to support Africa´s industrialisation. A partnership with the European Union can facilitate both renewable energy penetration and industrial development in Africa, while tapping into win-win opportunities for renewable energy trade.

REPowerEU: Joint European Action for more affordable, secure and sustainable energy

The European Commission proposed an outline of a plan (REPowerEU) to make Europe independent from Russian fossil fuels well before 2030, starting with fossil gas, in light of Russia's invasion of Ukraine. The REPowerEU plan aims at increasing the resilience of the EU energy system based on two pillars: [6]

- Diversifying gas supplies, via higher Liquefied Natural Gas (LNG) and pipeline imports from non-Russian suppliers, and larger volumes of biomethane and renewable hydrogen production and imports; and,
- Reducing faster the use of fossil fuels by boosting energy efficiency, increasing renewables and electrification, and addressing infrastructure bottlenecks.

In this document, we will be addressing mainly the first pillar of the REPowerEU plan. However, the second pillar is essential to increase energy independence and therefore, security of energy supply. Energy efficiency is a fast and cost-effective way of achieving gas demand reduction, reduce the use of other resources and decrease energy bills. Energy efficiency solutions have not been prioritized so far in the EU. The more Europe is able to increase its own renewable energy production, the less it will have to rely on countries outside the EU for energy imports. Increasing the share of domestic EU renewable energy in combination with more ambitious energy efficiency will improve security of energy supply.

In 2021, according to the U.S. Energy Information Administration (EIA), the United States accounted for 26% of all LNG imported by the EU-27 and the United Kingdom. Qatar accounted for 24% and Russia for 20%. Other suppliers were Nigeria and Algeria.[7]

According to the REPowerEU plan, the EU could import 50 billion cubic meters (bcm) more of LNG (e.g. from Qatar, USA, Egypt, West Africa) on a yearly basis. Diversification of pipeline sources (e.g. Azerbaijan, Algeria, Norway) could deliver another 10 bcm/year. However,

[6] European Commission, 2022: COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS REPowerEU: Joint European Action for more affordable, secure and sustainable energy. COM/2022/108 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A108%3AFIN

[7] Energy Information Administration, 2022: Three countries provided almost 70% of liquefied natural gas received in Europe in 2021. Today in Energy. February 22, 2022. https://www.eia.gov/todayinenergy/detail.php?id=51358

securing 50 bcm/year of LNG in the current market is a large effort. The size of the global LNG market was 523 bcm in 2021, and Europe (including UK) together with Turkey imported 108 bcm. Achieving the 50 bcm target would imply significant diversions from other markets. These diversions can only be achieved with continuous high European prices at a premium to other markets.[8]

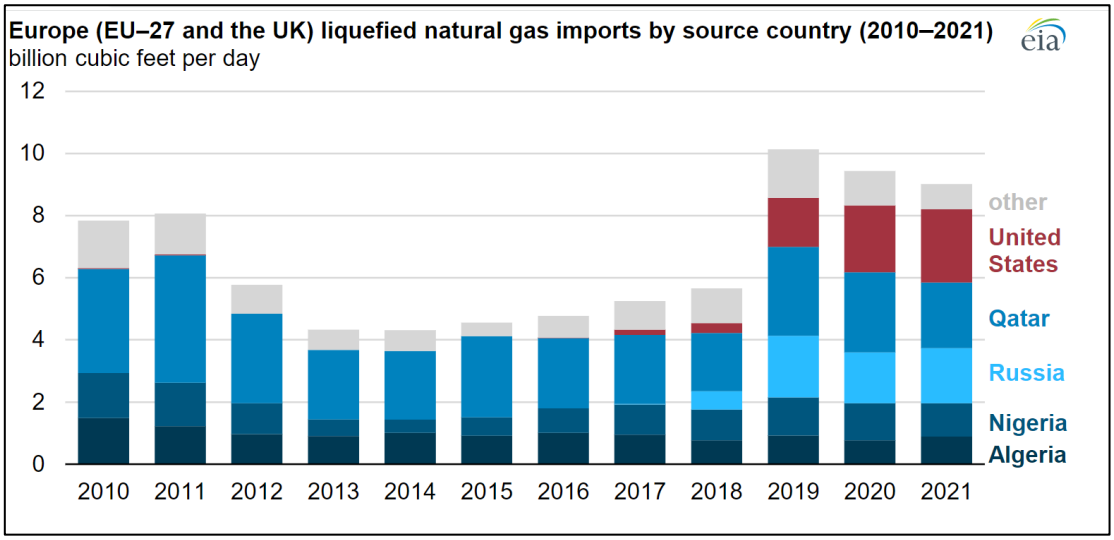

Figure 1: Europe (EU-27 and the UK) liquefied natural gas imports by source country (2010-2021)

Source: Graph by the U.S. Energy Information Administration, based on data from the International Group of Liquefied Natural Gas Importers (GIIGNL) annual liquefied natural gas trade reports (2010–2020) and CEDIGAZ (2021). https://www.eia.gov/todayinenergy/detail.php?id=51358. Last accessed 12.4.2022

LNG can contribute to enhancing the diversity of gas supply and improving energy security in the EU. Countries in Europe that have access to LNG import terminals are more resilient to supply interruptions than those that are dependent on a single pipeline gas supplier, particularly those countries heavily dependent on Russia. However, Europe's LNG import terminals still have limited capacity and some EU member states do not have sufficient regasification capacity to adsorb additional LNG. Moreover, LNG import terminals are not optimally distributed across the EU, which is one of the factors contributing to the supply vulnerability of certain Member States that have little or no choice of gas supplier.

Total European regasification capacity is approx. 170 bcm but most spare capacity is on the Iberian Peninsula and there are not enough pipelines to transport natural gas to other countries. The full use of this capacity in Spain requires a restructuring of the Spanish-French

[8] The Oxford Institute for Energy Studies, 2022: The EU plan to reduce Russian gas imports by two-thirds by the end of 2022: Practical realities and implications. March 2022. https://www.oxfordenergy.org/publications/the-eu-plan-to-reduce-russian-gas-imports-by-two-thirds-by-the-end-of-2022-practical-realities-and-implications/#:~:text=Energy%20Transition%20Research-,The%20EU%20plan%20to%20reduce%20Russian%20gas%20imports%20by%20two,of%20Russia's%20invasion%20of%20Ukraine.

gas trade towards using Spain as a primary launching point for baseload continental LNG imports and seasonal supply.[9]

Some EU member states are trying to install regasification capacity, mainly through Floating Storage and Regasification Units (FSRU), which are faster and cheaper to build than land-based LNG import terminals, but even those could take at least four to five years to become operational.[10],[11], [12]

As part of the REPowerEU measures, the European Commission will assess possible measures and investments in hydrogen-ready gas infrastructure and interconnections to overcome bottlenecks in the use of LNG capacity.

EU partnerships with third countries to collectively purchase gas and hydrogen could improve resilience and bring down prices. The European Commission has established together with the Member States an EU Platform for the common purchase of gas, LNG and hydrogen. It is a voluntary coordination mechanism, bringing together the Commission and the Member States, which intend to make use of the collective political and market weight of the EU.[13] Joint procurement could help the EU negotiate lower prices in the long term.

The EU platform for common gas purchases will support cooperation in the following areas:

- Demand pooling
- Efficient use of EU gas infrastructure (LNG import terminals, gas storage, gas security of energy supply, identification of infrastructure needs)
- International outreach to gas partners and markets to help secure well-priced imports in the short term and prepare the ground for future energy partnerships with key suppliers. This includes developing arrangements with the main LNG exporting and importing countries for diversification of supplies to the EU, also considering other energy carriers beyond LNG and gas, including towards hydrogen.[14]

LNG purchases from European countries in the current tight LNG market are leading to higher prices for other LNG buyers, in particular Asian and Latin American countries.[15] Even

[9] Joseph, I., 2022: https://twitter.com/ira_joseph/status/1511794651417751565
[10] FSRUs can typically import about 5 bcm a year
[11] Dempsey, H., 2022: Europe battles to secure specialised ships to boost LNG imports. Financial Times. https://www.ft.com/content/bc5f79a6-729e-47ff-bf46-cb23c460fa6f?shareType=nongift
[12] Euractiv, 2022: Europe faces struggle to escape Russian gas this year. 18 March 2022. https://www.euractiv.com/section/energy/news/europe-faces-struggle-to-escape-russian-gas-this-year/
[13] European Commission, 2022: Energy Security: Commission hosts first meeting of EU Energy Purchase Platform to secure supply of gas, LNG and hydrogen. First meeting of EU Energy Purchase Platform (europa.eu)
[14] European Commission, 2022: COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS. Security of supply and affordable energy prices: Options for immediate measures and preparing for next winter. Brussels, 23.3.2022 COM(2022) 138 final https://energy.ec.europa.eu/communication-security-supply-and-affordable-energy-prices_en
[15] Sandbu, M., 2022: The case for joint European energy procurement is irresistible. Financial Times. https://www.ft.com/content/c84f2482-4b6e-4257-a258-95642432f522?shareType=nongift

long-term LNG contracts are getting more expensive given the expectation that the market will stay tight for a number of years.

Global LNG demand is significantly outpacing supply. Given the size of the EU natural gas market and the imports of Russian gas to Europe, European interventions in this tight market have significant consequences for buyers and sellers. Specifically, the fossil gas purchases of EU Member States are leading to gas scarcity in developing countries that cannot afford the fossil gas anymore. This is creating blackouts in several countries (e.g. Pakistan) and driving some of them to use other energy sources, particularly coal.

Thus, international coordination is key and LNG consumers in developing countries to mitigate negative impacts of the EU gas procurement strategy on their energy security and their wellbeing. In addition, coordination of the fossil gas markets needs to be accompanied by initiatives to support the development of renewable energy and the improvement of energy efficiency in other countries outside the EU.

Europe will also need to support investments to add additional natural gas supply if it wants to diversify its fossil gas supply away from Russian gas. Support to investments will need to be attached to Monitoring, Reporting and Verification (MRV) of methane emission reductions (i.e. methane leakage), and commitments by the beneficiary to implement decarbonisation technologies such as CCS/CCU or replace natural gas with renewable gases, in order not to lock-in emissions.[16] A recent study by Davis *et al.* (2022) estimates that capturing flared, vented or leaked gas in North Africa, could bring Europe up to 23 bcm of natural gas via pipelines and LNG facilities.[17]

In order to diversify its gas imports, the EU is proposing long-term strategic relationships with several countries (including Egypt and Israel) that start with LNG and then move also into renewables, especially hydrogen.

In the long term, Europe can become an importer of renewable hydrogen. Increasing the demand for renewable hydrogen in the EU, however, will require, among others, refineries, steel production, fertilizer producers and other chemical industries to switch from natural gas to hydrogen. This requires substantial technology development and investments.

Renewable hydrogen trade will also require the development of international standards and certification schemes for renewable hydrogen. Certification can promote the consumption of renewable hydrogen. However, certification needs to be standardised at the international level. Consumers need trustworthy certification systems, which enable the traceability of the

[16] Tsafos, N., 2022: Europe needs a smarter way out of Russian gas. 28 March 2022. Euractiv. https://www.euractiv.com/section/energy/opinion/europe-needs-a-smarter-way-out-of-russian-gas/

[17] Davis, M., Toledano, P., Schorr, P., 2022: North Africa can reduce Europe's dependence on Russian gas by transporting wasted gas through existing infrastructure. Flareintel, 29 March 2022. https://flareintel.com/insights/north-africa-can-reduce-europes-dependence-on-russian-gas-by-transporting-wasted-gas-through-existing-infrastructure

origin of the hydrogen and avoid false and misleading claims about the share of renewable energy in the hydrogen they consume.[18],[19]

Moreover, supply chains need to be develop, from production to transport, storage and distribution. These supply chains include water supply for hydrogen production and supply of minerals for the production of the electrolysers and fuel cells, among others. Several countries, including Germany and Japan are already making investments.

Developing the supply chain also includes establishing training and development opportunities in hydrogen related areas, developing technologies for future commercialisation and the creation of innovative solutions and business models. [20]. National governments are starting to get involved in setting up international supply chains for hydrogen. More international cooperation is required to create hydrogen supply chains and associated trade routes.[21]

REPowerEU foresees the creation of a **Hydrogen Accelerator**. The hydrogen accelerator aims at increasing the production of renewable hydrogen both in the EU and worldwide to replace imported Russian gas. By 2030, approximately 10 million tonnes of hydrogen should be produced in the EU and another 10 million tonnes should be imported. The European Commission plans to develop the regulatory framework for a European market for hydrogen and support the development of an integrated gas and hydrogen infrastructure, hydrogen storage facilities and port infrastructure. New cross border infrastructure should be hydrogen compatible.

In addition, the Commission will support pilot projects on renewable hydrogen in the EU neighbourhood. The first project foreseen is a Mediterranean Green Hydrogen Partnership. The Commission plans Green Hydrogen Partnerships with other countries/regions as well as a Global European Hydrogen Facility together with the industry.

Today, LNG facilities are primarily used for the import of natural gas from third countries. In the future, they could act as facilitators for the import of renewable gases into the EU. Biomethane, hydrogen and methanol can in principle be liquefied and transported using LNG facilities provided some adaptations.[22] If biomethane or synthetic methane meets the gas

[18] IRENA Coalition for Action , 2022: Decarbonising end-use sectors: Green hydrogen certification, International Renewable Energy Agency, Abu Dhabi.

[19] Hydrogen Europe, 2021: H2ero Net Zero: different energy carriers require separate systems of Guarantees of Origin. July 2021. https://www.world-hydrogen-summit.com/wp-content/uploads/2022/02/hydrogen-europe-gos-paper.pdf

[20] HyTrEc2, 2018: Hydrogen Supply Chain Map for the North Sea Region. March, 2018. Interreg North Sea Region.

[21] IRENA (2021), Green hydrogen supply: A guide to policy making, International Renewable Energy Agency, Abu Dhabi.

[22] European Commission, 2021: COMMISSION STAFF WORKING DOCUMENT. IMPACT ASSESSMENT REPORT Accompanying the Proposal for a Directive of the European Parliament and of the Council on common rules for the internal markets in renewable and natural gases and in hydrogen (recast). Proposal for a Regulation of the European Parliament and of the Council on the internal markets for renewable and natural gases and for hydrogen (recast). SWD(2021) 455 final PART 1/2. Brussels, 15.12.2021

quality specifications, no changes are needed in LNG terminals. However, LNG infrastructure cannot be directly used for hydrogen due to chemical and physical differences with methane. Significant adaptations are necessary, which could make the costs prohibitive. Thus, new hydrogen transport infrastructure could be more cost effective.

Hydrogen can be converted into ammonia and methanol and LNG ships and terminals can be adapted to transport these energy carriers. The associated costs for liquefaction, transport, storage and regasification stages appear to be smaller. Modern LNG ships are typically ammonia-ready. Export and import LNG terminals could be repurposed for about 11% of the investment costs.[23]

On the import side, the infrastructure for hydrogen and LNG could share the same location. LNG import terminals in the EU could in principle be combined with entry points for (liquid) hydrogen or hydrogen derivatives. These terminals will serve to import hydrogen produced in other regions of the world where renewable energy is available at larger scale and lower cost than in the EU.[24]

Natural gas in Africa

Africa possesses reserves of natural gas. According to the BP statistical review of world energy (2021), Africa had proved reserves of natural gas of 12.9 trillion cubic meters in 2020. This figure may be revised upwards in view of recent discoveries in Mozambique, Tanzania and Senegal, among others. The total natural gas production in Africa is a very small fraction of the total proved natural gas reserves.

https://op.europa.eu/en/publication-detail/-/publication/23b8497d-5d8b-11ec-9c6c-01aa75ed71a1/language-en/format-PDF/source-search

[23] ENTEC, 2022: The role of renewable H_2 import & storage to scale up the EU deployment of renewable H_2. https://op.europa.eu/en/publication-detail/-/publication/7ab70e32-a5a0-11ec-83e1-01aa75ed71a1/language-en

[24] Bolter, R., 2020: German LNG Terminal and RWE to explore Hydrogen opportunities via Brunsbüttel. RWE. https://www.rwe.com/en/press/rwe-supply-and-trading/2020-06-18-german-lng-terminal-and-rwe-to-explore-hydrogen-opportunities-via-brunsbuettel

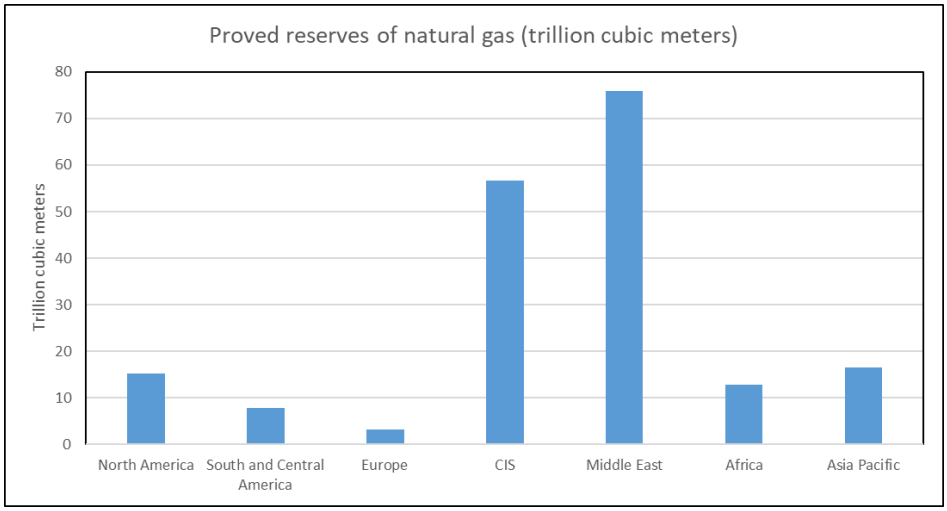

Figure 2: Proved reserves of natural gas (trillion cubic meters). Source: BP statistical review of world energy (2021).[25]

The biggest African natural gas resources lie in Sub-Saharan Africa. Nigeria has about 43% of the continent's proved reserves, and Tanzania. Senegal has recently discovered major offshore fields.

Table 1: Proved reserves and production of natural gas (trillion cubic meters) in African countries

Country	Proved reserves of natural gas (trillion cubic meters)	Production (trillion cubic meters)
Algeria	2.3	0.0815
Egypt	2.1	0.0585
Libya	1.4	0.0133
Nigeria	5.5	0.0494
Other Africa	1.6	0.0286
Total	12.9	0.2313

Source: BP statistical review of world energy (2021)

The figure below shows the electricity generation mix in Africa in 2020. Already today, natural gas is the largest and fastest-growing source of energy in Africa's power sector. Renewable energies, other than hydropower, account for a small fraction of the total electricity generation in the continent.

[25] BP (2021), Statistical Review of World Energy – 2021. ttps://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-natural-gas.pdf

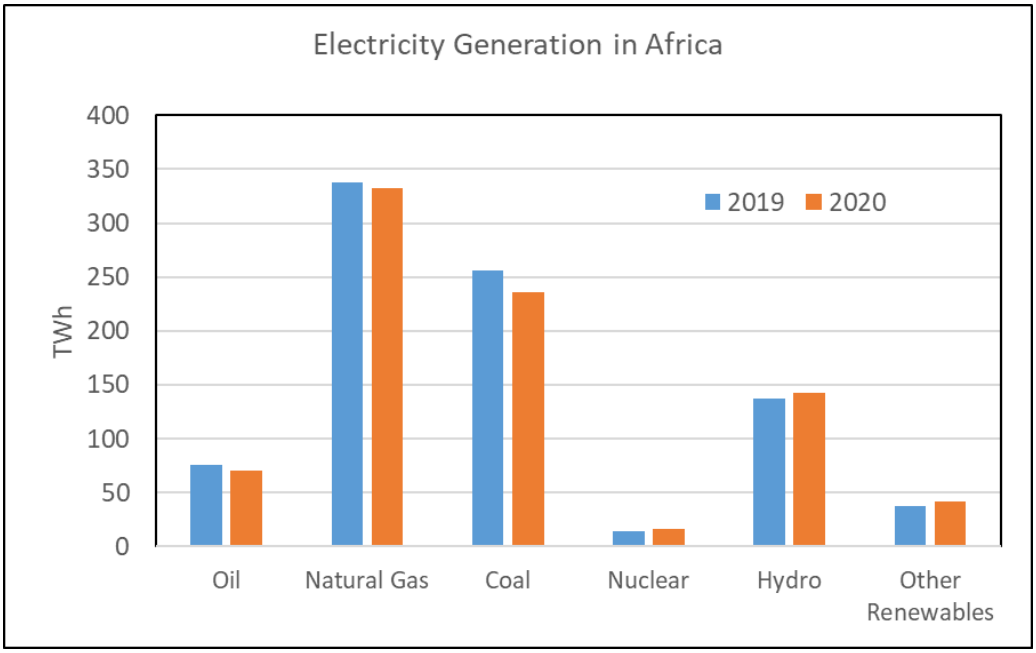

Figure 3: Electricity Generation in Africa in 2019 and 2020: Source: BP statistical review of world energy (2021).[26]

African countries want to exploit their fossil gas resources both for domestic consumption and for exports. They argue that the rest of the world does not have a right to tell Africa not to use those resources. However, infrastructure is poor and many gas fields have not been developed. African governments have been slow to act when gas production opportunities arise and securing financing has become difficult particularly due to climate change concerns of industrialised countries.

Industrialised countries have been arguing for a long time that Africa should not develop its fossil gas resources but rather leapfrog to a renewable energy-based economy. In view of the current energy and political crisis due to the war in Ukraine, a down-to-earth approach may be required to accelerate Africa´s development and improve energy security in Europe. Such an approach may require a combination of increased LNG exports from Africa to Europe while at the same time supporting the development of renewable electricity and renewable hydrogen in Africa. Renewable hydrogen could be used for Africa´s own domestic consumption as it industrialises and for hydrogen exports towards Europe in the long term.

On the domestic side, African countries are using natural gas in order to move away of coal and oil for power generation and for residential and industrial needs, among others. Natural gas is already the fastest-growing energy source in Africa's electricity generation, and increased at about 4.2% per year from 2011 to 2019. Several large countries, such as Egypt, Morocco, South Africa, Nigeria, Ghana and Ivory Coast are increasingly depending on gas for

[26] BP (2021), Statistical Review of World Energy – 2021. Africa's energy market in 2020. British Petroleum. https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-africa-insights.pdf

power production. African countries can also dedicate part of their fossil gas resources to exports, for instance towards Europe, generating revenues for Africa and helping Europe to reduce its reliance on Russian natural gas.[27]

According to a report released by the African Energy Chamber[28], Sub-Saharan Africa could boost its natural gas exports via pipeline and or LNG shipping by 2025/2030. However, gas-producing countries such as Mozambique, Nigeria, Niger and Tanzania require large investments to develop infrastructure that enables production and LNG exports to increase.[29] In addition, security considerations need to be factored in. For example, investments in Mozambique have been delayed as the country is impacted by insurgency. Moreover, the security of maritime trade routes needs to be ensured.

Pipeline infrastructure and LNG terminals will take years to build and cannot help the EU in the short term. Investments in fossil LNG would also compete with investments in renewable energy. It may be more useful to invest directly in renewable energy and, specifically, in renewable hydrogen production and infrastructure.

Besides issues of infrastructure development and security, methane leakage and other environmental impacts must be addressed if natural gas exports from Africa to the EU will be further developed. As part of the proposal for a methane regulation published in December 2021, the European Commission included a requirement on importers of fossil energy to the EU to provide Member States with information on measures related to measurement, reporting and mitigation of methane emissions undertaken by exporters.[30],[31]

For example, large methane plumes have been detected by satellite near oil and gas fields, processing facilities and pipelines in Algeria. A satellite monitoring system will have to be set up and/or enhanced. Binding rules on monitoring, reporting, verification, leak detection and repair must be implemented in new gas infrastructure developments in Africa. Governments will have to introduce policies to incentivise reduction of methane emissions, including onsite use of captured gas, expenditures in abatement technologies, or repair of transmission equipment.[32]

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[27] Ramachandran, V., 2022: Germany Should Look to Africa for Gas, Not Russia. Foreign Affairs. 11 March 2022 https://foreignpolicy.com/2022/03/11/germany-putin-russia-gas-energy-africa-development/

[28] African Energy Chamber (2022): The State of African Energy 2022. https://africa-energy-portal.org/reports/state-africa-energy-2022

[29] Omotori, V.,(2022): Infrastructure Rollout Will Enable Africa to Expand LNG Exports and Meet Global Demand. 17 March 2022. https://tdpelmedia.com/infrastructure-rollout-will-enable-africa-to-expand-lng-exports-and-meet-global-demand-2

[30] European Commission, 2021: Questions and Answers on reducing methane emissions in the energy sector. 15 December 2021. https://ec.europa.eu/commission/presscorner/detail/en/QANDA_21_6684

[31] European Commission, 2021: Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on methane emissions reduction in the energy sector and amending Regulation (EU) 2019/942. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2021%3A805%3AFIN&qid=1639665806476

[32] IEA, 2021: Driving Down Methane Leaks from the Oil and Gas Industry. International Energy Agency. August 2021. https://www.iea.org/reports/driving-down-methane-leaks-from-the-oil-and-gas-industry

Water scarcity in Africa can also be a significant issue, since natural gas and oil extraction as well as power generation using natural gas are dependent on water. If production takes place in water-stressed areas, the impacts can be significant. Moreover, if fracking is used to extract shale gas, significant local environmental and social impacts of fracking fluids (a mix of water and chemicals) can be expected.[33]

Selected exporting countries

Algeria

Algeria exports approximately 65 bcm of natural gas per year. There are currently three pipelines that connect Algeria to Europe, two of which are active, as shown in the table below.[34]

Table 2: Capacity of pipelines between Algeria and Italy and Algeria and Spain.

Pipeline	Destination	Nameplate capacity (bcm/year)	Current gas flow (bcm/year)	Possible additional capacity (bcm/year)
TransMed	Italy	32	22	9
MedGaz	Spain	8	8	2
Maghreb-Europe	Spain via Morocco	12	Closed in October 2021 after the transit agreement between Algeria and Morocco was not renewed	

Source: Fakir, I., 2022: Given capacity constraints, Algeria is no quick fix for Europe's Russian gas concerns. https://www.mei.edu/publications/given-capacity-constraints-algeria-no-quick-fix-europes-russian-gas-concerns

Platt Analytics estimated that Algeria could provide an additional 7 billion cubic meters of fossil gas to Europe in 2022, largely through higher shipments via spare pipeline capacity [35] However, Algeria upstream gas supply seems constrained and its domestic demand is increasing.

Still, Algeria has recently signed an agreement with Italy to gradually raise flows in the Transmed pipeline starting this year and reach additional 9 bcm/year by 2023-2024. Italy has

[33] Andrew J Kondash *et al* 2019 *Environ. Res. Lett.* 14 124028. https://iopscience.iop.org/article/10.1088/1748-9326/ab4d71

[34] Fakir, I., 2022: Given capacity constraints, Algeria is no quick fix for Europe's Russian gas concerns. https://www.mei.edu/publications/given-capacity-constraints-algeria-no-quick-fix-europes-russian-gas-concerns

[35] Platts Analytics, 2022: Website.

also stated its intention to work together with Algeria to develop renewable energy and renewable hydrogen.[36]

Using the spare capacity through Spain to supply other EU Member States would require the pipeline capacity between Spain and France to be increased. This capacity is currently limited to 20 Mcm/d. However, there appears to be opposition in France to the construction of new pipelines connecting Spain and France.

As for the Maghreb-Europe pipeline, Morocco has announced plans to use it in reverse flow to import natural gas from Spain, in order to guarantee its security of energy supply. Morocco´s plan would be to import gas from Spanish LNG operators. The LNG could come, for instance, from Qatar. However, it is uncertain whether this plan will materialise.[37] At the same time, Morocco has set targets for renewable electricity capacity to reach 70% by 2040 and 80% by 2050.

Angola

Angola is the second largest oil producing country in sub-Saharan Africa and an OPEC member and approx. 0.5 bcm of natural gas production. When not flared or reinjected into wells, the natural gas feeds the Angola LNG plant. The country hold about 0.3 trillion cubic meters of fossil gas reserves. Little investment in natural gas production has taken place in the last few years. In 2018, the Angolan government issued its first law enacted to regulate natural gas exploration, production, monetization and commercialization.[38] Among others, the law provides more attractive gas production and gas income taxes. Italy has recently signed an agreement to increase the gas production. Besides LNG, the agreement also includes renewables, biofuels, and training in the technological and environmental sectors.[39]

Egypt

Egypt was heavily dependent on natural gas importer until 2018. After the discovery of gas fields and reforms that led to significant foreign direct investments, Egypt became a gas

[36] Reuters, 2022: Italy clinches gas deal with Algeria to temper Russian reliance. April 11, 2022. https://www.reuters.com/business/energy/italy-signs-deal-with-algeria-increase-gas-imports-2022-04-11/

[37] North Africa Post, 2022: Moroccan energy minister confirms plan to reserve flow of Maghreb-Europe pipeline. February 3, 2022. https://northafricapost.com/55377-moroccan-energy-minister-confirms-plan-to-reserve-flow-of-maghreb-europe-pipeline.html#:~:text=Moroccan%20energy%20minister%20confirms%20plan%20to%20reserve%20flow%20of%20Maghreb%2DEurope%20pipeline,-Algeria%2C%20Energy%2C%20Europe&text=Moroccan%20energy%20minister%20Leila%20Benali,gas%20to%20Spain%20via%20Morocco.

[38] U.S. International Trade Administration, 2021: Angola country commercial guide: Oil and Gas. https://www.trade.gov/country-commercial-guides/angola-oil-and-gas

[39] Easu, I., 2022: Italy inks gas supply deals in Angola and Congo-Brazzaville. Upstream energy explored. https://www.upstreamonline.com/politics/italy-inks-gas-supply-deals-in-angola-and-congo-brazzaville/2-1-1204635

exporter.[40] Currently Egypt is exporting more LNG to Europe, rather than Asia. In the first quarter of 2022, main buyers were Turkey, Spain, South Korea, France, Thailand and Greece.

Libya

Libya has a vast amount of oil and gas reserves. However, its fossil fuel industry has been affected by political instability and conflict, including armed attacks on key pipelines and production facilities. Conflict substantially disrupted Libyan exports of oil and gas and LNG export terminals ceased to operate after the civil war in 2011. [41]

However, Libya still produces natural gas that is transported to Italy through the Green Stream pipeline. This natural gas pipeline crosses the Mediterranean Sea connecting the Libyan coast with Sicily. The natural gas pipeline has a capacity of around 8 billion cubic meters per year.[42]

Libya has also significant potential for renewable energy, in particular solar and wind energy. Recently, foreign investors have been investing in the development of solar power plants in Libya. Oil majors, for example, have started investments in both fossil fuels and renewable electricity. The country has, however, serious concerns about water scarcity and other impacts of climate change.

Mauritania and Senegal

The Greater Tortue Ahmeyin field is a cross-border offshore gas field between Senegal and Mauritania. It is the deepest offshore project in Africa until now. The LNG project is expected to produce up to 10 million tonnes of LNG a year (approx. 13.7 bcm/year). The governments of Mauritania and Senegal signed an inter-government co-operation agreement to develop the cross-border Greater Tortue Ahmeyim offshore gas field in February 2018. Production is scheduled to start in late 2023. Floating liquefaction plants above the offshore gas field will produce, liquefy, store, and transfer the gas to LNG tankers.[43]

Mozambique

Mozambique is pursuing the LNG Mozambique project together with TotalEnergies, the first onshore LNG development. The project started with the discovery of an offshore fossil gas reservoir in northern Mozambique in 2010. The project has a planned total production capacity of 13.1 million tonnes of LNG per annum. The initial plan was for the project to

[40] Espanol, M., 2022: Egypt breaks LNG export records with eye on Europe https://www.al-monitor.com/originals/2022/02/egypt-breaks-lng-export-records-eye-europe#ixzz7QKlL7p3Y
[41] S&P Global, 2021: Libya's upstream appeal re-emerging on low-cost, low-carbon credentials. https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/112321-libyas-upstream-appeal-re-emerging-on-low-cost-low-carbon-credentials
[42] ENI, 2022: Our work in Libya. https://www.eni.com/en-IT/eni-worldwide/africa/libya.html
[43] NS Energy, 2020: Greater Tortue Ahmeyim LNG Project. https://www.nsenergybusiness.com/projects/greater-tortue-ahmeyim-lng-project/#

produce the first LNG cargo in 2024 but the project is delayed due to insurgence upheavals in the country.[44] Full production is delayed to at least 2026, if the project is completed.

Italy has expressed its interest in sourcing LNG from Mozambique and Libya, among others.

Nigeria

Nigeria has a plan to supply natural gas to Europe. Nigeria's gas project involves an agreement with Algeria and Niger to construct a 4,000 km long Trans-Saharan Gas Pipeline (NIGAL) that would bring gas to Algeria via Niger and could transport up to 30 billion cubic meters/year fossil gas to Europe.[45] The new pipeline would connect to the existing Trans-Mediterranean, Medgaz, and Galsi pipelines that supply Europe from transmission hubs on Algeria's Mediterranean coast.

However, Nigeria itself has a domestic energy crisis and may require this fossil gas to meet domestic demand. Nigeria will also need to substantially increase its renewable energy capacities. In addition, there are substantial security risks associated with the NIGAL pipeline.

Tanzania

Tanzania has significant offshore reserves of natural gas (more than 1 trillion cubic meters). The government of Tanzania in cooperation with oil and gas majors (Shell, Equinor and ExxonMobil) is advancing projects to develop LNG export terminals but the Final Investment Decision (FID) has not been made yet. [46]

LNG import terminals in Africa

So far, there are no imports of LNG in Sub-Saharan Africa. Ghana is building a $350 million Liquefied Natural Gas (LNG)-power terminal to import LNG. The terminal is expected to deliver 2.34 bcm/yr to meet Ghanaian gas needs mainly in the electricity generation sector. This reliance on LNG is likely to increase fuel price risks for Ghana and will not solve the current problem of unaffordable power generation contracts.[47] In addition to Ghana, other African countries have plans to build LNG terminals. This may exacerbate their dependence on volatile and very tight LNG markets. Alternatively, these African countries could start developing their renewable energy potentials. Renewable energy would help mitigate their risk exposure to high LNG prices. Current LNG price and future prices expected in a tight global LNG market re making renewables an attractive investment.

[44] TotalEnergies, 2022: Mozambique LNG. https://mzlng.totalenergies.co.mz/en
[45] Fátúnmbí, D., 2022: https://twitter.com/davidfatunmbi/status/1507025861492494339
[46] Reuters, 2022: Shell says Tanzania LNG project is making good progress. https://www.reuters.com/business/energy/shell-says-tanzania-lng-project-is-making-good-progress-2022-02-21/
[47] Nicolas, S., 2021: IEEFA Ghana: Reliance on LNG means increased fuel price risk and further unaffordable generation contracts. https://ieefa.org/ieefa-ghana-reliance-on-lng-means-increased-fuel-price-risk-and-further-unaffordable-generation-contracts/

Cooperation on natural gas between Africa and Europe

Cooperation opportunities between African and European countries for natural gas exports towards Europe could in principle be further developed. However, this will require Europe to make substantial investments in natural gas production, pipelines and LNG infrastructure. Investments that could be made in renewable energy instead. In this context, security considerations need to be addressed (safe maritime routes, security partnerships).

In addition, environmental impacts including methane leakage, hydrogen leakage and CO_2 emissions must be thoroughly addressed. Investments should be attached to certain conditions, including monitoring, reporting and verification of methane and CO_2 emission reductions. Financial institutions need to evaluate projects based on full life-cycle emissions.[48] Financing must also be linked to the highest social and environmental standards.

Cooperation requires development of trade relationships, substantial investments, opening of markets and recognition of African countries as equal partners. Cooperation that starts with fossil LNG will have to provide perspectives for a shift towards renewable energies in the medium and long term, including hydrogen and include initiatives to improve energy efficiency of the gas production and transport and reduce methane leakage.

Cooperation initiatives cannot be based only on fossil fuels but they also have to integrate renewable energy and energy efficiency in the partner countries. This requires know-how transfer to partner countries, financial mechanisms, support to develop the private sector and to empower local communities, among others.

Renewable energy in Africa

Africa needs to accelerate the growth of renewable energy sources. At the end of 2021, Africa had about 56 GW of renewable installed capacity and accounts for about 2% of the global installed renewable electricity generation capacity.[49] [50] Only 20 % of the total installed electricity generation capacity in Africa in 2019 was based on renewable sources (IRENA, 2020b). Hydropower still accounts for the largest share of installed renewable energy capacity in Africa (approx. 67 %).[51]

[48] NRDC, 2020: SAILING TO NOWHERE: LIQUEFIED NATURAL GAS IS NOT AN EFFECTIVE CLIMATE STRATEGY. Natural Resources Defence Council. https://www.nrdc.org/sites/default/files/sailing-nowhere-liquefied-natural-gas-report.pdf

[49] IRENA, 2022: Renewable Capacity Statistics 2022. April 2022. https://www.irena.org/publications/2022/Apr/Renewable-Capacity-Statistics-2022

[50] IRENA and AfDB (2022), Renewable Energy Market Analysis: Africa and Its Regions, International Renewable Energy Agency and African Development Bank, Abu Dhabi and Abidjan. https://irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jan/IRENA_Market_Africa_2022.pdf?la=en&hash=BC8DEB8130CF9CC1C28FFE87ECBA519B32076013

[51] KfW, GIZ and IRENA, 2021: The Renewable Enery Transition in Africa. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/March/Renewable_Energy_Transition_Africa_2021.pdf

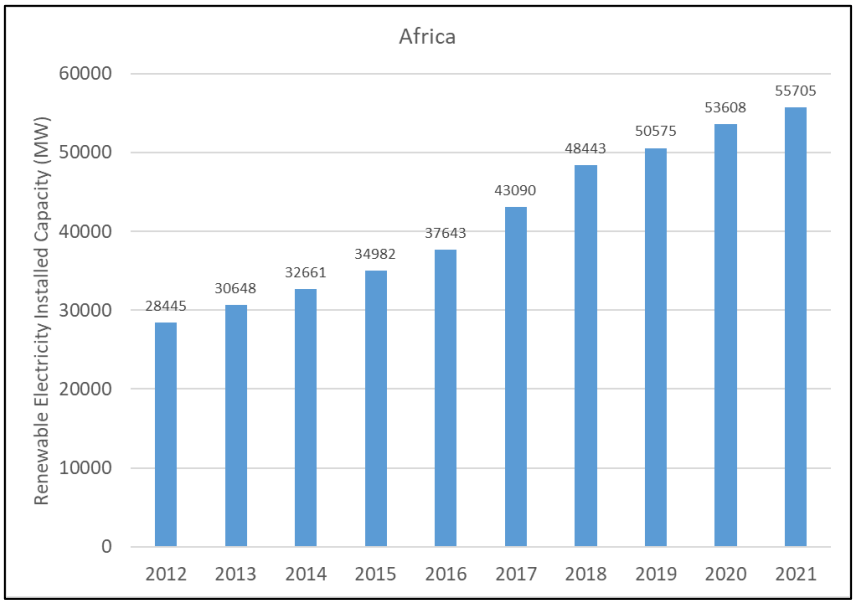

Figure 4: Renewable electricity installed capacity in Africa (MW). Source: IRENA, 2022: Renewable Capacity Statistics 2022. April 2022. https://www.irena.org/publications/2022/Apr/Renewable-Capacity-Statistics-2022

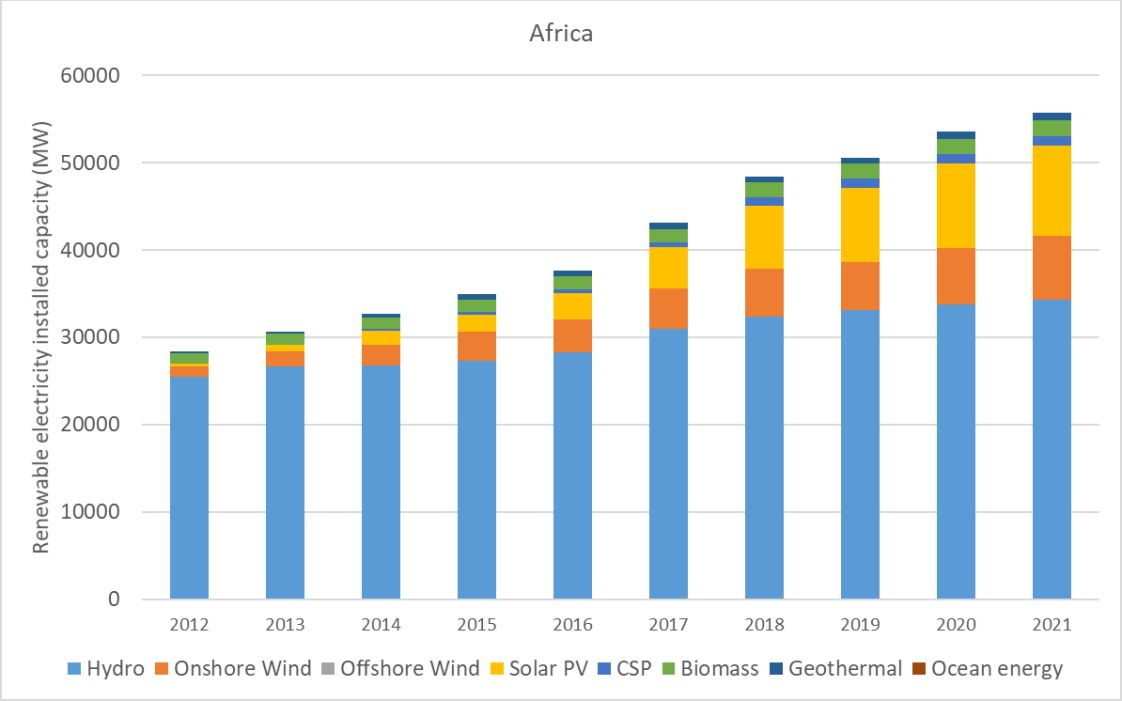

Figure 5: Renewable electricity installed capacity by technology in Africa (MW). Source: IRENA, 2022: Renewable Capacity Statistics 2022. April 2022. https://www.irena.org/publications/2022/Apr/Renewable-Capacity-Statistics-2022

Increasing renewable energy capacities is important for Africa to achieve development goals and move towards a clean and sustainable energy system. In the long term, countries with large renewable energy potentials could attract energy-intensive industries and become green industrialisation hubs. Increasing the renewable energy capacities in Africa may also open opportunities for exports towards Europe.

Africa is endowed with substantial renewable energy resources. Indigenous renewable energy solutions can help Africa to develop and improve security of energy supply. According to IRENA (2020), Africa as a whole could cover approximately 25% of its energy needs through indigenous renewable energy by 2030.[52]

The development of renewable energy sources is essential to achieve the objectives of the African Union Agenda 2063.[53] The pan-African policy of the Africa Union Commission (AUC) recognises the role of an Africa-centred implementation of the energy transition. The Africa Energy Transition Programme led by the Africa Energy Commission (AFREC) recognises the role of renewable energy sources.

Renewable electricity potentials for selected technologies

Selected renewable energy potentials in different African regions are presented in the table below. For comparison, the world´s electricity final consumption was approx. 22,848 TWh in 2019.

Table 3: Selected renewable energy potentials in different African regions

Region	Concentrated Solar Power	Solar PV	Wind (areas with wind turbine capacity factor greater than 30%)
Units	TWh/year	TWh/year	TWh/year
Central Africa	29 909	61 643	1 567.7
Eastern Africa	175 777	219 481	30 860.0
Northern Africa (Western Sahara)	93 544	109 033	22 500.9
Southern Africa	149 610	162 817	10 011.1
Western Africa	22 747	103 754	1 692.2
Total	471 587	656 728	66 631.9

Source: IRENA (2014): Estimating the Renewable Energy Potential in Africa. https://www.irena.org/publications/2014/Aug/Estimating-the-Renewable-Energy-Potential-in-Africa-A-GIS-based-approach

The IEA estimates that electricity demand in Africa in 2019 was about 700 TWh and that in 2040 it can range from 1600 to 2300 TWh.[54] By dynamically increasing the capacity of renewable electricity plants, Africa´s domestic demand for electricity can be met in the long term without electricity supply being too exposed to the risks posed by volatile fossil fuel

[52] IRENA, 2020: SCALING UP RENEWABLE ENERGY DEPLOYMENT IN AFRICA. DETAILED OVERVIEW OF IRENA'S ENGAGEMENT AND IMPACT. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Feb/IRENA_Africa_Impact_Report_2020.pdf?la=en&hash=B1AD828DFD77D6430B93185EC90A0D1B72D452CC

[53] African Union, 2019: Agenda 2063: The Africa We Want. https://au.int/agenda2063/overview

[54] IEA (2019) Africa Energy Outlook 2019. World Energy Outlook Special Report.

markets. In addition, additional RES electricity capacity can be built to produce renewable hydrogen that can be exported to Europe.

For example, the total wind power installed capacity in Africa was about 6,500 MW in 2020 (and about 7,300 MW in 2021). The potential for electricity generation from wind is, however, much larger (more than 66 631.9 TWh). By working together, Africa and the European Union can help increase the contribution of wind energy in the continent and generate opportunities for green hydrogen exports. This requires substantial cooperation on policy and regulatory frameworks, private sector development, R&D and training of a skilled workforce, among others. It also requires suitable financial and de-risking instruments.

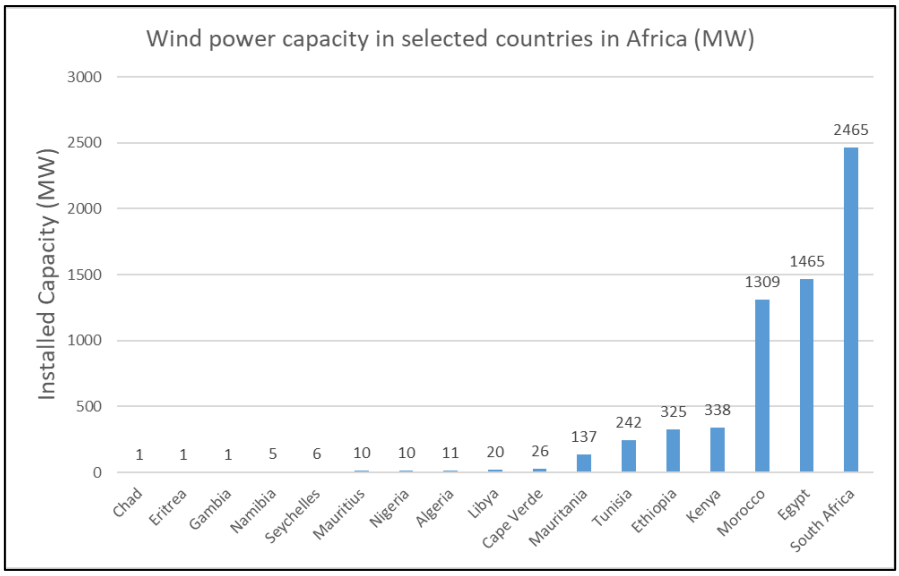

Figure 6: Wind power installed capacity in selected countries in Africa (MW) in 2020. Source: Africa-EU Energy Partnership's (AEEP) Policy Brief Wind Energy: Joining Forces for an African Lift-Off. https://africa-eu-energy-partnership.org/publications/wind-energy-joining-forces-for-an-african-lift-off

The African Solar Industry Association (AFSIA) has estimated the total solar capacity in Africa by the end of 2021 at 8.7 GWp. New capacity additions amounted to approximately 721 MWp in 2021.[55],[56] Installed capacity is not growing at a sufficient pace, despite the large solar potential across the continent. At the end of 2021, Africa had only 1.3% of the global solar PV installed capacity.

Geothermal potential is estimated at about 15,000 MW in East Rift System Countries in East Africa. Currently, only approx. 900 MW of installed geothermal electricity capacity exists in the region, with power plants in Ethiopia and Kenya. Other countries are either at the

[55] African Solar Industry Association, 2021: Annual Solar Outlook 2022. http://afsiasolar.com/wp-content/uploads/2022/02/AFSIA-Annual-Outlook-Report-2022-final.pdf

[56] It should be noticed that it is not possible to track all installed capacity for residential use and some projects (large-scale, commercial and industrial, mini-grid) are not recorded in AFSIA´s database.

surface exploration stage or exploration drilling stage. The geothermal potential is other regions of Africa is still unknown.[57]

Challenges in the African electricity sector

The electricity sector in Africa still faces large challenges. These challenges include:

- Low electricity access rates (The share of Africans with access to electricity in their homes increased to 54 percent in 2018 (IEA, 2019c). But, substantial efforts are needed to grant access to electricity to the remaining population in the continent.
- very low reliability,
- low capacity reserve margins,
- high transmission and distribution system losses,
- high operating costs and financially unsustainable grid operators and electricity suppliers,
- insufficient security of supply

Renewable electricity can help overcoming these challenges. A number of measures are required to increase the share of renewable electricity. These include:

- Adaptation to regulatory and legal frameworks to facilitate private investment in renewable energy and provide incentives to utilities and other actors to expand access.
- The capacity of the grid to integrate renewables has to increase
- Capacity building for key planning institutions is necessary
- Financial instruments that provide patient capital, equity and help de-risking projects should be expanded
- The development of innovative business models needs to be supported
- Development of local value chains
- A skilled workforce must be trained
- support common technical standards at regional and continental levels for RES
- Improvement of resource data for renewables, planning and zoning (RES development zones and restricted areas)

To develop renewable energy projects in Africa, it is key to support project development activities from the early stages to maturity and increase the number of bankable projects. For projects in early stages, it is necessary to provide patient capital. For more advanced projects, accessing sufficient equity is a challenge.[58]

It is also necessary to mitigate financial risks for private investors by providing partial risk guarantees, and increase the role for financial instruments such as blended debt and grants

[57] IRENA (2015), Africa 2030: Roadmap for a Renewable Energy Future. IRENA, Abu Dhabi. www.irena.org/remap

[58] GET.Invest, 2022: https://www.get-invest.eu/

to decrease risk.[59] By building stable policy and regulatory frameworks, developing a pipeline of viable projects and offering targeted de-risking instruments, African governments and their development partners, including the European Commission, can facilitate the private sector investments necessary to bridge this gap.

Renewable hydrogen

Hydrogen is an energy vector that can be produced from fossil or renewable energy sources. For example, so-called green hydrogen can be produced via electrolysis, by using renewable electricity to split water into hydrogen and oxygen. Electrolysis is a mature and commercialized technology but cost reductions are still necessary and possible. The hydrogen produced is gaseous and can be liquefied, compressed (CGH2) or converted to other energy carriers (ammonia, synthetic methane, methanol, power-to-liquids, Liquefied Organic Hydrogen Carriers) before being transported. Liquid hydrogen derivatives appear cheaper to store and transport than hydrogen.

Until now, hydrogen use has been limited to industrial applications and the capacity to scale up production is well below current expectations, due to current costs and available production pathways. Significant efforts are being made by a number of governments and companies to scale up the penetration of hydrogen as a replacement fuel in the long term.[60]

Renewable hydrogen could play a role in the energy and industrial transformation in selected sectors such as industry (e.g. steel, fertilizers and chemicals), refineries, heavy-duty transport and storage of renewable electricity.

The European Commission hydrogen strategy published in 2020 foresees installing at least 40 GW of renewable hydrogen electrolysers and the production of up to 10 million tonnes of renewable hydrogen in the EU.[61] REpowerEU, the plan of the European Commission to make the EU independent of Russian fossil fuels, aims at adding 10 million tonnes of imported renewable hydrogen for a total of 20 million tonnes. This would require an electrolyser capacity between 250-400 GW.

However, it is not clear whether the EU will be able to produce 10 million tonnes of renewable hydrogen by 2030. Although the EU will increase its own hydrogen production in the future, the demand is likely to exceed production, leading to a further increase in imports. This

[59] Obonyo, R., 2021: Push for renewables: How Africa is building a different energy pathway. https://www.un.org/africarenewal/magazine/january-2021/push-renewables-how-africa-building-different-energy-pathway

[60] Yergin, D., The New Map. Energy, climate and the clash of nations. ISBN 9781594206436.

[61] European Commission, 2020: COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A hydrogen strategy for a climate-neutral Europe. 2020: Brussels, 8.7.2020. COM(2020) 301 final. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52020DC0301&from=EN

requires addressing the availability and affordability of renewable electricity and renewable hydrogen in other world regions.[62],[63]

Realising the potential of renewable hydrogen in different world regions could limit the risk of export concentration, leading to a more balanced system, which a single actor/country cannot influence or control. This would help changing the geopolitics of international energy trade.

In order to realise their potential, many countries will need technology transfer, infrastructure development and investment at scale. Hydrogen trade relations between buying and selling countries would contribute to develop local hydrogen value chains, stimulate green industrial development and create jobs in the producing countries.

Intergovernmental agreements and strategic partnerships can foster international hydrogen trade. Bilateral agreements will most likely govern the early stages of development of the international green hydrogen market. The removal of trade barriers and common robust certification systems with countries from outside the EU will play a crucial role in enabling cross-border trade of hydrogen and the development of a global hydrogen economy at a later stage.

The ability to produce large volumes of low-cost green hydrogen varies across world regions. IRENA has developed estimates of the technical potential for producing hydrogen under USD 1.5/kg by 2050. These estimates are depicted in the figure below. Sub-Saharan Africa is the region with the largest potential followed by the MENA region.[64]

[62] World Energy Council, 2021: Decarbonised hydrogen imports into the European Union: challenges and opportunities. October, 2021. https://www.weltenergierat.de/wp-content/uploads/2021/10/WEC-Europe_Hydrogen-Import-Study.pdf

[63] Breitschopf, B., 2022: The role of renewable H_2 import & storage to scale up the EU deployment of renewable H_2. Energy Transition Expertise Centre (ENTEC). https://op.europa.eu/en/publication-detail/-/publication/7ab70e32-a5a0-11ec-83e1-01aa75ed71a1/language-en

[64] IRENA (2022), Geopolitics of the Energy Transformation: The Hydrogen Factor, International Renewable Energy Agency, Abu Dhabi.

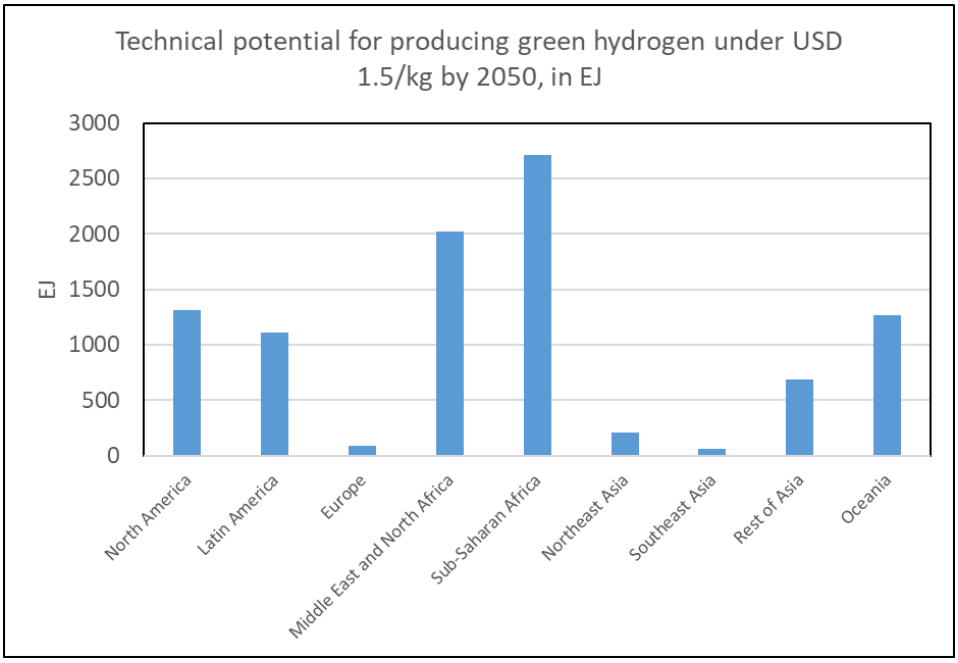

Figure 7: Estimates of technical potential for producing green hydrogen under USD 1.5/kg by 2050, in EJ. Source: IRENA (2022), Geopolitics of the Energy Transformation: The Hydrogen Factor, International Renewable Energy Agency, Abu Dhabi.

Another study examined the potential for production of gaseous hydrogen in some North African countries. This study identified the largest potentials in Morocco, Algeria, Tunisia and Egypt. North Africa is one of the regions identified by the EU hydrogen strategy as a potential exporting region towards the EU.[65],[66]

Table 4: Hydrogen potential of some North African countries. Source: Fraunhofer, 2022: IEE PtX Atlas. https://maps.iee.fraunhofer.de/ptx-atlas/

	Exajoules	TWh
Morocco	2.1	586
Algeria	2.3	649
Tunisia	1.4	385
Egypt	17	4720

Hydrogen could be, in principle, imported from North Africa to Europe via pipeline. However, it is unclear whether existing natural gas pipelines can be repurposed to transport compressed gaseous hydrogen (CGH2) or a new hydrogen pipeline infrastructure would be required. Hydrogen leakage rates are likely to be higher than for natural gas due to the small molecule size of hydrogen. Hydrogen would much more easily leak from existing natural-gas

[65] ENTEC, 2022: The role of renewable H_2 import & storage to scale up the EU deployment of renewable H_2. https://op.europa.eu/en/publication-detail/-/publication/7ab70e32-a5a0-11ec-83e1-01aa75ed71a1/language-en

[66] Fraunhofer, 2022: IEE PtX Atlas. https://maps.iee.fraunhofer.de/ptx-atlas/

pipelines, particularly if they are made from iron, rather than polyethylene or copper.[67] Leakage needs to be minimized due to safety concerns and its impact as a greenhouse gas through the interaction with other GHGs such as methane.

Cooperation between Africa and the European Union on renewable hydrogen

The European Commission has set cooperation with the African Union as one of its priorities under the EU Green Deal. Africa and the EU already have a longstanding cooperation on energy. Within the Africa-Europe Green Energy Initiative, the EU aims at supporting Africa to increase the share of renewable energy in Africa, increase access to affordable, reliable and sustainable energy and improve energy efficiency.[68]

The EU will support the development of the Continental Power System Masterplan for the infrastructure connecting the five African power pools. The initiative also includes an investment package including funding for electricity interconnections and transmission lines, as well as technical assistance for setting up the Africa Single Electricity Market.

Energy Transition Partnerships will be co-developed with a number of African countries. The initiative aims at providing a support package to partner countries that endorse enhanced climate objectives and new robust commitments to decarbonise their energy mix.

The Africa-Europe Green Energy Initiative also foresees the promotion of cooperation on clean hydrogen. Activities can encompass: [69]

- research and innovation
- regulatory policy
- direct investments and
- undistorted and fair trade in hydrogen, its derivatives, and the associated technologies and services

The African Union can become a cooperation partner on these areas of cooperation on renewable hydrogen.

EU interest in importing hydrogen from Africa is driven by the assumption that member states will require significant quantities of renewable hydrogen for hard-to-decarbonise sectors and imported renewable hydrogen may be more competitive and more abundant

[67] Collings, L., 2022: Hydrogen 'twice as powerful a greenhouse gas as previously thought': UK government study. Recharge News. https://www.rechargenews.com/energy-transition/hydrogen-twice-as-powerful-a-greenhouse-gas-as-previously-thought-uk-government-study/2-1-1200115

[68] African Union, 2021: A New Phase in Africa-EU Energy Collaboration: The Africa-EU Green Energy Initiative. 27.07.2021. https://africa-eu-energy-partnership.org/gei/

[69] European Commission, 2022: EU-Africa: Global Gateway. Investment Package - Green Energy Initiative. https://ec.europa.eu/commission/presscorner/detail/en/fs_22_1120

than domestically produced.[70] The level of EU imports of hydrogen will depend on demand, domestic EU hydrogen production, costs and availability of transport infrastructure. The two continents can explore a mutually beneficial hydrogen trade relation in the long term. [71] However, at the same time, Africa need to develop its renewable energy resources for domestic consumption to support its economic development and will require support from Europe for this purpose.

According to Nuñez-Jimenez and De Blasio (2022), the development of a long-distance hydrogen imports strategy from Africa to the EU will require the following measures, among others:[72]

- Policies to support renewable energy sources in Africa
- Support to research, innovation and pilot projects
- Long-term contracts and long-term investments in renewable hydrogen production capacity in Africa and enabling infrastructure both in Africa and the EU to help reduce market risk for producers
- International standards for renewable hydrogen production, transportation, and use.
- International certification of renewable hydrogen
- Reduction of market risks and removal of commercialisation barriers to renewable hydrogen use in the EU

The production and trade of renewable hydrogen could become a significant opportunity for economic and social benefits for Africa. However, it needs to be based on a fair trade system and support to the development of production capacity and enabling infrastructure in both Africa and the EU. The development of an intercontinental hydrogen market will depend on technology, infrastructure, environment, finance, global markets, and geopolitics.[73]

One important aspect to facilitate international hydrogen trade is the enhancement of the African Continental Free Trade Area (AfCFTA). The AfCFTA aims at creating a single market

[70] Moro, E., 2022: A hydrogen strategy for a balanced EU-Africa partnership. https://www.euractiv.com/section/energy-environment/opinion/a-hydrogen-strategy-for-a-balanced-eu-africa-partnership/

[71] Ravikumar Bhagwat, S., Olczak., M., 2020: Green Hydrogen bridging the Energy Transition in Africa and Europe. European University Institute, Robert Schumann Centre for advance studies. Florence School of Regulation. https://africa-eu-energy-partnership.org/publications/green-hydrogen-bridging-the-energy-transition-in-africa-europe/#:~:text=Green%20Hydrogen%3A%20Bridging%20the%20Energy%20Transition%20in%20Africa%20%26%20Europe,-Knowledge%20Facilitation%20Thriving&text=Green%20%E2%80%93%20and%20thus%20clean%20and,completely%20decarbonise%20our%20energy%20system.

[72] Nunez-Jimenez, A., De Blasio, N., 2022: The Future of Renewable Hydrogen in the European Union: Market and Geopolitical Implications. March 2022. Belfer Center for Science and International Affairs, Harvard Kennedy School. https://www.belfercenter.org/publication/future-renewable-hydrogen-european-union-market-and-geopolitical-implications-0

[73] De Blasio, N., Pflugmann, F., 2020: Geopolitical and Market Implications of Renewable Hydrogen: New Dependencies in a Low-Carbon Energy World. https://www.belfercenter.org/publication/geopolitical-and-market-implications-renewable-hydrogen-new-dependencies-low-carbon

for goods, services, facilitated by movement of persons in order to deepen the economic integration of the African continent in accordance the Agenda 2063. It also aims at promoting industrial development through diversification and regional value chain development. Improving the AfCFTA to facilitate trade in goods and services in the region would help promote renewable hydrogen production and trade in Africa.[74]

In parallel, a green industrialisation strategy for Africa should be pursued by the African Union and supported by the European Union. Green industrialisation would help Africa diversify away from exports of raw materials. Africa needs the support of the EU to implement such a strategy. Both sides could use synergies and reap the benefits.

The African Hydrogen Partnership Trade Association (AHP)
The AHP is an African umbrella association dedicated to the development of green and blue hydrogen, hydrogen based chemicals, fuel cell technology and related business opportunities in Africa.[75] The AHP facilitates the collaboration between governments, industry, technology and financial institutions and large end consumers of hydrogen

Renewable hydrogen can also be used as a feedstock and fuel by African industry to produce green products with higher value-added than raw materials, which currently account for about 49% of exports from Africa to the EU. Green products such as green steel, green fertilizers and less carbon-intensive cement for domestic consumption or exports to the European Union would diversify Africa´s export strategy towards green industrial products with more value added. This would help African countries profit from exports revenues and improve their balance of trade with the EU while avoiding some negative impacts of the EU Carbon Border Adjustment Mechanism (CBAM).[76] With today´s product portfolio, CBAM could affect several African countries. For example, Egypt and Algeria are large exporters of fertilizer, and Algeria is the EU's fifth largest cement exporter. If these countries were able to develop less carbon-intensive products such as fertilizers, cement and steel using renewable hydrogen, the impacts of CBAM in their balance of trade with the EU would lessen. [77]

[74] African Peer Review Mechanism, 2022: A Study on the opportunities on the AfCFTA for Women in the informal cross-border trade. https://au.int/sites/default/files/documents/41579-doc-STUDY_ON_OPPORTUNITIES_IN_THE_AFCFTA_FOR_WOMEN_IN_INFORMAL_AND_CROSS-BORDER_TRADE.pdf
[75] https://www.afr-h2-p.com/about
[76] "The CBAM system will work as follows: EU importers will buy carbon certificates corresponding to the carbon price that would have been paid, had the goods been produced under the EU's carbon pricing rules. Conversely, once a non-EU producer can show that they have already paid a price for the carbon used in the production of the imported goods in a third country, the corresponding cost can be fully deducted for the EU importer. The CBAM will help reduce the risk of carbon leakage by encouraging producers in non-EU countries to green their production processes."
https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3661
[77] Pleeck, S., Denton, F., Mitchell, I., 2022: An EU Tax on African Carbon – Assessing the Impact and Ways Forward. Blog. Center for Global Development. February 10, 2022. https://www.cgdev.org/blog/eu-tax-african-carbon-assessing-impact-and-ways-forward

Opportunites
Intercontinental renewable hydrogen trade between Africa and Europe
Renewable hydrogen use for domestic industry in Africa. Green products such as green steel, green fertilizer and green ammonia could be used for domestic purposes or exported to the EU
Development of the significant renewable electricity potentials in Africa
Broadening of the Partnership between Africa and Europe towards energy, trade, technology, security and climate policy issues
Training of a skilled African workforce
Cooperation on R&D with African universities and other research institutions
Cooperation between European and African companies
Development of ports, maritime trade and other infrastructure
Use of revenues from renewable hydrogen trade to advance economic development and energy access in Africa
Contribution to the security of energy supply of the EU

Several factors have to be considered as part of strategies to produce renewable hydrogen in Africa. Economics is a key driver. With the significant renewable energy potentials available in Africa, the continent is well positioned to produce cost-competitive renewable hydrogen in the medium term. It can also produce fertilizers cost-effectively given the fact that the price of grey fertilizer has already increased substantially due to the increase in natural gas prices. Other products that use hydrogen as a feedstock can also be produced in Africa in the future and used domestically or exported, helping to move Africa from raw materials exports towards higher value added products.

Regarding logistics, Africa is strategically located, giving it access to large markets and important maritime shipping routes. Africa has port network encompassing more than 100 ports. About 50 of them can handle containers and cargo. Maritime transport remains the main gateway of Africa to the global marketplace and Africa's international trade relies heavily on shipping and ports. However, African ports would have to be modernised to handle larger vessels and improve their access to containers and a better integration into global manufacturing and trading networks is necessary.

Besides economic and logistic factors, such as the availability of ports and hydrogen export terminals, the availability of water and land play an important role. Water is an essential resource for the production of renewable hydrogen via electrolysis and for every litre of water one cubic metre of hydrogen can be produced. However, water is not sufficiently available in several regions of Africa. A careful balance of water needs and sound energy-water-nexus strategies. [78] Water for electrolysis should not be diverted from communities,

[78] Ravikumar Bhagwat, S., Olczak, M., 2020: Green Hydrogen bridging the Energy Transition in Africa and Europe. European University Institute, Robert Schumann Centre for advance studies. Florence School of Regulation. https://africa-eu-energy-partnership.org/publications/green-hydrogen-bridging-the-energy-transition-in-africa-europe/#:~:text=Green%20Hydrogen%3A%20Bridging%20the%20Energy%20Transition%20in%20Africa%20%26%20Europe,-Knowledge%20Facilitation%20Thriving&text=Green%20%E2%80%93%20and%20thus%20clean%20and,completely%20decarbonise%20our%20energy%20system.

agriculture or regions of high environmental value. Thus, the production of hydrogen may require in many cases the installation of desalination plants. Oversizing desalination plants for electrolysers to be able to cover the water needs of nearby communities could help obtain a "social license to operate". As for land availability, it is important to consider competing needs such as food production and renewable electricity production for domestic use in African countries as well as environmental restrictions.

In addition, leakage of hydrogen into the atmosphere during production, storage, distribution and use has to be minimized to avoid negative impacts of hydrogen released into the atmosphere, specifically regarding its potential GHG effects and fire hazards. Hydrogen leakage rates are likely to be higher than for natural gas due to the small molecule size of hydrogen.[79] This means that existing gas pipeline infrastructure may not be able to handle hydrogen flows without considerable and expensive adaptations. The deployment of a new hydrogen pipeline infrastructure may be required. It also means that hydrogen production and storage facilities as well as export terminals will have to be designed and maintained to minimize leakage.

Another aspect concerns the availability of a qualified workforce in Africa. African institutions need to train technicians, engineers, logistic experts and other staff to be able to produce renewable electricity and renewable hydrogen and transport hydrogen. At the same time, research and development activities in African universities and other research institutions should be encouraged. Here, partnerships with European universities and companies would be useful.

Challenges
Ownership of the renewable hydrogen agenda in Africa
Lack of technological capacity in African countries
Undeveloped infrastructure (ports, pipelines, roads) to facilitate trade and exports
Insufficient industrial and value chain development in Africa
High costs of renewable hydrogen
Lack of skilled workforce in Africa
Low access rates to electricity
Structural problems in the African electricity sector
Water availability (desalination may be required) and competing land uses
Technical challenges to transport hydrogen or hydrogen derivatives (e.g. ammonia, methanol, Liquefied Organic Hydrogen Carriers)
Safety risks
Political instability
Risk of potential "green colonialism"
Lack of policy and investment frameworks

[79] Warwick, N., et al., 2022: Atmospheric implications of increased Hydrogen use. University of Cambridge and NCAS, University of Reading.
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1067144/atmospheric-implications-of-increased-hydrogen-use.pdf

Current renewable hydrogen projects in Africa

Today, there are several green hydrogen projects in Africa. Among others:

- Egypt renewable hydrogen project
- Mauritania Nour and Aman.
- South Africa´s hydrogen valley[80]
- Namibia SCDI Green hydrogen project
- Morocco´s HEVO Ammonia project

Egypt renewable hydrogen projects[81], [82]

Egypt is building a renewable hydrogen project based on wind and solar electricity through a 100 MW electrolyser. The project aims to use this green hydrogen as feedstock for green ammonia production, which will be produced at an existing ammonia plant in Ain Sokhna on the Gulf of Suez.

Egypt has also signed agreements with German, Belgian, and Italian companies in 2021 to set up additional renewable hydrogen projects in the country, using electrolysers with a capacity of 100 MW each

Nour and Aman projects in Mauritania[83]

The government of Mauritania together with a private company is conducting feasibility studies for two renewable hydrogen projects in Aman and Nour. The Nour project is expected to have a capacity of 10 GW. The Aman project could have a capacity of up to 30 GW. The feasibility study is evaluating the wind and solar resources in these regions.

[80] There are other projects in South Africa such as the Boegoebaai green hydrogen project, which Sasol is assessing as part of its new strategy and the Prieska Power Reserve that plans to start producing green hydrogen and ammonia in 2025.
[81] Goodrich, G., 2022: Top 5 Hydrogen Projects in Africa. Energy Capital&Power. https://energycapitalpower.com/top-5-hydrogen-projects-in-africa/
[82] Zaywa, 2022: PROJECTS: Egypt to establish 300-megawatt green hydrogen projects - govt. official. https://www.zawya.com/en/projects/projects-egypt-to-establish-300-megawatt-green-hydrogen-projects-govt-official-vqtg2zuv
[83] Shakhar, A., 2021: Mauritania announces Project Nour- a 10GW green hydrogen project. H2 Bulletin. 28 September 2021. https://www.h2bulletin.com/mauritania-announces-project-nour-a-10gw-green-hydrogen-project/

Namibia Hydrogen project

The Namibian government is developing a $9.4-billion renewable hydrogen project in the Tsau /Khaeb National Park, near the coastal town of Luderitz. The project is expected to produce 300,000 ton/year of renewable hydrogen and green ammonia for export from 2026 onwards. While a large focus would be on exporting to Europe, there was also potential to sell some of the output to neighbouring African countries. The project could be integrated into the Southern African Power Pool (SAPP). The project will use desalinated water, part of which will be supplied to communities. nearby. Once complete the integrated facility would have a renewables generation capacity of 5 GW and electrolyser capacity of 3 GW, with surplus electricity capacity to be fed into the Namibian grid and potentially into the Southern African power pool.[84]

In connection to the project, and in order to facilitate renewable hydrogen exports towards Europe, the Namibian Ports Authority (Namport) has signed a Memorandum of Understanding with the Port of Rotterdam (PoR), aiming to establish a trading route for green hydrogen.

Morocco´s HEVO Ammonia project

Morocco is a large producer of phosphorus fertilizer but relies on imported ammonia to produce fertilizer. The HEVO Ammonia Morocco project could help Morocco to become more independent of ammonia imports and/or used for exports towards Europe. The HEVO project will use wind power and solar energy to produce the renewable electricity needed. It is Morocco's largest announced renewable hydrogen and green ammonia project to date, with an estimated total investment value of more than 850 million USD. The first phase of the project is expected to begin in 2022 following the completion of a feasibility study. The project is expected to produce 183,000 tons of green ammonia when fully commissioned. The production of ammonia will be scaled up step-by-step as follows: 2,659 tons of green ammonia produced in 2022, 20,000 tons in 2023, 40,000 tons in 2024, and 60,000 tons in both 2025 and 2026. [85], [86]

South Africa´s hydrogen valley

The South African government's Department of Science and Innovation (DSI), in partnership with Anglo-American, Bambili Energy and ENGIE plan to transform the Bushveld complex, one of the most economically significant mineral deposit complexes in the world, and larger region around Johannesburg, Mogalakwena and Durban into a Hydrogen Valley.[87]

[84] Creamer, T., 2021: Namibia selects preferred bidder for pioneering $9.4bn green hydrogen project. Creamer´s media engineering news. https://www.engineeringnews.co.za/article/namibia-selects-preferred-bidder-for-pioneering-94bn-green-hydrogen-project-2021-11-05#.YYUx4ED3HkU.twitter

[85] Fusion Fuel, 2021: Fusion Fuel Announces HEVO Ammonia Morocco Project, Aims to Produce 183,000 Tons of Green Ammonia by 2026. https://ir.fusion-fuel.eu/news-releases/news-release-details/fusion-fuel-announces-hevo-ammonia-morocco-project-aims-produce

[86] Atchison, J., 2021: 183,000 tonnes per year green ammonia in Morocco. Ammonia Energy Association. 20 July 2021. https://www.ammoniaenergy.org/articles/183000-tonnes-per-year-green-ammonia-in-morocco/

[87] South Africa Department of Science and Innovation (DSI), Anglo-American, Bambili Energy and ENGIE, 2021: South Africa Hydrogen Valley Final Report. October 2021, https://www.dst.gov.za/images/2021/Hydrogen_Valley_Feasibility_Study_Report_Final_Version.pdf

Three renewable hydrogen hubs have been identified in South Africa's Hydrogen Valley. These hubs – in Johannesburg, Durban/Richards Bay, and Mogalakwena/Limpopo – will host pilot projects in the mobility (mining trucks, buses), industrial (ammonia/chemicals) and buildings (fuel cell power) sectors. Demand for hydrogen in the Valley is estimated to reach up to 185,000 tons of hydrogen by 2030.

South Africa has expertise in the Fischer-Tropsch process to produce fuels, abundant renewable energy resources, and is a large production capacity of platinum group metals (PGM), a key input for hydrogen applications.[88] These three elements can give the country a good position as a renewable hydrogen producer.

Concluding remarks

Europe needs to reduce consumption of Russian natural gas by diversifying its suppliers, reducing gas consumption and switching to other energy carriers, including renewable energy.

The existing global LNG market cannot supply the amounts that Europe needs without creating substantial constraints for other regions. The EU has to strengthen cooperation with alternative pipeline and LNG exporters – and with other major gas importers and consumers. It also has to develop international partnerships on renewable energy, including electricity and hydrogen. The EU also has to help govern the existing LNG and nascent hydrogen markets. The EU should promote free, liquid and transparent markets around the world.[89]

Europe's energy, climate and industrial policy choices have multiple impacts on broader global market balances. Strengthened international cooperation on several areas is essential to guarantee the security of energy supply in the EU while complying with environmental and climate policy goals in the long term. This cooperation should also help to prevent to extent possible major negative impacts on the security of energy supply and climate policy goals of other countries outside the EU.

A coordinated approach is necessary to avoid too large negative impacts of Europe´s interventions in the market. If Europe pursues scarce LNG supplies without a coordinated approach with other buyers and without investments to boost supply, prices will rise sharply and gas deliveries to buyers in other continents will be more difficult, threatening not only

[88] Salma, T., Tsafos, N., 2022: South Africa's Hydrogen Strategy. April 4, 2022. https://www.csis.org/analysis/south-africas-hydrogen-strategy

[89] European Commission, 2016: COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS on an EU strategy for liquefied natural gas and gas storage. Brussels, 16.2.2016 COM(2016) 49 final. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52016DC0049&from=EN

their energy security of supply but also their food security and triggering price increases in many sectors.[90]

Security considerations for the production and transport of both LNG and renewable hydrogen need to be addressed (e.g. safe maritime routes, democratic producing countries, diversification of suppliers and energy carriers) in order to guarantee Europe´s security of energy supply, reducing its vulnerability to single suppliers and single energy carriers. EU energy diplomacy instruments (Energy Diplomacy Action Plan) should be actively deployed in bilateral and multilateral contexts to guarantee peace and security of energy supply.

Cooperation strategies with other world regions should go beyond natural gas and hydrogen and include other renewable energy carriers. The EU should support the development of renewable energy sources and the implementation of energy efficiency in partner countries. A multi-pronged strategy is necessary to guarantee security of energy supply in different world regions and help secure economic development, stability and peace. Relying only on a fossil fuel trade strategy would be risky. Renewable energy potentials are less concentrated than fossil fuel reserves. Including renewable energy in international cooperation strategies will help diversify energy supply in terms of selling countries and energy carriers and democratise the global energy system, avoiding excessive influence by single market actors. At the same time, the EU has to step up efforts to increase its domestic share of renewable energy and improve energy efficiency.

Cooperation opportunities with African countries regarding LNG exports towards Europe could be developed. However, their development will require Europe to make substantial investments in natural gas production, pipelines and LNG infrastructure. Investments should be attached to certain conditions, including monitoring, reporting and verification of methane and CO_2 emission reductions. In addition, financing needs to be linked to the highest social and environmental standards, including air pollution and water regulations.

Care should be taken with regard to investment in LNG or gas infrastructure to avoid the risk of technology lock-in or stranded assets in fossil fuel infrastructure. Cooperation that starts with fossil LNG will have to provide perspectives for a shift towards renewable energies in the medium and long term, including hydrogen.

Investments in LNG infrastructure may compete with investments in renewable energy in Africa, which are needed to facilitate African domestic economic development. A careful balance must be cast between, on the one hand, investments on natural gas exploration and production and LNG export infrastructure and, on the other hand, investments in renewable energy technologies and infrastructure to advance the access of Africans to electricity, clean cooking and clean transport modes, among others.

[90] Tsafos, N., 2022: Europe needs a smarter way out of Russian gas. Euractiv. 28 March 2022. https://www.euractiv.com/section/energy/opinion/europe-needs-a-smarter-way-out-of-russian-gas/

Renewable energy systems can be more democratic than fossil fuels because the potentials are more evenly distributed across countries and regions. Therefore, an energy system based on renewables has better chances to be more peaceful and avoid undue influence of single energy suppliers on the markets.

Intercontinental renewable hydrogen trade can help the EU diversify its sources of energy and reduce geopolitical dependence on Russia and other fossil fuel exporters. Renewable hydrogen trade can rely on a larger number of exporting countries diminishing the influence of single producing countries on the market and contributing to a new geopolitical landscape.

The European Commission has given priority to cooperation with the African Union and the two continents could explore a mutually beneficial renewable hydrogen trade in the long term. The African Union can become a cooperation partner on research and development, regulatory policy and establishment of trade relationships. However, at the same time, Africa need to develop its renewable energy resources for domestic consumption to support its economic development and will require support from Europe for this purpose. There is a need to avoid potential "green colonialism".

Cooperation between Africa and Europe on renewable energy can become a building block for a broader cooperation on trade, security, technology, climate and environmental policy, thus strengthening the EU's external relations towards Africa as strategic partner. A sound cooperation requires development of trade relationships, substantial investments, opening of markets and recognition of African countries as equal partners.

Renewable hydrogen production in Africa for local and export markets would help reduce the costs of production through scaling up and learning-by-doing effects. Renewable hydrogen can be used as a feedstock and fuel by African industry to produce green products with higher value-added than raw materials such as green steel, green fertilizers and cement for domestic consumption or exports to the European Union. This could help African countries profit from exports revenues and improve their balance of trade with the EU while avoiding some negative impacts of the EU Carbon Border Adjustment Mechanism (CBAM). If African producers were able to develop less carbon-intensive products such as fertilizers, cement and steel using renewable hydrogen, the impacts of CBAM in their balance of trade with the EU would lessen.[91]

Africa could benefit from revenues from hydrogen exports. These revenues could be invested in access to modern forms of renewable energy and energy efficiency in Africa. This can lead, among others, to a reduction of air pollution and improvement of health conditions as well as economic development.

[91] Pleeck, S., Denton, F., Mitchell, I., 2022: An EU Tax on African Carbon – Assessing the Impact and Ways Forward. Blog. Center for Global Development. February 10, 2022. https://www.cgdev.org/blog/eu-tax-african-carbon-assessing-impact-and-ways-forward

However, the development of renewable hydrogen production capacities requires the rapid development of renewable electricity potentials in Africa. A careful balance should be cast between electricity generation capacity to meet domestic electricity demand in Africa and capacity to produce renewable hydrogen. Affordable electricity to meet domestic African demand is required to ensure the economic and social development of the continent. Access to domestic and international financing is necessary to advance the installation of renewable electricity capacity in Africa. At the same time, the structural problems of African electricity systems need to be solved.

*The **Global Forum on Sustainable Energy (GFSE)** is a neutral multi-stakeholder platform, which is facilitating international dialogue on energy for sustainable development by taking into accounts the special interests and challenges of developing countries. GFSE aims at the establishment of a sustainable world energy system from a social, economic and environmental perspective.*

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