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T1.1 "Assessment of Existing African Hydrogen Strategies and Roadmaps to identify project outcomes thanks to local stakeholders elicitation"

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EXECUTIVE SUMMARY

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101101469

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This document is the Deliverable "D1.1 Assessment of EU-AU green H2 potential interaction", developed within WP1 of the JUST GREEN-AFRH2ICA project.
The reports aims to provide an overview of on-going low carbon hydrogen collaboration and initiatives between Europe and Africa starting from an assessment of both Europe and Africa hydrogen national strategies, then followed by a review of initiatives currently promoted/on-going essentially by industrial consortia, and of transnational associations. The main intention is to understand the potential "space of collaboration" between the two continents on low carbon hydrogen import/export.

In details, it contains:

- An assessment of EU countries green hydrogen policies and plans, to understand if some specific countries (particularly those ones which have significant relationships with African countries) are already foreseeing potential extra-National import and/or if their green hydrogen production plans are aligned with EU hydrogen policies and with local potential green hydrogen demand (Chapter 2)
- An assessment of African green hydrogen policies and plans, to understand the level of awareness of local countries and government about the economic development potential that green hydrogen could unlock at local level (Chapter 3)
- The presentation of some examples of already on-going/promoted projects (co-funded by EU and AU institutions and governments or industries) for large scale green hydrogen project, that could be frontrunner for further projects replication
- An assessment of the results of M1-M6 stakeholders' activities (surveys and events) on some specific questions/topics related to i) which could be the first space/approaches of collaboration between EU and AU countries for green hydrogen promotion, ii) which could be the African areas where to act first to promote EU-AU interaction.

The analysis of **low carbon hydrogen strategies in EU-countries** shows clear intention to deploy hydrogen relying on importations with a target of 10Mtpa of non-EU hydrogen imports by 2030.

- EU countries have set **production targets** so far, for hydrogen market to organize around flagship projects until the next policy planning rounds.
- EU countries hydrogen roadmaps mainly set objectives for 2030. Only Belgium and the United Kingdom (non-EU) have 2050 targets in terms of **domestic consumption** and/or exports.
- **Export** from EU-countries is assumed to be intra-EU only. However, no consistent plan can be found among EU countries.
- EU has set a **2030 target of 10Mtpa for non-EU hydrogen imports** but there is no consistent breakdown of the share of this import among EU countries.

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- Large discrepancies remain in the evaluation of future domestic demand for hydrogen among EU countries.

Concerning **hydrogen corridors**, while the EU-27 low carbon hydrogen demand is expected to massively increase in the next decades, the amplification of 2030 objectives suggests that even more ambitious African green H2 import volumes could be reached by 2050.

Existing prospective studies tend to suggest that 2050 glow carbon H2 import volumes from Africa could generally be handled through **the repurposing of strategic cross-Mediterranean natural gas pipelines** as well as **ship transportation of liquefied hydrogen or ammonia.**

However, most ambitious import scenarios may lead to a strong concentration of hydrogen flows around a few Member States, which suggests **the need for significant adaptations in the deployment of a trans-European hydrogen infrastructure.**

The analysis of hydrogen strategy in African country show that only a limited number of countries, gathered in so called "Tier-1 countries" have a well defined strategy. It is the case for Algeria, Egypt, Kenya, Mauritania, Morocco, Namibia and South Africa. It is worth noting that it is not always a low carbon hydrogen that is targeted (e.g. Algeria). A large number of countries have some elements of hydrogen strategy (e.g. Tunisia, Ethiopia, …) and numerous country have no hydrogen ambition expressed.

Gathering these strategies and the initiatives that can be found such as industrial projects or alliances, a certain number of lessons can be drawn:

- Most African renewable hydrogen projects plan to mainly export green ammonia to Europe (mostly Germany) via shipping.
- There is only a handful of projects aiming at developing further added value locally. The most notorious examples include Morocco's OCP to cut ammonia imports with locally-produced green ammonia and South Africa's Sasol to progressively replace its fossil-based synthetic fuel industry with renewable molecules.
- In the current state of information, the pipeline of African hydrogen projects together with the claimed ambition of several countries appear not mature enough to provide the EU with 100% of its projected import quantities: the annual output of announced projects amounts to ca. **9Mtpa by 2030**. This quantity has to be compared with the EU target of Repower EU of 10 Mtpa in 2030 .
- Therefore assuming that EU countries buy all the available green ammonia production by 2030, 1Mtpa of complementary volumes need to be sourced from other exporting regions (e.g. Chile, Australia, middle-East …). Besides, African countries are being courted by other importing countries, namely Eastern countries, and one cannot reasonably assume that 100% of Africa's renewable hydrogen output will be shipped over to Europe. Consequently, **the share of African H2 in EU import should be much below 90%.**

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- By 2030, the southern hydrogen corridors across the Mediterranean sea will most probably not be ready to supply hydrogen to Europe. Furthermore, the pipeline of low-carbon/renewable hydrogen projects from northern African countries such as Algeria or Tunisia remains to be built. Consequently, the EU shall essentially rely on green ammonia imports via its major import hubs (Rotterdam, Antwerp, Hamburg, Bremerhaven) where projects of ammonia cracking units are being developed.
- By 2050, Africa's hydrogen & derivatives production output is expected to significantly increase, potentially reaching well over 20Mtpa available for export. However, EU's import needs/objectives are not yet specified this far in time.

The way most low carbon hydrogen production projects can be deployed cannot be directly derived from the European "hydrogen valley" model. **Specific African Hydrogen Hubs** appear to be the most relevant option. They have also to be coupled to a careful analysis of the water resource.

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1. INTRODUCTION

Due to its great RES potential (large open arid spaces along windy coastlines) many regions in Africa offer a great potential for producing low-cost, price competitive green electricity with a minimal impact on bio habitat and biodiversity. Many African countries, when water is also available could leapfrog to the new age of hydrogen technologies. Developing hydrogen economies in Africa would have indeed an impact on import/export African economy: reducing the economic burden of importing costly refined fossil fuels, also making African energy intensive industries (e.g. fertilizer, chemicals, mining) more attracting and generating revenue streams from exporting green H2, while creating employment, skills and wealth domestically as well as opportunity for African Countries to meet their own decarbonization goals. Thanks to a low RES energy cost, African hydrogen produced by electrolysis could be both, "renewable" or "low carbon" and competitive with Diesel and Petrol withing 2030. As such it could materially assist the World to decarbonize. African low carbon hydrogen could also become a major enabler of EU hydrogen accelerator recently mentioned in RePowerEU program, which is foreseeing 10 Mt/yr of hydrogen import, by EU.

To do so, it's important that European and African hydrogen plans will dialogue and this is one of the mission of JUST GREEN AFRH2ICA project.

In order to form the strongest possible international alliance for utilizing Africa's hydrogen potential and creating markets and green wealth in Africa, EU and AU hydrogen stakeholders must indeed work together facilitating the collaboration between governments, industry, technology and financial institutions and large end consumers of hydrogen across continents. JUST GREEN AFRH2ICA aims therefore to create awareness and to make compelling propositions at 360° (technological – financing – regulatory/policy) for the benefit of AU/EU of developing green hydrogen economies.

Since early 2020s (thus before the promotion of RePoweEU plan) low carbon hydrogen is one of the central discussion topics between EU and AU as highlighted during the 2022 European Union-African Union summit. Since its 2020 Hydrogen Strategy, EU has made its ambitions to import hydrogen from the African continent clear: in its 2020 Hydrogen Strategy, the European Commission foresaw 40 GW of renewable hydrogen electrolysers in the EU neighbourhood, a large proportion of which are expected to be in North Africa, by 2030.

Alongside EU plans to import renewable hydrogen from the neighbourhood, member states are setting up bilateral hydrogen initiatives with countries across the African continent. Germany is a frontrunner in this sense, having set up a global hydrogen import scheme and bilateral initiatives with African countries (foreseeing investment and R&D initiatives), including Morocco, Namibia and South Africa.

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EU interest in importing low carbon hydrogen from Africa is driven by the assumption that member states will require significant quantities of renewable hydrogen to decarbonize certain economic sectors (for example, the chemicals industry, steel industry and heavy transport sectors such as maritime and aviation) that exceeds cost-effective domestic potential.

One of the goal of WP1 is therefore to understand (as much as possible from a quantitative point of view) how EU and AU can cooperate and support each other in this sense, understanding how much hydrogen EU could realistically needs and how much hydrogen AU could realistically produce and export.

The present document constitutes the Deliverable D1.1 "Assessment of EU-AU green H2 potential interaction", developed within WP1 of the JUST GREEN-AFRH2ICA project. The report aims to analyse current strategies and road maps for Hydrogen production, use, importation and exportation defined both, in European countries and in African countries, and to identify any points of attention. Special attention is given to the matching between quantified goals defined in the Repower EU strategy, especially for H2 importations, and the renewable H2 production ambitions displayed by African Union and AHP.

In order to avoid as much as possible the colored hydrogen approach (green, blue, grey, etc.) which tend to be abandoned for more rigorous classifications, we have preferred the terms "low carbon" or "renewable" hydrogen in the document. This approach will be followed in project's forthcoming deliverable too.

Structure of the Deliverable

To comprehensively cover all the topics previously introduced, the following structure was chosen for the document:

- Section 2 is dedicated to the analysis of national road maps in several EU countries among the most active, including Great Britain;
- Section 3 presents the hydrogen roadmaps of several African countries and an assessment of the overall green hydrogen plan at continental level in order to understand if African continental policy plan is aligned with EU one;
- Section 4 describes ongoing initiatives between AU and EU, mainly carried by industrial consortia, for hydrogen production and usage;
- Section 5 presents the first outcomes of stakeholders activities, namely workshops and surveys on the specific topic of EU-AU sectors of collaboration for green hydrogen promotion in order to identify African areas/countries as well as sectors where to act first to boost EU-AU green hydrogen collaboration;

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- Section 6 gives an analysis of the matching between all these strategies and initiatives concerning H2 production and exportation form Africa and importation in Europe and highlight main points of attention;
- Section 7 presents deliverable's conclusions and next steps.

Relation to Other Tasks and Deliverables

This Deliverable D1.1 is based on Task 1.1 and Task 1.2 and it provides relevant inputs to T1.3 and T1.4, towards the final goal of WP1: setup the scene for WP2 and WP3 modelling and road mapping activities.

The goal of T1.1 is indeed to set the basis of the overall project: to do so the state of the art of existing AU Hydrogen experiences will be assessed from a policy, expertise, technological and previous assessment point of view. T1.2 aims in parallel to analyse current EU strategies about hydrogen with a specific focus on import, assessing different EU Member states strategies and roadmaps. This assessment will identify the main locations, quantities and timeframe of the European demand where H2 import from Africa appears relevant.

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2. EUROPEAN HYDROGEN ROADMAPS AND PLAN ASSESSMENT

2.1 Review of H_2 strategies in EU countries

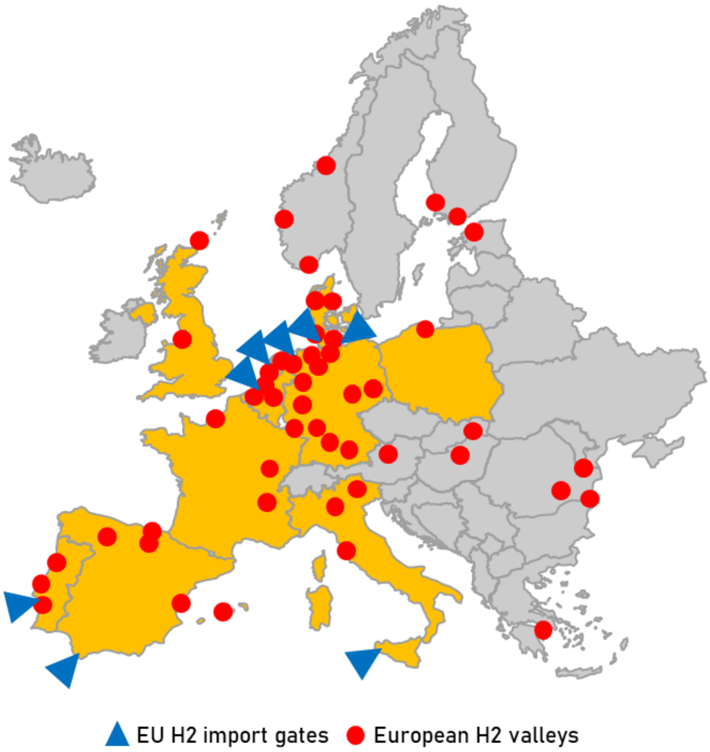

Figure 1: Hydrogen initiatives across Europe and countries analysed in this report

CEA has undertaken a thorough country-by-country analysis of the hydrogen roadmaps in a selection of EU and non-EU countries (countries in yellow on the map above). The detailed results are synthetized hereafter. A synthesis of quantitative domestic production/production forecasts or targets as well as import/export target details when available, is provided as a conclusion to this analysis.

2.1.1. Germany (DE)

Germany announced a hydrogen production target of 10GW by 2030, reaching up to between 50 and 80GW by 2050. In the meantime, if Germany is to reach its climate targets for 2030 and its GHG neutrality target for 2050, importing renewable energy from beyond the European internal market will become a medium and long-term necessity. It is unlikely that the large quantities of hydrogen that will be needed for the energy transition can be

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produced in Germany alone, as Germany's renewable energy generation capacity is limited. This means that Germany will continue to import much of its energy from abroad.

The German government established the National Hydrogen Council (NWR) on 10 June 2020 and confirmed its agenda on 27 June 2023. The Council consists of 26 high-ranking experts from business, science and civil society who are not part of the public administration. With a series of 34 measures, the German Government intends to mainly intervene in the Industry, Transport, Heat market and Infrastructure sectors:

- **Industry -** The switchover to hydrogen as a base substance and fuel is key and many government programs are in place. Its actions are mainly aimed at supporting investment in the Chemicals, Industry, Logistics and Aviation sectors.
- **Transport -** The use of green H2 in transport must be integrated in the framework of the European directive REDII. A series of grants and €8.1 billion investments have been put in place to develop the hydrogen-powered vehicle fleet and associated infrastructure.
- **Heating -** Utilizing hydrogen to decarbonize the heating sector. Up to EUR 700 million is to be made available for achieving this objective in 2020-2024.
- **Infrastructures** - The potential of the existing infrastructure and the new elements will be supported by a new regulatory framework at national and European levels.

In parallel, Germany wants to position itself as a leading provider of green hydrogen technology on the global market through a series of strategic programs (e.g. hydrogen technologies 2030, European Flightpath 2050, etc). At the European level, Germany is proactive in the context of the preparations for the legislative package on sector coupling and gas market design.

Germany will foster and intensify international cooperation and partnerships on hydrogen, as illustrated with the Joint Communiqué of Intent to establish a German-Namibian hydrogen partnership, but also with Angola and several other African countries.
Goals and ambitions are detailed as follow:

- Assuming global responsibility: reduce greenhouse gas emissions globally
- Making hydrogen a competitive option: especially in the steel or chemicals industry, or in certain parts of the transport sector. In the longer term, parts of the heat market will also be addressed.
- Developing a domestic market for hydrogen technology in Germany, paving the way for imports:
    - Establishing hydrogen as an alternative for other energy source, especially for sectors that cannot be electrified :aviation, parts of heavy-duty transport, mobile systems for the defence
    - Making hydrogen a sustainable base material for the industrial sector (especially chemicals industry and steel production)

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- Enhancing transport and distribution infrastructure to be able to import and develop the sales markets for hydrogen and the products derived from it.

- Fostering science, mobilising skilled labour
- Shaping and accompanying transformation processes
- Strengthening German industry and securing global market opportunities for German firms to play a key role in international competition for the development and export of hydrogen and Power-to-X (PtX) technologies.
- Regarding global cooperation as an opportunity for example joint projects and trialling of technology in the area of the North Sea and in southern Europe in particular
- Building up and securing the quality assurance infrastructure for hydrogen production, transport, storage and use, and building trust
- Improving the policy environment and addressing current developments on an ongoing basis.

Sources:

https://www.bmwk.de/Redaktion/EN/Publikationen/Energie/the-national-hydrogen-strategy.pdf?__blob=publicationFile&v=6
https://fleishmanhillard.eu/wp-content/uploads/sites/7/2022/02/FH-National-Hydrogen-Strategies-Report-2022.pdf
https://energycapitalpower.com/aec-german-african-green-hydrogen/
https://www.bmwk.de/Redaktion/DE/Pressemitteilungen/2023/07/20230726-markthochlauf-fuer-wasserstoff-beschleunigen.html

2.1.2. Netherlands (NL)

The Dutch National Hydrogen Programme (NWP) involves the development of the Dutch hydrogen market which is imperative if the Dutch economy wants to become more sustainable. Renewable and low-carbon hydrogen as well as hydrogen derivatives will contribute to making industry, mobility, building and electricity generation more sustainable.

Because of the country's experience with hydrogen, extensive port, transport and storage infrastructure, existing industry, large-scale rollout of offshore wind energy and favourable location for transit in relation to neighbouring countries, the Netherlands have an excellent starting position for the extensive upscaling of hydrogen deployment.

NWP participants are advocating a target of at least 80 petajoule (PJ) for the domestic production of renewable hydrogen by 2030. Depending on the number of operating hours, this would amount to between 6-8 gigawatt (GW) of installed electrolysis capacity. Part of it will be produced domestically (3-4 GW target for 2030), assuming amongst other things that offshore wind-to-hydrogen will scale up. However, complementary hydrogen quantities will also have to be imported.

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The Netherlands' five principal areas of focus are:

1. **Carbon-free feedstock for the process industry** - Hydrogen is already widely used (approximately 100 PJ converted to energy value) and the need for hydrogen will continue to grow as a result of new sustainable chemical processes. In time, this feedstock will have to be carbon-free hydrogen. There is no alternative;
2. **Carbon-free energy carriers for high temperature heat for the process industry** There are few alternatives for temperatures above approximately 600 degrees;
3. **Controllable carbon-free capacity** - Energy storage for prolonged periods and energy transport over longer distances. These will be necessary in an energy supply in which the share of non-controllable weather-dependent sustainable energy is increasing significantly and where the energy sources (mainly offshore wind) are situated at a considerable distance from users. Those needs will chiefly begin to increase around 2030;
4. **Zero-emission mobility and transportation** - Passenger transport for greater distances and road transport as a focus ahead of 2025. Heavy road transport over long distances, shipping and rail are solid options for the longer term (toward 2030). In addition to battery electric transport, the Netherlands will be committing significantly to hydrogen as part of the policy that aims to achieve zero-emissions mobility. The transition from grey to green hydrogen is crucial in that regard;
5. **Building** -Possibly for buildings and districts that cannot easily be made more sustainable in other ways for various reasons.

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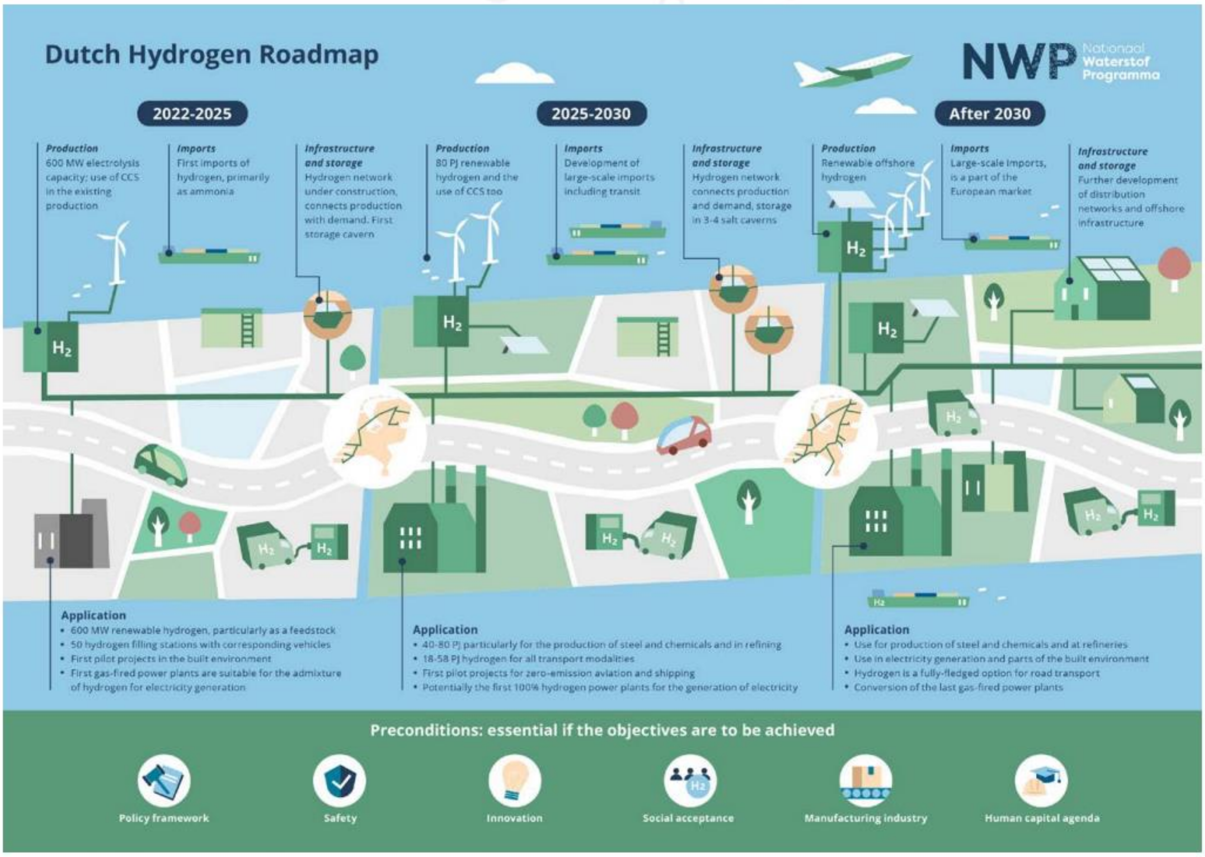

Figure 2: Dutch Hydrogen Roadmap

Sources:

[Hydrogen Roadmap (nationaalwaterstofprogramma.nl)](https://nationaalwaterstofprogramma.nl)

https://fleishmanhillard.eu/wp-content/uploads/sites/7/2022/02/FH-National-Hydrogen-Strategies-Report-2022.pdf

2.1.3. Denmark (DK)

Denmark already produces large amounts of green electricity from wind turbines and solar panels and has the potential to produce even more green electricity in the future. Denmark has one of the most ambitious plans for reducing greenhouse gas emissions in the EU, aiming at cutting them by 70% by 2030 and reaching net-zero in 2050. This electricity will be used directly in households, companies and for transport, but will also be converted to hydrogen and other Power-to-X products that can displace fossil fuels in the heaviest forms of transport and industry where electrification is not feasible.

Denmark's government strategy relative to power-to-X contains four main items:

1. Ensuring that **Power-to-X contributes to achieving the objectives of the Danish Climate Act** (70% GHG reduction target in 2030 and the long term climate-neutrality target by 2050 at the latest), as well as international climate targets that Denmark has committed to meeting within the EU and via the Paris Agreement. The

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Government pushes therefore for ambitious requirements in the Fit-for-55 package (including within the aviation and shipping sector), initiate an analysis of biological resources for the green transition. The government is investing DKK 1.25 billion through a PtX tender aimed at operating support for the production of hydrogen and other PtX products, as well as DKK 344 million from EU's post-covid cohesion fund (REACT-EU) and the Just Transition Fund into green technologies, and approximately DKK 850 million into he EU level with IPCEI.

2. Ensuring that the **regulatory framework and infrastructure are in place** for Denmark to utilise its strengths and allow Power-to-X to perform on market terms in the long term. The Government has therefore initiated a 360- degree review of regulations related to hydrogen, created a regulation for a national hydrogen market and given Energinet and Evida (Danish utilities) the option to own and operate hydrogen infrastructure. The Government is also carrying out an analysis of opportunities and needs in relation to the role of Danish ports as green transport hubs.
3. Ensuring that the **integration between Power-to-X and the Danish energy system is improved**: The Government will allow for geographically differentiated consumption tariffs for major electricity consumers (such as PtX plants), incentivising them to seek geographically appropriate locations based on electricity grid loads. The Government will also provide the application-based option to establish direct links between actors such as major electricity consumers and renewable energy producers when deemed socioeconomically appropriate, thereby allowing them to pay lower tariff payments to the public electricity grid or avoid them entirely.
4. Ensuring that **Denmark can export Power-to-X products and technologies**: Denmark is potentially well positioned to becoming an exporter of green hydrogen and PtX products at competitive prices. The Danish Energy Agency's analyses show that the short-term production costs for renewable hydrogen in Denmark are on par with production costs for renewable hydrogen in Morocco. The Government will therefore support the export of hydrogen and PtX products and technologies that can contribute to the achievement of international climate targets while also promoting Danish businesses' commercial opportunities, by establishing the framework conditions for a hydrogen infrastructure, as well as increasing access to venture capital. The Government will also propose that Denmark should aim to build upwards of 4 - 6 GW of electrolysis capacity by 2030. In addition, the Government will work with the Danish business community to revise the Energy Export Strategy from 2017 with a view to creating a partnership-based approach to supporting the export of PtX products and technologies. It involves creating the framework for a hydrogen infrastructure that can eventually be linked to a common European hydrogen infrastructure (i.e. Germany, Netherlands, Belgium).

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Denmark is also active on a geopolitical level, taking participations in energy exporting countries: Denmark was one of the first countries to support electricity sector and renewable energy projects in Egypt by providing finance for the wind farm projects at Zafarana.

Sources:
https://ens.dk/sites/ens.dk/files/ptx/strategy_ptx.pdf
https://fleishmanhillard.eu/wp-content/uploads/sites/7/2022/02/FH-National-Hydrogen-Strategies-Report-2022.pdf

2.1.4. Belgium (BE)

The federal government of Belgium is orienting its hydrogen roadmap around 4 main pillars:

1. Become **an import hub in renewable gases**. Indeed Belgium does not have the means to be self-sufficient energetically speaking (electrolysis capacity target: 150MW by 2026), but has important port infrastructures (Antwerp) and is investing in H2 transportation infrastructures. Belgium's objective is to have a hydrogen import capacity of 100 to 165TWh by 2050 that will serve the needs of neighboring EU countries. In order to be able to meet the need for imports, Belgium is gradually setting up 3 routes which are:
    - **The North Sea route** is one of the major renewable resource for Europe and benefits from favorable wind schemes, which allow for the production of renewable hydrogen at a low cost. The synchronized development of offshore electricity and hydrogen networks, coordinated with the other countries surrounding the North Sea, will allow to rapidly harnessing this energy.
    - **Southern route:** Piped imports from Southern Europe (mainly Iberia) and North Africa is a promising long-term solution. It nevertheless requires the development of hydrogen transport networks through Europe and will therefore require more time before being ready. The shipping route may be a temporary solution here. MoU have been signed with Oman and Namibia.
    - **The shipping route** consists in importing H2-derivatives via ship. It is expected to become the most competitive and thus the preferred solution for supplying H2-derivatives to Belgium. H2-derivatives can either be directly used or be converted back to H2-molecules. The reverse conversion to H2-molecules enables to diversify their supply and allows the constitution of strategic stocks that will soon be needed for the security of supply when H2-molecules gain in importance in the energy mix.
2. **Maintain Belgium leadership in hydrogen technologies.** To this end, the country is investing massively in R&D in the fields of production, transport and storage of hydrogen and hydrogen-derived products.

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3. **Establish a robust domestic hydrogen market**, which involves transport infrastructure planning, and development of an open-access Hydrogen backbone to be completed by 2030 with a first section of 100 to 160km of hydrogen pipelines by 2026.
4. **Strengthening Belgium cooperation with organizations, institutions and countries both inside and outside Europe** (e.g. MoU Namibia, MoU Oman). Belgium has the ambition to have its hydrogen transport network interconnected with at least Germany, France and the Netherlands by 2028 in order to support its international positioning as an import and transit hub for renewable energy in Europe.

The federal government has identified 4 sectors that renewable H2-molecules and H2-derivatives will help to make climate neutral by 2050: industry and heavy transport will drive the initial increase in demand. The power sector will follow with its flexibility needs and for coping with longer periods of scarce wind and sun. Eventually, the building sector could partially rely on H2-molecules and/or H2-derivatives on the longer run. The Belgian Strategy adopts a phased approach to achieve the lowest possible carbon emissions, whilst at the same time establishing a level playing field in hydrogen given the current economic context. Other low-carbon alternatives that could be explored during this transition phase are hydrogen produced by pyrolysis from fossil methane, or steam methane reforming with carbon capture and storage.

Sources:
Ecology minister Tinne Van Der Straeten report:
https://d3n8a8pro7vhmx.cloudfront.net/tinnevanderstraeten/pages/133/attachments/original/1636365530/H2_strategie_FR.pdf?1636365530
Fleishmanhillard Report https://fleishmanhillard.eu/wp-content/uploads/sites/7/2022/02/FH-National-Hydrogen-Strategies-Report-2022.pdf
https://www.iea.org/policies/14753-belgium-namibia-mou-on-green-hydrogen
https://www.iea.org/policies/14752-belgium-oman-mou-for-cooperation-in-green-hydrogen

2.1.5. France (FR)

In 2020, France set out an ambitious national strategy committed to developing a decarbonized hydrogen sector. Backed by 9 billion euros of public funding to enable sector expansion on an industrial scale right across France, its objective is to build **6.5GW of installed electrolyzer capacity by 2030** thereby reducing CO2 emissions by 6 million tons each year.

In 2021, the French National Association for Hydrogen 'France Hydrogène' published its 'Road-map for an ambitious hydrogen strategy' exploring two scenarios: the 'Ambition 2030' scenario with an annual production target of 680,000 tons of low carbon or renewable hydrogen per year and a second scenario, 'Ambition+ 2030' which bets on a significant

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increase of the initial target with 1,090,000 tons of low carbon or renewable hydrogen per year by 2030. They aim to meet the regulatory requirements of the 'Fit for 55' package. Seven large clusters have been identified to act as cornerstones for a large-scale roll-out of hydrogen projects where the pooling of production and different end uses of the produced hydrogen would deliver cost reductions.

The law on the energy transition for green growth has set targets of 32% renewable energy in final energy consumption and 40% renewable energy in electricity production by 2030. The law also sets the objective of reducing CO2 emissions by 81% by 2050 compared with 2015.

In order to achieve these objectives, the French hydrogen roadmap is based on three pillars:

1. **Production of H2 by electrolysis for industry:** Introducing 10% decarbonized hydrogen in industrial hydrogen by 2023 (i.e. about 100,000 t) and 20-40% by 2028 with 6.5GW installed electrolyser capacity. It is worse noticing that the French strategy is to produce hydrogen domestically and not to import it.
2. **Valorization by mobility uses** in complementarity to the battery sector with a focus given on captive fleets and heavy duty vehicles:
    - 5000 light commercial vehicles and 200 heavy vehicles (buses, trucks, TER, boats) as well as the construction of 100 stations, fueled by locally produced hydrogen by 2023.
    - 20,000 to 50,000 light commercial vehicles, 800 to 2000 heavy vehicles and 400 to 1000 stations by 2028.
3. **Stabilization of energy grids in the medium-long term** thanks to gaseous storage and power to gas (direct injection)

The list of recommendations includes:

1. **H2 role in the Energy Transition**
    - Volume listed in 1 and 2 above will guide governmental actions
    - Implementing an H2 traceability system
    - Ensure that the environmental impact of hydrogen is highlighted in greenhouse gas regulations
2. **Accompanying measures**
    - The Government mobilizes €100M starting from 2019 to finance experiments and initial deployments targeting several uses, including industry, mobility and stationary uses.
3. **Integration of H2 in energy systems**
    - In order to prepare for the arrival of "power-to-gas", gas transporters and distributors have to determine the technical and economic conditions (deposits, technical locks, safety, environmental balance, etc.) that are acceptable for injecting hydrogen into the grid, for the installations connected to the grids and for the uses (including gas mobility), in conjunction with manufacturers.

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4. **Development of industrial sectors and support for innovation**
    - The national Investment Program supports, through calls for proposals or calls for expressions of interest dedicated to hydrogen, the development of French heavy/high range hydrogen vehicles (trucks, buses, boats, trains, etc.), the chain of associated components, and competitive production and storage systems for decarbonized and sustainable hydrogen.

Sources:
https://www.tresor.economie.gouv.fr/Articles/120903c7-34bc-49b1-a324-b1f6ba0dbf53/files/4c3ada61-fd66-479a-a683-91a63f8d6b87
https://www.ecologie.gouv.fr/sites/default/files/Plan_deploiement_hydrogene.pdf
https://www.wfw.com/articles/the-french-hydrogen-strategy/
https://s3.production.france-hydrogene.org/uploads/sites/4/2023/01/VF-Executive-summary-FH-2022-EN-Web.pdf

2.1.6. Italy (IT)

Italy has interesting characteristics to take advantage of the hydrogen development :

- The presence of a widespread gas transport infrastructure that also offers connections to North Africa
- The competitiveness of the national manufacturing sector
- The ability to integrate hydrogen into the energy system characterized by an important role of renewables and distinctive expertise on biomethane

In order to fully commit to a strategic and long-term vision, the Italian government has put in place 6 pillar actions that can be summarized as follows:

1. Supporting the **role of Italy as the "conductor" of a European strategy on hydrogen** through the elaboration of an incisive industrial development vision and a national hydrogen strategy.
2. Creating an **innovation ecosystem** (scientific, technological, research, partnerships of SME networks and "group leader" companies in the energy world) and accelerating the development of a specific industrial supply chain through the reconversion of existing industries and attracting new investments.
3. Supporting nation-wide **decarbonized hydrogen production.**
4. Promoting the widespread adoption of **hydrogen in final consumption sectors** thanks to regulatory basis and incentive scheme.
5. Incentivizing the development of **specialist expertise**, both creating new professions and accompanying the transition of existing ones.
6. **Raising awareness among public opinion** and the business world on the benefits deriving from the use of this carrier.

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In order to kick-start the development of the hydrogen market, the government plans to install about 5GW of electrolysis capacity by 2030, corresponding to 2% of hydrogen penetration in the final energy demand. Hydrogen penetration in final energy demand is expected to reach 23% in 2050.

According to this scenario, the sector that will most benefit from the introduction of hydrogen is the transport sector, which is forecast to use 39% of the entire hydrogen demand by 2050, with an initial focus on heavy duty and public transportation.

Industry being the most energy-consuming sector, after electricity production, hydrogen has also huge potential in most energy-consuming industries in terms of heat consumption (chemicals, paper, steel and metal processing, Food&Beverage, textiles, automotive and rubber and plastics, which together count for 63% of the total consumption of natural gas in the Italian industrial sector), but also used as a feedstock.

Great potential is also envisaged for the residential sector, which is expected to consume 32% of hydrogen demand in Italy by 2050.

Domestic production of green hydrogen could be supplemented by imports and the national strategy intends to take advantage of the existence of a well-developed and interconnected gas network that also offers import and export opportunities. The country's location is ideal to become a hub for hydrogen trade.

However, the main barriers to hydrogen development that still have to be overcome include: the high costs of technologies that have not yet reached full technological maturity, limited implementation of demonstrative projects throughout the supply chain, and the lack of a clear regulatory and normative framework covering key aspects.

Sources:
https://www.snam.it/export/sites/snam-rp/repository/file/Media/news_eventi/2020/H2_Italy_2020_ENG.pdf
https://fleishmanhillard.eu/wp-content/uploads/sites/7/2022/02/FH-National-Hydrogen-Strategies-Report-2022.pdf

2.1.7. Spain (ES)

The main strategic and legislative documents setting hydrogen roadmap are Spain's Strategic Energy and Climate Framework, the National Integrated Energy and Climate Plan ("PNIEC") 2021-2030, the Draft Law on Climate Change and Energy Transition, the Long-Term Decarbonisation Strategy 2050, the Fair Transition Strategy and the Energy Storage Strategy.

According to the Hydrogen Roadmap, "nowadays, hydrogen consumption in Spain is around 500,000 t/year, mainly grey hydrogen, used as a raw material mainly in refineries and chemical product manufacturers, with the remaining consumption corresponding to sectors such as metallurgy".

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Nevertheless, the Hydrogen Roadmap relies on Spain's potential to position itself as a technological leader in the production and use of green hydrogen, given the advantageous climate and large areas available for the installation of renewable energy projects (solar or wind). In this regard, the Hydrogen Roadmap defines ambitious targets that can be framed within the three phases defined in the EU Hydrogen Strategy:

1. **A first phase from 2020 to 2024**
   - Installation of 300 to 600 MW of electrolysis
2. **A second phase from 2025 to 2030**
   - Installation of 4 GW of electrolyser plants
   - Industry: minimum renewable hydrogen contribution of 25% of the total hydrogen consumed in 2030 in all industries.
   - Transport: 150-200 fuel cell buses in 2030, 5,000-7,500 light and heavy-duty fuel cell vehicles for freight transport in 2030 and 100-150 public access hydrogen stations by 2030.
   - Power sector/energy storage: commercial hydrogen projects operational by 2030 for electricity storage and/or use of surplus renewable energy.
3. **A third phase from 2030 to 2050**
   - Economy based on the production and application of renewable hydrogen.
   - Competitiveness of hydrogen production using renewable energy compared to other production technologies.
   - Decarbonization of society by 2050.
   - Increased manageability of renewable energies.
   - Quality, sustainable and competitively priced energy supply.

To reach these targets, the Spanish hydrogen roadmap is articulated around a series of 60 measures covering:

- **New regulatory instruments**: addressing the regulatory barrier (hydrogen production considered as industrial activity), establishment of a Guarantee of Origin System, consider green taxation.
- **Sectoral measures**: (i) establish a national statistical system on hydrogen consumption and production in Spain, differentiating by types of hydrogen and by consumption sectors; (ii) evaluate the feasibility of establishing renewable hydrogen penetration targets for the period 2025-2030 in sectors where electrification is inefficient; (iii) design financial instruments to support Spanish hydrogen-intensive industries to adapt processes and infrastructure for the continuous supply of renewable hydrogen; (iv) develop long-term national decarbonisation strategies based on renewable hydrogen; and (v) identify current hydrogen consumption locations, promoting and encouraging the creation of hydrogen "valleys" or "clusters".

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- Cross-cutting instruments and R&D promotion

By 2030, investments for renewable hydrogen production or mobility projects will amount 8.9 b€.

In addition, the connections with Algeria and France should give Spain export opportunities provided that the existing pipeline network is modernized, especially through the TEN-T corridors

Sources:
https://energy.ec.europa.eu/system/files/2020-05/1-2_es_20200526_spain._renewable_hydrogen_roadmap_0.pdf
https://www.wfw.com/articles/the-spanish-hydrogen-strategy/
https://energia.gob.es/es-es/Novedades/Documents/hoja_de_ruta_del_hidrogeno.pdf

2.1.8. Portugal (PT)

Portugal has established its National Hydrogen Strategy according with the attachment of the Council of Ministers' Resolution 63/2020. This Strategy aims to contribute to the national and EU decarbonization goal, introducing an element of incentive and stability for the energy sector, promoting the gradual introduction of hydrogen as a sustainable pillar, and integrated into a comprehensive strategy of transition to a decarbonized economy, as well as a strategic opportunity for the country.

Hydrogen will facilitate and accelerate the energy transition in various sectors, with a **particular focus on transport and industry**:

1. Complements the electrification strategy, reducing decarbonization costs;
2. It substantially reinforces security of supply, as hydrogen allows renewable electricity to be stored for long periods of time;
3. Reduces energy dependence by using endogenous sources of renewable origin;
4. Reduces GHG emissions in various sectors of the economy as it more easily promotes the replacement of fossil fuels (refining, chemistry, metallurgy, cement, mining, ceramics and glass)
5. Promotes efficiency in energy production and consumption (scalable, close to the place of consumption and distributed throughout the national territory);
6. Promotes economic growth and employment through the development of new industries and associated services.

The characteristics of Portugal energy system determined the selection of a set of strategic configurations for the hydrogen value chain : Power-to-Gas (P2G), Power-to-Mobility (P2M), Power-to-Industry (P2I), Power-to-Synfuel (P2FUEL), Power-to-Power (P2P).

Ongoing or starting initiatives in this direction are:

- Regulating hydrogen injection in the gas networks

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- Setting hydrogen incorporation targets
- Supporting investment in hydrogen projects
- Implementing a mechanism to support the production of hydrogen
- Advancing national industrial hydrogen hub in Sines
- Decarbonizing the industry as national priority sector
- Decarbonizing the transport sector
- Implementing a collaborative laboratory (COLAB)
- Using wastewater for the production of hydrogen

Quantified targets for 2030 are:

- 5% of hydrogen in road transportation consumption, industry energy consumption and overall final energy consumption.
- 15% of hydrogen injected into the natural gas grid.
- 50 to 100 hydrogen refueling stations developed on a national scale.
- 2 to 2.5GW of installed capacity for hydrogen production (including industrial project for the production of green hydrogen in Sines : 2.85 billion euros, 1 GW
- Investment of EUR 7 billion in hydrogen production projects.

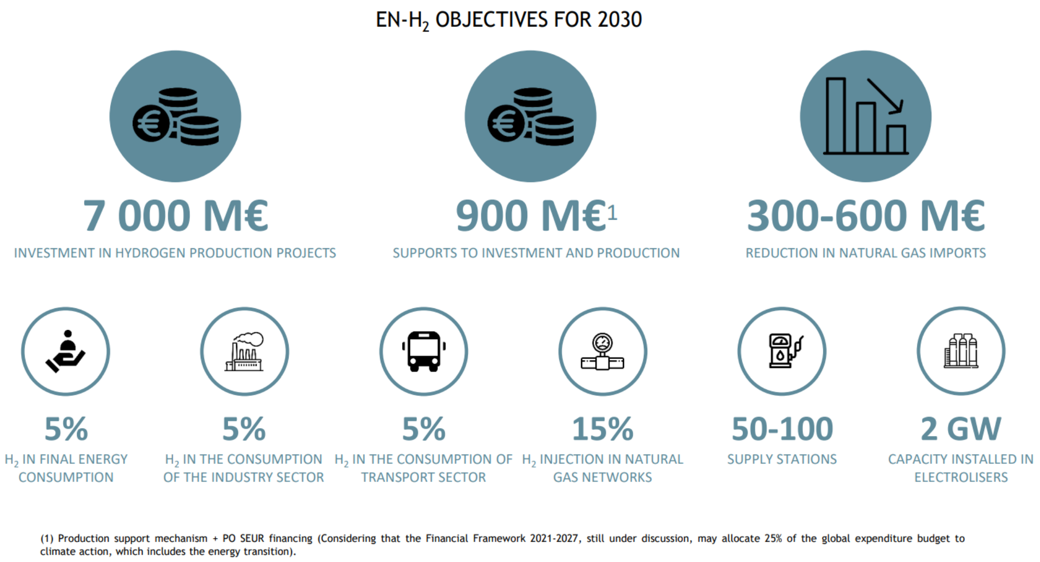

Figure 3: Portugal Hydrogen ambition for 2030

Sources:

https://www.dgeg.gov.pt/en/transversal-areas/international-affairs/energy-policy/national-strategy-for-hydrogen/

https://kig.pl/wp-content/uploads/2020/07/EN_H2_ENG.pdf

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2.1.9. Poland (PL)

Poland is currently in 3rd position among European hydrogen producers, just behind Germany and the Netherlands, with an annual production of approx. 1.3 million tons per year, but only a marginal share of hydrogen comes from renewable sources.

The Polish Hydrogen Strategy until 2030 with an outlook until 2040 (PHS) sets 6 main objectives for hydrogen economy development:

1. **Implementation of hydrogen technologies in the power and heating sector**
   By supporting research and development in the field of co- and poly-generation systems for buildings using fuel cells and supporting effective cooperation of the gas system and electric power system
2. **Use of hydrogen as an alternative fuel for transport**
   - Targets for 2025: 100 to 250 zero-emission hydrogen buses, min 32 hydrogen filling stations, hydrogen purification constructed, first hydrogen train under construction.
   - Targets for 2030 : 800-1000 hydrogen buses, network of refuelling stations will continue to develop and production of hydrogen-based fuels will set off (such as ammonia or methanol).
3. **Supporting the decarbonization of industry**
   - The industrial sector has the potential to become the largest user of low-carbon hydrogen due to the lack of alternative decarbonization options. Public support will be provided in this sector in particular steel, refining and chemicals.
   - By 2030, at least 5 hydrogen valleys, understood as centers of excellence for the implementation of the hydrogen economy, sector integration, industry climate transformation, and infrastructure construction, are planned.
4. **Hydrogen production in new installations**
   - Support conditional to the level of emissions associated with the production of hydrogen rather than specific technologies (technology-neutral approach), for research and development and for launching installations
   - Target 2025: 50 MW – 2030: 2 GW from low- and zero-emission sources and processes.
5. **Efficient and safe hydrogen transmission, distribution and storage**
   Primarily by road and rail (tankers, tank trucks), then, as demand increases, by means of the existing gas infrastructure or dedicated hydrogen pipelines. Amongst the potential big scale hydrogen storage facilities, salt caverns were considered to be the most optimal solution.
6. **Create stable regulations**
   The objective is to remove barriers towards the development of the hydrogen market and encourage a gradual increase in the use of RES for electrolysis.

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These objectives are complemented by horizontal and non-legislative actions such as:
i) Use of Polish R&D potential in the field of hydrogen technologies,
ii) Development of factories for electrolysers, fuel cells, hydrogen storage tanks, hydrogen-powered vehicles, and other components, and
iii) Concluding a Hydrogen Economy Sector Deal, creating a Hydrogen Valley Ecosystem, establishing of a Hydrogen Technology Centre for building competencies for the hydrogen economy, educational activities and public campaigns, European and international cooperation....

Table 1: Elements of Polish hydrogen strategy by 2030

STRATEGY INDICATORS

Indicator name	Unit of Mea-surement	Base value (2020)	Target value (2030)
Installed capacity of the low-carbon hydrogen production facilities	MW	0	2000
Number of hydrogen valleys	pcs	0	5
Number of hydrogen buses in service	pcs	0	1000
Number of hydrogen stations	pcs	0	>32
Conclusion of the Hydrogen Economy Sector Deal	pcs	0	1
Creation of the Hydrogen Valley Ecosystem	pcs	0	1
Establishment of the Hydrogen Technology Centre	pcs	0	1

Sources:
https://www.gov.pl/attachment/06213bb3-64d3-4ca8-afbe-2e50dadfa2dc

2.1.10. United Kingdom (GB)

UK ambition is 1) to become a global leader in hydrogen, with 5GWof low carbon hydrogen production capacity by 2030 for use across the economy and 2) to reach the world-leading emissions reductions target for Carbon Budget Six (CB6) by 2030 and Net-Zero by 2050. The national objective is mainly to decarbonize the industry, power, heat in buildings and transport sectors.

This ambition for hydrogen goes beyond decarbonization. It also means a focus on supporting industry to develop sustainable, home-grown supply chains, create high quality jobs, and capitalize on British innovation and expertise.
The Ten Point Plan (TPP) designated hydrogen as a key priority area in the Net Zero Innovation Portfolio, with a £1 billion (allocated up to 2025) fund to accelerate commercialization of low-carbon technologies and systems for net zero.

UK has potential to produce large quantities of both electrolytic 'green' and CCUS enabled 'blue' hydrogen and aims to quadruple offshore wind capacity to 40GW by 2030
Strategic outcomes expected by 2030:

- **Progress towards 2030 ambition**
  5GW of low carbon hydrogen production capacity with potential for rapid expansion post-2030; 1GW preliminary production capacity by 2025.
- **Decarbonization of existing UK hydrogen supply**
  Existing hydrogen supply decarbonized through CCUS and/or supplemented by electrolytic hydrogen injection.
- **Lower cost of hydrogen production**
  A decrease in the cost of low carbon hydrogen production driven by learning from early projects, more mature markets and technology innovation.
- **End-to-end hydrogen system with a diverse range of users**
  End user demand in place across a range of sectors and locations across the UK, with significantly more end users able and willing to switch.
- **Increased public awareness:** Public and consumers are aware of and accept use of hydrogen across the energy system.
- **Promote UK economic growth and opportunities, including jobs:** Established UK capabilities and supply chain that translates into economic benefits, including through exports. UK is an international leader and attractive place for inward investment.
  Over £4 billion of investment is planned to be unlocked throughout the 2020s
- **Emissions reduction under Carbon Budgets 4 and 5:** Hydrogen makes a material contribution to the UK's emissions reduction targets, including through setting us on a pathway to achieving CB6.
- **Preparation for ramp up beyond 2030:** The pathway to net zero requires that hydrogen infrastructure and technologies are in place with potential for expansion. Well established regulatory and market framework in place.
- **Evidence-based policy development:** Modelling of hydrogen in the energy system and input assumptions improved based on wider literature, qualitative and quantitative evidence and real-world learning. Delivery evidence from innovation and deployment projects collected and used to improve policy making

Concerning the international exchanges, the objective of the UK is to be able to supply its hydrogen in Europe as well as internationally.

In Europe, the potential for pan-European dedicated hydrogen transport infrastructure and the use of existing or new gas interconnectors between the UK and Belgium, Netherlands and Ireland may enable the UK to trade hydrogen or low carbon gas with our neighbours in the future.

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Internationally, the UK support to develop hydrogen roadmaps in Mexico and South Africa (e.g. UK And South Africa Commit to Unlock Investments for Major Infrastructure Projects and Green Hydrogen) through the UK Partnering for Accelerated Climate Transitions program, and UK Clean Energy Innovation Facility support for scoping green hydrogen production, priority uses and export opportunities in Morocco (The Morocco-UK power project is expected to supply 3.6GW of clean energy from Morocco to the UK).

Sources:
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1011283/UK-Hydrogen-Strategy_web.pdf
https://fleishmanhillard.eu/wp-content/uploads/sites/7/2022/02/FH-National-Hydrogen-Strategies-Report-2022.pdf
https://www.powermag.com/morocco-project-could-support-uks-renewable-goals-hydrogen-economy/
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https://hydrogen-central.com/uk-south-africa-commit-unlock-investments-major-infrastructure-projects-green-hydrogen/

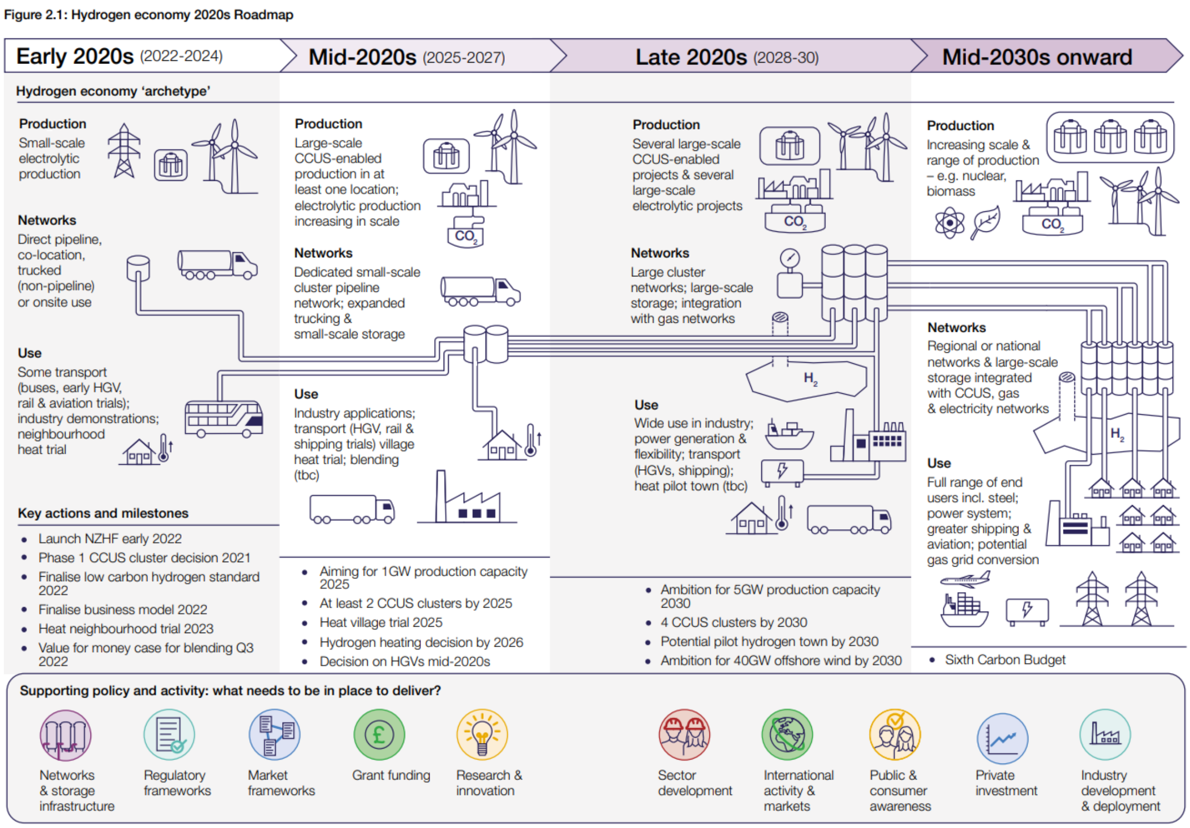

Figure 4: UK Hydrogen roadmap

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2.1.11. Synthesis of quantitative data

1. Data collection methodology

We have built an Excel file with over 250 entries (both EU and African Union countries) to track all the publicly available data regarding hydrogen production/demand/import/exports at the national level by 2030 and 2050 time horizons.

Different data sources are presented by order of reliability: first national roadmap data, then industry reports with, amongst others the EHB (European Hydrogen Backbone) and the TYNDP (Ten-Year-Network-Development-Plan), and also a diversity of industry forecasts reported in press articles.

There is a lot of information on the topic but also a lot of missing data. In the absence of reported data, estimations are possible to some extent. Even when roadmaps are published, a large part of the information is still missing or might need updates, especially in the post-REPowerEU context. Besides, one must keep in mind that meaningful data for 2030 is scarce, and very scarce for 2050.

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Table 2: Example of data collection table (non exhaustive)

id	Regic	Cour	Country na	Time h	Data type1	Data type2	Scenario	Original da	Unit1	Conversio	Rated data	Unit2	Data accura	Carbon intens	Source type	Data source	Source url	Comment	Release dat
EU04	EU	EU	European Un	2030	Export	n/a	min	-	Mtpa	-	-	Mtpa	Reported	Renewable	National roadmap	REpowerEU	https://energy.ec.eurc	No export quantities	may-25
KY01	AU	KY	Kenya	2030	Consumption	-	min	0,05	GW	Electrical	0,00	Mtpa	Reported	Renewable	National roadmap	Baseline study on the potential t	https://energypedia.ir		janv-22
KY04	AU	KY	Kenya	2030	Export	n/a	min	0,45	GW	Electrical	0,04	Mtpa	Estimate	Renewable	National roadmap	Baseline study on the potential t	https://energypedia.ir	Assuming that the re	janv-22
KY02	AU	KY	Kenya	2030	Production	-	min	0,50	GW	Electrical	0,05	Mtpa	Reported	Renewable	National roadmap	Baseline study on the potential t	https://energypedia.ir		janv-22
IT04	EU	IT	Italy	2030	Export	intra-EU	min	1,00	GW	Electrical	0,10	Mtpa	Reported	Renewable	Industry report	Green Hydrogen in Italy Develop	TBC	The clean electricity	TBD
MA01	AU	MA	Marocco	2030	Consumption	-	min	4,00	TWh	LHV	0,12	Mtpa	Reported	Renewable	National roadmap	Feuille de route hydrogène vert l	https://www.mem.gov		oct-21
ZA01	AU	ZA	South Africa	2030	Consumption	-	min	0,17	Mtpa	-	0,17	Mtpa	Reported	Low-carbon and	National roadmap	HSRM - Hydrogen Society Road	https://www.dst.gov.z		
BE04	EU	BE	Belgium	2030	Production	-	min	2,20	GW	Electrical	0,21	Mtpa	Reported	Renewable	Industry report	La Revue L'Energie - Decarbonis	https://www.wec-fran		oct-21
MA05	AU	MA	Marocco	2030	Export	n/a	min	7,30	TWh	LHV	0,22	Mtpa	Reported	Renewable	National roadmap	Feuille de route hydrogène vert l	https://www.mem.gov		oct-21
EG02	AU	EG	Egypt	2030	Production	-	min	0,22	Mtpa	-	0,22	Mtpa	Reported	Renewable	Article analysis	ReNewPower	https://renewpower.ir	On the assumption th	nov-22
MA02	AU	MA	Marocco	2030	Production	-	min	2,80	GW	Electrical	0,27	Mtpa	Reported	Renewable	National roadmap	Feuille de route hydrogène vert l	https://www.mem.gov		oct-21
AO02	AU	AO	Angola	2030	Export	n/a	min	0,28	Mtpa	-	0,28	Mtpa	Reported	n/a	Article analysis	Reuters	https://www.reuters.c		juin-22
DK01	EU	DK	Denmark	2030	Consumption	-	min	3,00	GW	Electrical	0,29	Mtpa	Reported	Renewable	Industry report	CIP Fonden Evaluation du marc	https://cipfonden.dk/v		mars-23
ES11	EU	ES	Spain	2050	Export	n/a	min	0,30	Mtpa	-	0,30	Mtpa	Reported	Renewable	Industry report	La Revue L'Energie - Decarbonis	https://www.wec-fran		oct-21
NA02	AU	NA	Namibia	2030	Production	-	min	0,30	Mtpa	-	0,30	Mtpa	Reported	Renewable	Article analysis	Energy Monitor	https://www.energym	Use of the press rele	juin-22
DK02	EU	DK	Denmark	2030	Production	-	min	4,00	GW	Electrical	0,38	Mtpa	Reported	Renewable	National roadmap	The Government's strategy for F	Strategi for Power-to-X (ens.dk)		2021
DK05	EU	DK	Denmark	2030	Export	intra-EU	min	4,00	GW	Electrical	0,38	Mtpa	Reported	Renewable	Industry report	CIP Fonden Evaluation du marc	https://cipfonden.dk/v	According to the vari	mars-23
ES02	EU	ES	Spain	2030	Production	-	min	4,00	GW	Electrical	0,38	Mtpa	Reported	Renewable	National roadmap	Spain Renewable Hydrogen Roa	https://agh2.org/wp-c		oct-21
TU02	AU	TU	Tunisia	2030	Production	-	min	4,00	GW	Electrical	0,38	Mtpa	Reported	Renewable	National roadmap	Study on the opportunities of "P	https://www.giz.de/er		avr-22
MA06	AU	MA	Marocco	2030	Export	n/a	max	15,40	TWh	LHV	0,46	Mtpa	Reported	Renewable	National roadmap	Feuille de route hydrogène vert l	https://www.mem.gov		oct-21
DE06	EU	DE	Germany	2030	Production	-	min	5,00	GW	Electrical	0,48	Mtpa	Reported	Renewable	National roadmap	The National Hydrogen Strategy	https://www.bmwk.de	14TWh assuming 40	2020
IT02	EU	IT	Italy	2030	Production	-	min	5,00	GW	Electrical	0,48	Mtpa	Reported	Renewable	National roadmap	Stratégie Nationale Hydrogène	https://www.mimit.go		nov-21
KY06	AU	KY	Kenya	2050	Production	-	min	5,00	GW	Electrical	0,48	Mtpa	Estimate	Renewable	National roadmap	Baseline study on the potential t	https://energypedia.i	Assuming that the re	janv-22
MA03	AU	MA	Marocco	2030	Production	-	max	5,20	GW	Electrical	0,50	Mtpa	Reported	Renewable	National roadmap	Feuille de route hydrogène vert l	https://www.mem.go		oct-21

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2. Results and preliminary conclusions on H_2 plan in EU countries and UK

All the data collected are gathered in Table 3 and Table 4 gathering the quantitative targets for Hydrogen demand production, exportation and importation respectively by 2030 and 2050.

Table 3: Synthesis quantified data related to Hydrogen plans of EU countries and UK by 2030

EU 2030 [Mtpa]	Demand	Production	Export			Import			Comments / hypothesis
			intra-EU	non-EU	Total	intra-EU	non-EU	Total	
Germany	2,7 - 2,9 - 3,3 - 3,9	0,5 - 1	n/a	-	n/a	n/a	1,5 - 2,1	1,5 - 2,1	
France	1	0,6	2	-	2	2	n/a	2	2 Mtpa transit (South corridor B)
Netherlands	1,4 - 1,7	0,3 - 0,4 - 0,6 - 0,8	n/a	-	n/a	n/a	n/a	n/a	
Italy	0,7 - 1,4	0,5	*0,1*	-	0,1	n/a	n/a	n/a	Export within the EU only
Spain	0,6 - 1,4	0,4 - 1	*2,5*	-	2,5	n/a	n/a	n/a	Export within the EU only
Belgium	0,8 - 1,1	0,2	n/a	-	n/a	n/a	*0,6*	0,6	Assuming non-EU imports
Poland	0,7	n/a	n/a	-	n/a	n/a	n/a	n/a	
Austria	0,2	0,1 - 0,2	n/a	-	n/a	n/a	n/a	n/a	
Denmark	0,3 - 0,8	0,4 - 0,6	*0,4*	-	0,4	n/a	n/a	n/a	Export within the EU only
Portugal	0,15	0,2	n/a	-	n/a	n/a	n/a	n/a	
European Union	14,7 - 20	10 - 12	-	-	-	-	5,4 - 10	5,40 - 10	
United Kingdom	0,8 - 1,3	1	-	-	-	-	n/a	n/a	

Legend 0,1 - 0,2 National roadmap data (min – max) 0,2 EHB data 2,5 Other industry reports *2,5* Estimation

Table 4: Synthesis quantified data related to Hydrogen plans of EU countries and UK by 2050

EU 2050 [Mtpa]	Demand	Production	Export			Import			Comments / hypothesis
			intra-EU	non-EU	Total	intra-EU	non-EU	Total	
Germany	11 - 15,2 - 21	3,2 - 5,5	n/a	n/a	n/a	n/a	n/a	7,8 - 15,5	
France	1,1 - 4,5 - 4,8	1,8 - 4,0	n/a	n/a	0,7	n/a	n/a	0 - 5	
Netherlands	3,9 - 4,6 - 4,7	2,6 - 3,0	n/a	n/a	n/a	n/a	n/a	1,3 - 1,7	
Italy	5,6 - 6,0 - 8,0	2,2 - 2,6	n/a	n/a	n/a	n/a	n/a	3,8 - 5,4	
Spain	2,6 - 3,5 - 7,8	2,9 - 3,9	*0,3 - 0,7*	n/a	0,3 - 0,7	n/a	n/a	n/a	100% of Spanish exportswithin EU
Belgium	2,8 - 3,3 - 3,8 - 6	1,8 - 2,0	n/a	n/a	n/a	n/a	n/a	1,0 - 1,3 - 6,0 - 10,5	
Poland	4,7	4,7	n/a	n/a	n/a	n/a	n/a	n/a	
Austria	1,6	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Denmark	2	6	n/a	n/a	n/a	n/a	n/a	n/a	
Portugal	0,8	0,8	n/a	n/a	n/a	n/a	n/a	n/a	
European Union	33 - 42,6	n/a	-	-	-	-	n/a	n/a	
United Kingdom	7,4 - 7,5 - 13,8	n/a	-	n/a	2,9	n/a	n/a	n/a	

Legend 0,1 - 0,2 National roadmap data (min – max) 0,2 EHB data 2,5 Other industry reports *2,5* Estimation

EU-countries have set production targets so far, for hydrogen market to organize around flagship projects until the next policy planning rounds.

EU countries hydrogen roadmaps mainly set objectives for 2030. Only Belgium and the United Kingdom (non-EU) have 2050 targets in terms of domestic consumption and/or exports.

Export from EU-countries is assumed to be intra-EU only. However, no consistent plan can be found among EU countries.

EU has set a **2030 target of 10Mtpa for non-EU hydrogen imports** but there is no consistent breakdown of the share of this import among EU countries. To our knowledge, the only consistent pan-european planning exercise so far has been the TYNDP (ten-year network

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development plan) by the European Hydrogen Backbone (EHB), which is detailed, in the next paragraph.
Large discrepancies remain in the evaluation of future domestic demand for hydrogen among EU countries.

- On a 2030 horizon, uncertainties lie mostly in keeping the schedule with large industry projects (DRI projects in steel works, ...) and subsequent midstream infrastructure. Other nascent hydrogen uses (transportation, high-grade industrial heat, mobility) should not bring a significant contribution to the overall volumes by 2030.
- On a 2050 horizon, all large industry projects should be in production or well advanced, as well as the hydrogen backbone infrastructure to funnel hydrogen to the main consumption sites. The other hydrogen uses cannot be considered as negligible anymore at this point in time but the extent of hydrogen uptake in mobility and transportation markets remains full of uncertainties as of 2023.

2.2 Assessment of potential EU "Hydrogen doors"

The integration of African green hydrogen import potentials into European hydrogen roadmaps is intrinsically linked to the identification of potential hydrogen corridors within the energy system. In particular, these volumes need to be supported by an accurate infrastructure deployment, both in terms of entry points into the European energy system and of relevant transmission and storage capacities at country level within the system.
In this context, we propose an assessment of main "Hydrogen doors" into the European energy system, based on a joint review of the expected import volumes and planned infrastructure in reference 2050 scenarios.

2.2.1 Review of North African import volumes in reference 2050 scenarios

The integration of green hydrogen in the European energy system is notably driven by both decarbonation and energy source diversification objectives, as reaffirmed in the 2022 REPowerEU Plan[1]. According to ENTSOs' scenarios, green hydrogen demand is expected to increase gradually until 2050, and may reach more than 60 million tons per year at EU-27 scale[2].
In the medium run, this demand is mostly supported by the amplification of hydrogen uses in the industry and transportation sectors. However, hydrogen-fired power generation also

[1] EUR-Lex - 52022DC0230 - EN - EUR-Lex (europa.eu)
[2] https://2022.entsos-tyndp-scenarios.eu/

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represents a significant part of hydrogen needs in 2040 and 2050 scenarios. The corresponding demand volumes at EU-27 level for “Distributed Energy“ and “Global Ambition“ TYNDP 2022 scenarios is presented in Figure 5.

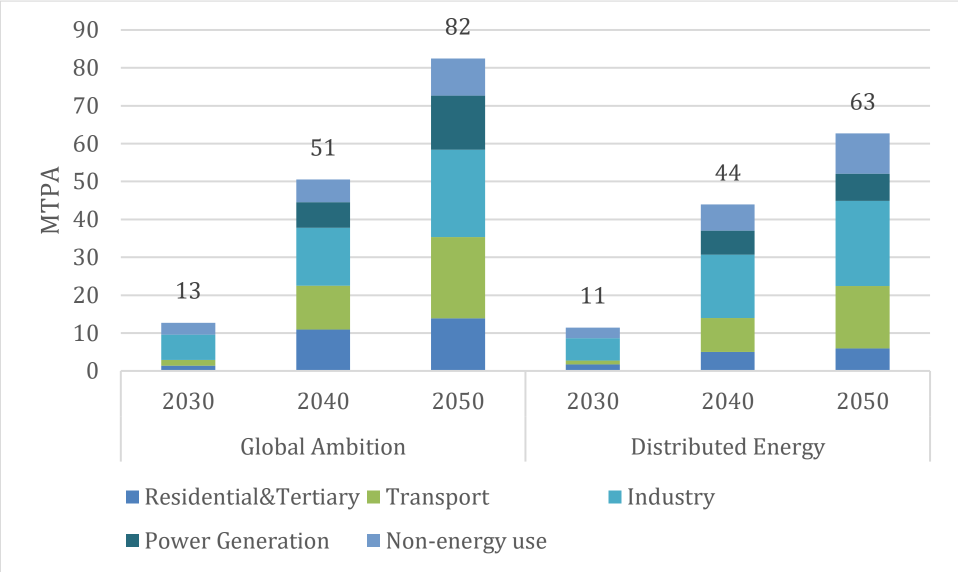

Figure 5: EU-27 hydrogen demand per sector - TYNDP 2022 Scenarios

For a 2030 horizon, these scenarios tend to expect domestic H2 generation to support the essential part of the EU-27 demand, relying either on electrolysis (P2G) or steam-methane and autothermal reforming with carbon capture (SMR/ATR-CCS). Extra-EU imports therefore mostly contribute to H2 supply in 2040 and 2050 horizons, as detailed on Figure 6.

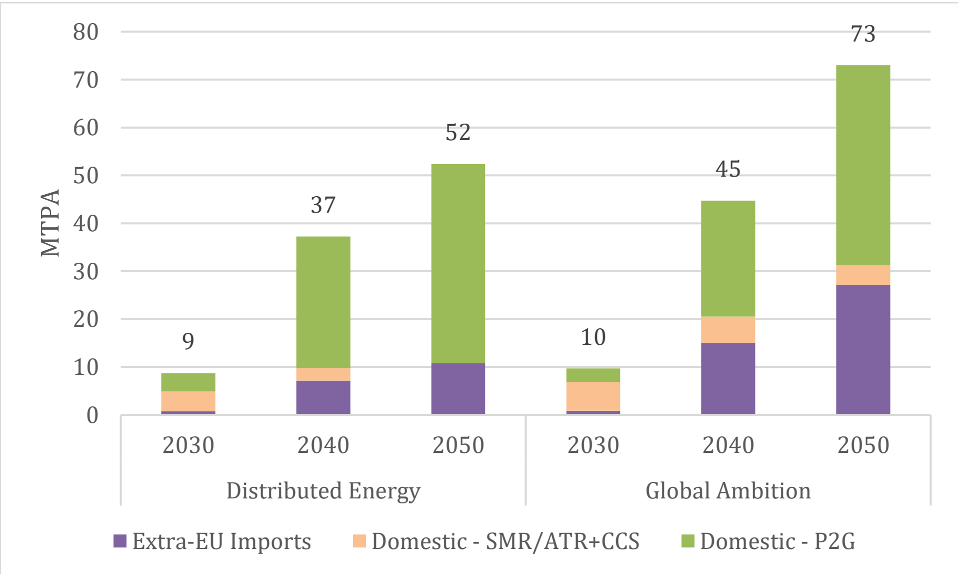

Figure 6: EU-27 Hydrogen Supply - TYNDP 2022 Scenarios

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Nonetheless, as a response to Russia's invasion of Ukraine and the global energy crises, the European Commission has set clear objectives for an accelerated integration of green hydrogen in the energy system. In particular, the REPowerEU Plan defines a 20 MTPA objective for domestic renewable hydrogen supply in 2030[3], including 10 million tons of domestic P2G, 6 million tons of gaseous or liquefied hydrogen imports and 4 million tons of ammonia and other derivatives. As illustrated in Figure 7, this projection mostly relies on an increase of hydrogen uses defined in the *Fit for 55* package, complemented with power generation and blending.

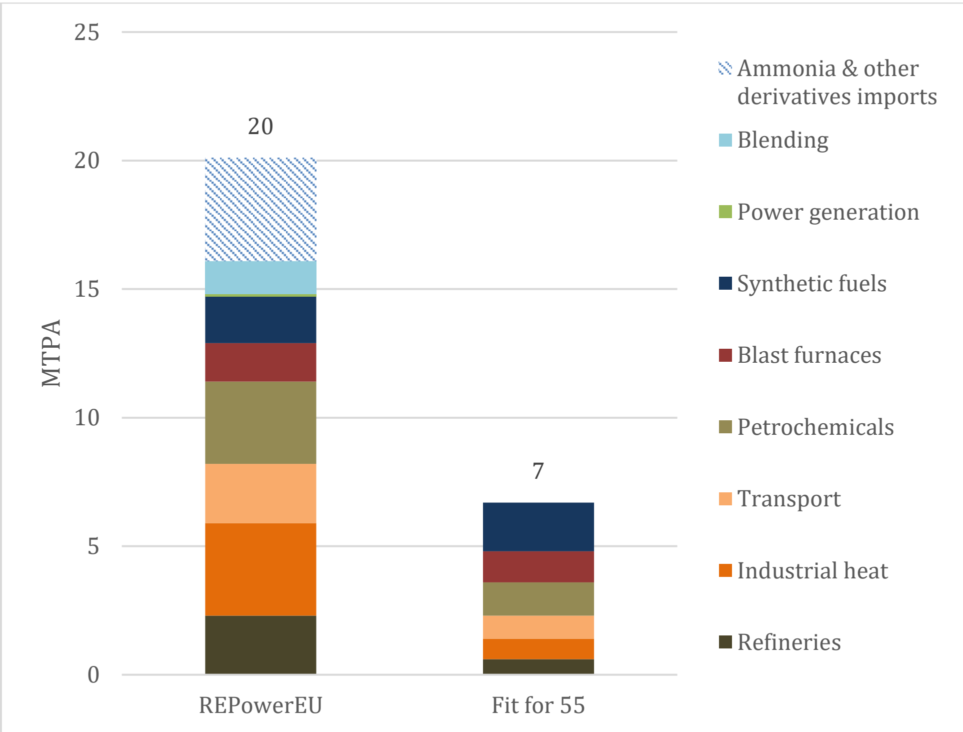

Figure 7: 2030 hydrogen uses by sector for EU-27 - REPowerEU v. Fit for 55 ambitions

In the context of a stronger reliance on extra-EU imports from 2030 onwards, 2050 scenarios for EU-27 hydrogen supply could also become more optimistic. In particular, the European Hydrogen Backbone initiative proposed a projection of the 2030 to 2050 H2 supply through five main European corridors, two of which involving North African import volumes[4]. Under this new assessment, 2050 H2 import potentials would represent 3.4 MTPA from Morocco and 11.3 MTPA from Tunisia and Algeria. These values are notably coherent with Morocco's

[3] REPowerEU: affordable, secure and sustainable energy for Europe (europa.eu)
[4] EHB-Supply-corridor-presentation-Full-version.pdf

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national hydrogen roadmap[5], but the estimation of export potentials from Tunisia and Algeria is said to be dependent on local demand and infrastructure development.

Table 5: 2040 and 2050 North African green H2 import potentials in reference European scenarios

Scenario	2040 import potential	2050 import potential
TYNDP 2022[6] – Distributed Energy	7.8 MTPA	7.8 MTPA
TYNDP 2022 – Global Ambition	7.8 MTPA	7.8 MTPA
European Hydrogen Backbone initiative[7]	5.9 MTPA (DZ+TU: 4.5; MA: 1.4)	14.7 MTPA (DZ+TU: 11.3; MA: 3.4)

Table 5 presents a summary of the North-African import potentials mentioned in this section. While additional hydrogen flows could be considered from other African regions, either through long-distance ship transportation, ammonia or other derivatives, liquefied and gaseous H2 imports from and through North African countries may represent the main hydrogen supply to the EU from the African continent. The identification of these volumes and of the associated entry points into the European energy system may therefore represent a key driver for the deployment and adaptation of a domestic H2 infrastructure.

2.2.2. Identification of main entry points to Europe in reference 2050 scenarios

As previously mentioned, low carbon hydrogen exports from North Africa represent the most evident source of low carbon hydrogen imports into the European energy system. In this context, the repurposing of cross-Mediterranean natural gas pipelines appears as the main avenue for hydrogen transfers between both continents.

In particular, the European Hydrogen Backbone initiative identifies two existing natural gas pipelines as repurposing candidates: the Maghreb-Europe Gas (MEG) pipeline between Morocco and Spain, and the Transmed pipeline between Tunisia and Italy (Sicily). The Medgaz pipeline between Algeria and Spain is also mentioned in a study from the German Agency for International Cooperation (GIZ) GmbH[8]. Table 6: presents the main characteristics of these pipeline projects. In particular, it can be noted that the sole repurposing of the MEG and Transmed pipelines seems sufficient to handle import potentials presented in Table 5.

[5] Feuille de route de l'hydrogène vert (mem.gov.ma)
[6] https://2022.entsos-tyndp-scenarios.eu/
[7] EHB-Supply-corridor-presentation-Full-version.pdf
[8] 21_12_07_Hydrogène_vert_en_Algérie_-_Rapport_PE.pdf (energypartnership-algeria.org)

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Table 6: Main characteristics of cross-Mediterranean natural gas pipelines[9]

Project	From	To	H2 transmission potential
MEG	Tangier (MA)	Tarifa (ES)	4.9 MTPA
Transmed	El Haouaria (TU)	Mazaro del Vallo (TU)	12.6 MTPA
Medgaz	Béni Saf (DZ)	Almeria (ES)	3.2 MTPA

As detailed in section 2.2 significant volumes of hydrogen could also be imported and used directly in the form of ammonia or other derivatives. Consequently, ship transportation of liquid hydrogen (LH2) constitutes another serious avenue for extra-EU hydrogen imports. In the last *System Assessment Report* from TYNPD 2022, ENTSOG notably identifies a 4.9 MPTA import capacity (164 TWh LHV per year) for LH2 imports by 2030, which could become even more significant in 2040 and 2050 scenarios.
While these capacities are not exclusively associated with African low carbon hydrogen volumes, future LH2 terminals may offer an opportunity to handle extra-EU imports through more Member States, which could support a more efficient distribution of infrastructure development efforts.

2.2.3. Assessment of main hydrogen corridors involving African low carbon H2 integration in the European energy system

As discussed in previous paragraphs, low carbon H2 imports from the African continent may already represent several million tons per year by 2030, either supported by Spain and Italy or by a greater number of Member States thanks to LH2 or ammonia ship transportation.

As hydrogen demand is highly driven by industry and transport uses, this supposes the development of hydrogen corridors within the European energy system in order to transport imported hydrogen volumes towards regions with highest needs. In particular, the European Hydrogen Backbone initiative identifies two main corridors involving African green hydrogen imports, respectively from the Iberian Peninsula to Germany and from Italy to Germany.

African low carbon H2 import volumes are therefore to be put in perspective with the planned infrastructure along these corridors. ENTSOG has notably published the cross border H2 transmission capacities used in the latest *System Assessment Report*[10], in which two levels of infrastructure deployement are considered:

- Hydrogen Infrastructure Level 1: composed of all hydrogen projects submitted to the TYNDP 2022 as well as hydrogen projects submitted to the first PCI selection process under the TEN-E Regulation.

[9] 21_12_07_Hydrogène_vert_en_Algérie_-_Rapport_PE.pdf (energypartnership-algeria.org)
[10] https://tyndp2022.entsog.eu/system-assessment/

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* Hydrogen Infrastructure Level 2: composed of Hydrogen Infrastructure Level 1 and additional infrastructure assumptions needed to enable policy objectives, such as the 2030 hydrogen imports targets defined by the REPowerEU Plan.

On the one hand, the cross-border capacities corresponding to Level 2 infrastructure development is therefore supposed to support the extra-EU H2 import dynamics projected in TYNDP 2022 scenarios. However, as the recent intensification of H2 integration ambitions paves the way for more ambitious 2050 extra-EU import targets (see Table 5), questions remain regarding the robustness of these cross-border capacities to more ambitious import potentials.

Figure 8 presents a quantification of relative 2050 hydrogen transfers induced by African low carbon H2 imports along the corridors identified by the European Hydrogen Backbone initiative. Relative flows were evaluated based on national demand and supply volumes estimated by EHB for the year 2050. The corresponding volumes are therefore put in perspective with annual cross border capacities provided in the latest ENTSOG *System Assessment Report*[11]. First observations show that even Level 2 of infrastructure deployment tends to be insufficient to support the routing of ambitious import volumes of African green hydrogen. For example, it appears that EHB 2050 import potentials from Tunisia and Algeria could imply a net export of 8.4 MTPA for Italy, which only presents a 3 MTPA export capacity towards other Corridor A countries according to ENTSOG's *System Assessment Report*. The same saturation of planned transmission capacities can be observed for Corridor B countries, which are supposed to handle imports from Morocco.

[11] https://tyndp2022.entsog.eu/system-assessment/

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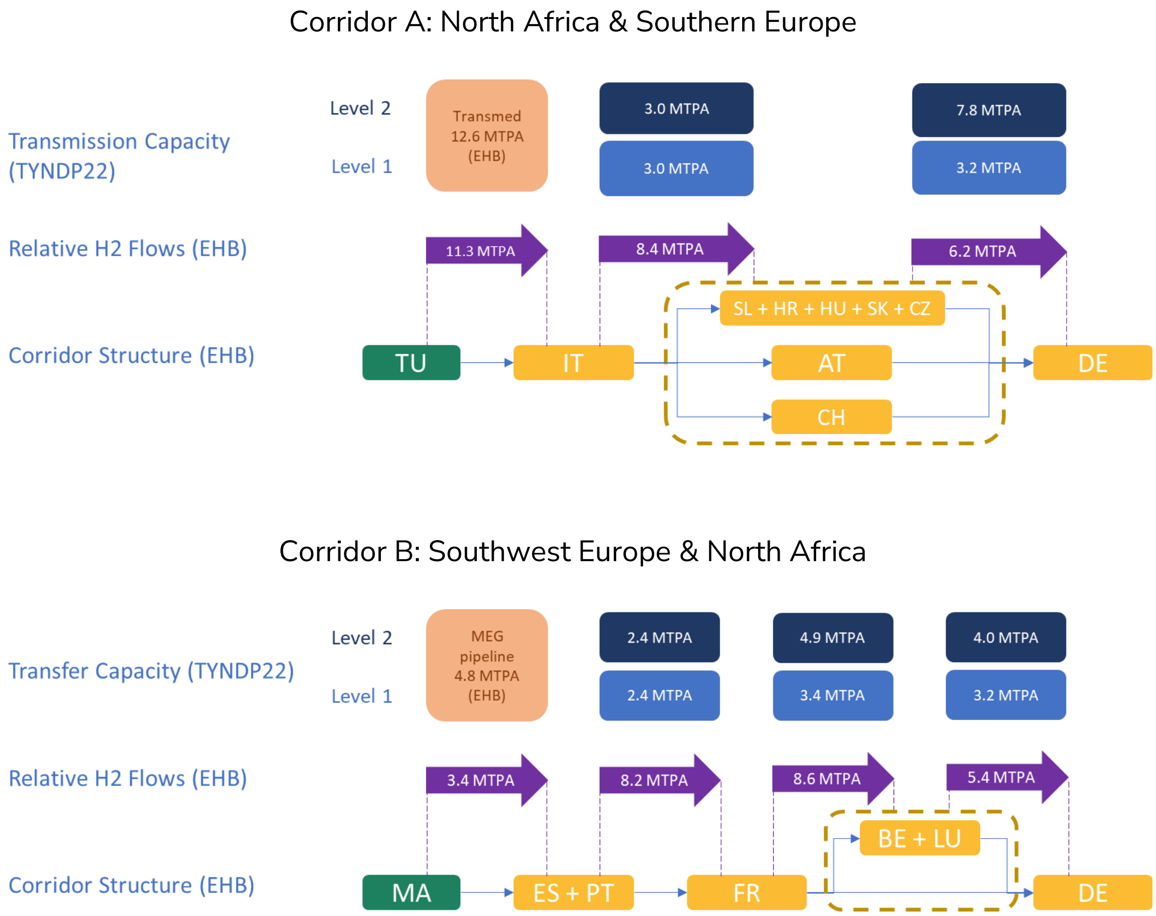

Figure 8: 2050 hydrogen flows v. TYNDP 2022 cross-border capacities along EHB corridors

While this analysis concentrates on pipeline transmission and may disregard the possible contribution of other European countries outside a given corridor, it illustrates how extra-EU imports can create a polarization of trans-European hydrogen transfers that concentrates infrastructure needs over a few strategic Member States.

It is nonetheless clear that LH2 and ammonia imports could help distribute infrastructure deployment efforts upon other regions of Europe, as illustrated in Figure 9. However, questions remain regarding residual adaptations of infrastructure deployment within the European energy system. From a general perspective, this assessment therefore tends to confirm that both the volume and spatial organization of African green hydrogen imports are likely to challenge current system-wide estimates of 2050 infrastructure needs.

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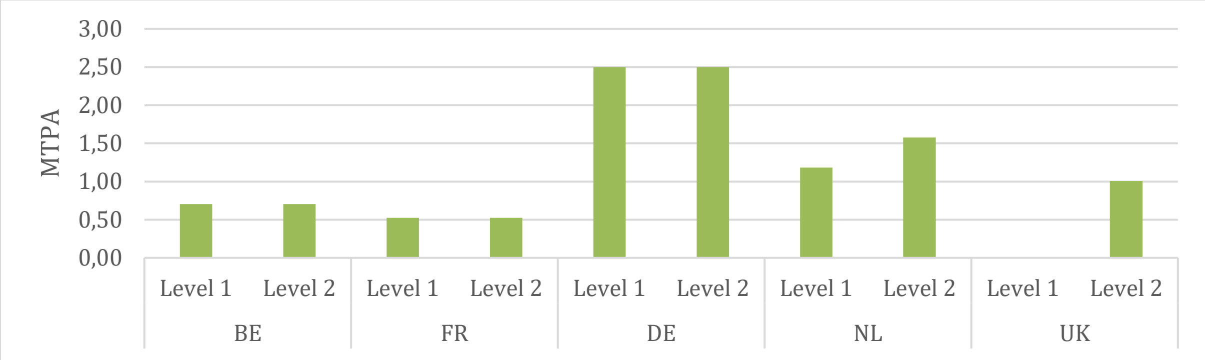

Figure 9: 2050 LH2 import capacities by country - TYNDP 2022 System Assessment Report (ENTSOG)

2.2.4. Main conclusions regarding H_2 corridors

Main outcomes from section 2.2 can be defined as follows:

While the EU-27 green hydrogen demand is expected to massively increase in the next decades, the amplification of 2030 objectives suggests that **even more ambitious African green H2 import volumes could be reached by 2050**.

Existing prospective studies tend to suggest that 2050 green H2 import volumes from Africa could generally be handled through **the repurposing of strategic cross-Mediterranean natural gas pipelines** as well as **ship transportation of liquefied hydrogen**.

However, most ambitious import scenarios may lead to a strong concentration of hydrogen flows around a few Member States, which suggests **significant adaptations in the deployment of a trans-European hydrogen infrastructure.**

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3. AFRICAN NATIONAL HYDROGEN ROADMAPS AND STRATEGIES ASSESSMENT

The goal of this chapter is to present and compare existing African "Hydrogen roadmaps" (elaborated by African Hydrogen Partnership as well as by local governments) to have a database helpful to be compared/benchmarked with EU one presented in chapter 2 in order to identify point of contacts and of mutual benefits.

Considering African high renewable potential and the commercial and infrastructural interactions between EU and Africa, it's relevant to develop mutual benefit hydrogen roadmaps that could unlock African green hydrogen potential.

3.1 Introduction

To kick off project activities, it is important to assess the current level of development of green hydrogen projects/policies in Africa and understand how such plans could interact with European ones, answering to four key questions that could drive local National hydrogen plans.

<u>QUESTION 1:</u> can Africa produce enough green hydrogen also to target export to Europe?

The possibility to export relevant quantities of green hydrogen African Renewable (RES) potential is globally acknowledged: thanks to green hydrogen production via electrolysis, this RES potential could be unlocked. In order to understand if Africa would be able within 2030 to produce green hydrogen needs from EU, an analysis of the existing National hydrogen policies/plan have been performed together with an assessment of current renewable production. Such assessment is the basis of all project activities. **It's relevant to highlight that only few countries have setup H2 plans (Egypt, South Africa, Morocco, Namibia, Algeria) as presented in the next paragraphs**

A more precise assessment of current and future green hydrogen potential of different African countries (currently under finalization by JULICH and UNIGE) will be presented in D1.2, while in the next table and paragraphs, green hydrogen production intentions stated in the different countries existing "Hydrogen policies/plans" will be duly presented and highlighted.

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Table 7: Presentation of main African existing hydrogen policies and evaluation of low carbon hydrogen production targets defined thereby

Country	Green Hydrogen Production Target	RES Production
Egypt	**Policy view:** 60 kt/yr since 2035 **MoU/Industrial view:** 2,5 Mt/yr announced (+ 3 Mt/yr green ammonia)	24 TWh (2021 – hydro, solar, wind) 750/1100 MW wind/solar (2035)
South Africa	**Policy view:**500 kt/yr since 2030 - **MoU/Industrial view:** 30 GW electrolysis by 2040, 1 Mt/yr and 780 kt/yr green ammonia	9,5 TWh (2021 – solar, hydro, wind) 4,5 GW of wind and solar by 2030
Kenya	**Policy view:**under development **MoU/Industrial view:** 1,7 Mt/yr of green hydrogen	9,5 TWh (2021 – geothermal,hydro) Within 2035 +3GW geothermal
Algeria	**Policy view:**540 kt/yr since 2040 **MoU/Industrial view:** 1,8 Mt/yr of green/blue Hydrogen	0,7 TWh (2021 – solar) +13 GW solar by 2030
Morocco	**Policy view:**540 kt/yr since 2040 **MoU/Industrial view:** 1,8 Mt/yr of green/blue Hydrogen	7 TWh (2021 – solar, wind, hydro) by 2030 +10 GW wind, solar, hydro
Mauritania	**Policy view:**under development - **MoU/Industrial view:** 3,4 Mt/yr of green hydrogen + 10 Mt green ammonia	0.27 TWh (2021 – solar, wind) +40 GW wind, solar by 2030
Namibia	**Policy view:**1 Mt/yr by 2030, 5 Mt/yr by 2040, 10 Mt/yr by 2050 **MoU/Industrial view:** up to 15 Mt by 2050	1.67 TWh (2021 –hydro, solar) >5000 GWh/yr by RES by 2035

***QUESTION 2:* where is Hydrogen demand in Africa?**

Another driver that can boost green hydrogen plans in African countries is the presence of an existing local hydrogen demand, to be covered by a clean self-production of this energy vector/fuel. Currently hydrogen is mostly used in Africa in Refineries (grey hydrogen) and ammonia/chemical/fertilizer production plants. Nevertheless **sectors like cement, mining, steel could be decarbonized thanks to hydrogen use.** Current sectors/countries could be attractive for hydrogen usage (and therefore these countries could soon develop self-production green hydrogen plans):

- ***FERTILIZER:*** Ethiopia, Algeria, Morocco, Egypt, South Africa
- ***STEEL:*** Egypt, Namibia, Nigeria, Zimbabwe, Morocco, Tunisia
- ***REFINERY:*** Egypt, Algeria, Morocco, South Africa, Nigeria
- ***MINING:*** DR Congo, Mali, Zambia, Mauritania

***QUESTION 3:* are African infrastructure ready to export hydrogen to Europe?**

The presence of natural gas infrastructure (where hydrogen could be injected to be transferred to EU) and/or the presence of relevant routes/fleet operating between Africa and Europe can be another driver to support the setup of green hydrogen value chains in specific African countries.

Hydrogen could be indeed exported via ships (as pure H2 or as ammonia or other hydrogen carriers) or via NG pipeline. As already presented in §2.2, current Africa/Italy and Africa/Spain pipelines could be able to transfer the whole planned production (considering 1 to 5% in volume of NG pipeline capacity and current NG export rates): H2 injection/extraction units must be considered. Looking at ships, H2 tankers have still to be fully developed, while ammonia tankers are state of the art. Of course **African ports must be ready to host this type of vessel**. Generally speaking H2 should be transferred from North Africa and sub-

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Saharian area via existing pipelines (developing internal infrastructure), while via Tankers from Sourthern/Eastern Africa (also opening extra-EU export of hydrogen).

***QUESTION 4:* where to act first in Africa (from a geographical and sectorial point of view)?**
This is actually one of the key question of the overall project: according to the results of this chapter (thus considering existing policies, H2 demand and NG infrastructure), **North Africa is for sure a key area of development particularly looking at export to EU**. Namibia and South Africa could be relevant countries too considering the presence of shipping routes between Africa and Europe (Netherlands, Belgium, Germany, Spain, France) relevant European investment in such areas and shipping , as well as Ethiopia and Ghana. Generally speaking once defining where to act first, it's relevant to consider further than aspects above presented, political stability and electrification.

In the next pages, starting from a preliminary assessment of African countries low carbon hydrogen policies, a preliminary analysis of national plans that AU countries are currently promoting and putting in place for deploying low carbon hydrogen is presented.
A deeper analysis of them will be then presented in D1.2 "Assessment of African Green H2 SotA context" where a complete presentation of activities performed in T1.1 will be presented to show "Region per region" (among the four areas identified in T1.1 subtask) which is local green hydrogen potential, not only looking at assessment of National hydrogen policies, but also at other local aspects/drivers that would support the identification in each area of the use cases to be studied and modelled in WP2.

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3.2. African continental presentation

In the current sub-chapter (and in following §3.3-3.4) a preliminary presentation of African low carbon hydrogen potential (as analysed by AHP) is described. This analysis will be further expanded in D1.2.

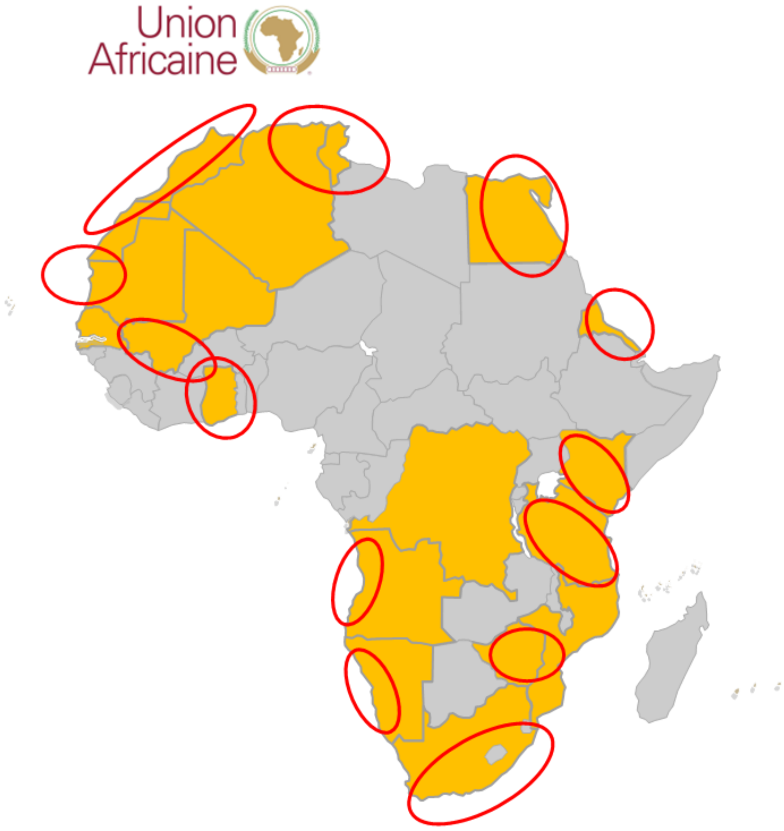

Figure 10: African countries where Hydrogen roadmaps or industrial programs are announced and countries analysed in the Just Green Afrh2ica project

According to African Hydrogen Partnership (who is managing a living low carbon hydrogen database, constantly updated by the partner), African countries' commitment to developing green hydrogen projects can be segmented in three categories depending on the degree of maturity of their Hydrogen strategy definition as well as on the analysis of locally in place initiatives.

Table 8: Tier-1 countries with rather well defined hydrogen strategy

Algeria	In depth analysis of the regulatory environment. National Plan approved in May 2021 (but not available)
Egypt	Egypt's Energy Strategy 2035 to Include Green Hydrogen
Kenya	There are no laws or policies regulating the production, storage, and distribution of green hydrogen in Kenya, the existing general legal framework supports the adoption and utilisation of clean energy in the country (wind and solar)
Mauritania	No specific strategies, but different initiatives on going at governmental and industrial level to promote green hydrogen locally

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Morocco	Morocco's Green Hydrogen Roadmap and Hydrogen Strategy
Namibia	Namibia Green Hydrogen Strategy (Developed and launched, online version to be published)
South Africa	South African Hydrogen Society Roadmap

As presented in Table 9, gathering Tier-1 AU countries low carbon hydrogen policies, except for Namibia (which is setting up very ambitious low carbon hydrogen production values particularly targeting 2050 horizon), an overall amount of around 3 Mt/yr of low carbon hydrogen is currently declared to be produced in AU countries within 2040. This is a value quite distant from RePowerEU Plan imports need (10 Mt/yr) and, furthermore, this production value is not fully dedicated to export.

Table 9: Tier-2 countries with elements of hydrogen ambition available

Angola	Plans to conduct conceptual and engineering studies for the development of a green hydrogen production program as part of its energy transition strategy. https://www.bunkerspot.com/africa/55677-africa-sonangol-mulling-green-hydrogen-production (login necessary)
Botswana	No national plan or regulation adopted. Tlou Energy developing private hydrogen strategy.
Cameroun	No national plan or regulation adopted.
Côte d'Ivoire	Preparative measures for the new Hydrogen Programme to kick start in four WASCAL member countries (Côte d'Ivoire, Togo, Niger, and Senegal)
Djibouti	No national plan or regulation adopted.
DRC	In 2021, the then German Chancelor's Africa Commissionner Gunter Nooke proposed to use excess electricy from hydroplant INGA 3 to produce hydrogen. Fortescue Future Industries has conducted preliminary studies for nearly USD 25 million on a use of the Pioka, Matadi and Grand Inga dam.
Ethiopia	Taskforce pooled from the Ministry of Finance and the Ministry of Water and Energy (MoWE) is finalizing a new policy and strategy document on Green Hydrogen
Niger	Preparative measures for the new Hydrogen Programme to kick start in four WASCAL member countries (Côte d'Ivoire, Togo, Niger, and Senegal)
Senegal	Preparative measures for the new Hydrogen Programme to kick start in four WASCAL member countries (Côte d'Ivoire, Togo, Niger, and Senegal)
Togo	Preparative measures for the new Hydrogen Programme to kick start in four WASCAL member countries (Côte d'Ivoire, Togo, Niger, and Senegal)
Tunisia	Hydrogen has been designated as a key green energy, notably in the context of the Tunisian-German Alliance for Green Hydrogen
Uganda	THE RENEWABLE ENERGY POLICY FOR UGANDA (cites hydrogen without entering into much details)
Zambia	No national plan or regulation adopted.
Zimbabwe	No mention of hydrogen in the Renewable Energy Policy of 2019; however, Zimbabwe is involved in the Green Hydrogen Atlas, and the Ministry of Energy and Power Development has indicated "clean hydrogen" as a priority low-emissions technology.

It is worth highlighting that among Tier-2 countries (Table 9) there are countries like Ethiopia (which has already today a significant renewable power production mostly through

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hydropower) and Tunisia (who has efficient NG infrastructure connected with EU) which could have a relevant hydrogen export potential.

Among Tier-3 countries (Table 10 below), there are countries like Tanzania, Mozambique and Ghana who could have (for several different reasons) a relevant hydrogen export potential.

Table 10: Tier-3 countries with no hydrogen ambition expressed

Benin	No national plan or regulation adopted.
Burkina Faso	No national plan or regulation adopted.
Burundi	No national plan or regulation adopted.
Cape Verde	No national plan or regulation adopted.
CAR	No national plan or regulation adopted.
Chad	No national plan or regulation adopted.
Comoros	No national plan or regulation adopted.
Congo-Brazzaville	No national plan or regulation adopted.
Equatorial Guinea	No national plan or regulation adopted.
Eritrea	No national plan or regulation adopted.
Eswatini	No national plan or regulation adopted.
Gabon	No national plan or regulation adopted.
Gambia	No national plan or regulation adopted.
Ghana	No national plan or regulation adopted. Calls by Institute for Energy Security think tank to the Government to develop national plan.Impact Hydrogen and Jacob Lawren Ltd developing a roadmap towards a Hydrogen Value Chain.
Guinea	No national plan or regulation adopted.
Guinea-Bissau	No national plan or regulation adopted.
Lesotho	No national plan or regulation adopted.
Liberia	No national plan or regulation adopted.
Libya	No national plan or regulation adopted.
Madagascar	No national plan or regulation adopted.
Malawi	No national plan or regulation adopted.
Mali	No national plan or regulation adopted.
Mauritius	No national plan or regulation adopted.
Mozambique	No national plan or regulation adopted.
Nigeria	No national plan or regulation adopted.
Rwanda	No national plan or regulation adopted.
Sao Tome and Principe	No national plan or regulation adopted.
Seychelles	No national plan or regulation adopted.
Sierra Leone	No national plan or regulation adopted.
Somalia	No national plan or regulation adopted.
South Sudan	No national plan or regulation adopted.

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Sudan	No national plan or regulation adopted.
Tanzania	No national plan or regulation adopted.

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3.3 Examples of national strategies of African countries

In this sub-chapter examples of some African Hydrogen National policies and strategies are detailed.

3.3.1 South Africa hydrogen roadmap

Currently, African energy infrastructure historically dominated by coal needs and many power stations will thus need to be decommissioned over the next three decades while renewable energy to the national portfolio is largely represented by wind (2.5 GW) and solar PV (2 GW).

The REIPPPP (Renewable Energy Independent Power Producer Procurement Program) has to date contracted a total of 6.4 GW of capacity, with a further allocation of 1 GW of solar PV and 1.6 GW of wind having been recently promulgated.

The Hydrogen Society Roadmap (HSRM) outlines a number of targets, including the creation of an export market for low carbon hydrogen and ammonia, the implementation of a Center of Excellence in manufacturing for hydrogen products, the development of domestic hydrogen supply chains, the production of 500 kilotons of green hydrogen by 2030, and a long term target of 15 GW power generation based on hydrogen by 2040. Further targets include a 1 MW small-scale electrolysis facility operated by 2025, and the deployment of 10 GW electrolyzers in the Northern Cape and 1.7 GW electrolyzers in the Hydrogen Valley by 2030.

The implementation of the HSRM is expected to contribute to the goal of a just and inclusive net-zero carbon economic growth for societal wellbeing by 2050 through the following high-level outcomes:

- Decarbonization of heavy-duty transport
- Decarbonization of energy-intensive industry (cement, steel, mining, refineries)
- Enhanced and green power sector (main and micro-grids)
- Centre of Excellence in Manufacturing for hydrogen products and fuel cell components
- Creating an export market for South African green hydrogen
- Increase the role of hydrogen (grey, blue, turquoise and green) in the South African energy system in line with the move towards a net-zero economy

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South Africa, alongside Egypt, Kenya, Morocco, Mauritania and Namibia, launched the Africa Green Hydrogen Alliance, with the intention to foster collaboration and ensure the continent is able to lead in the development of green hydrogen for energy transition.
The timeline of the HSRM roadmap can be summarized as follows:

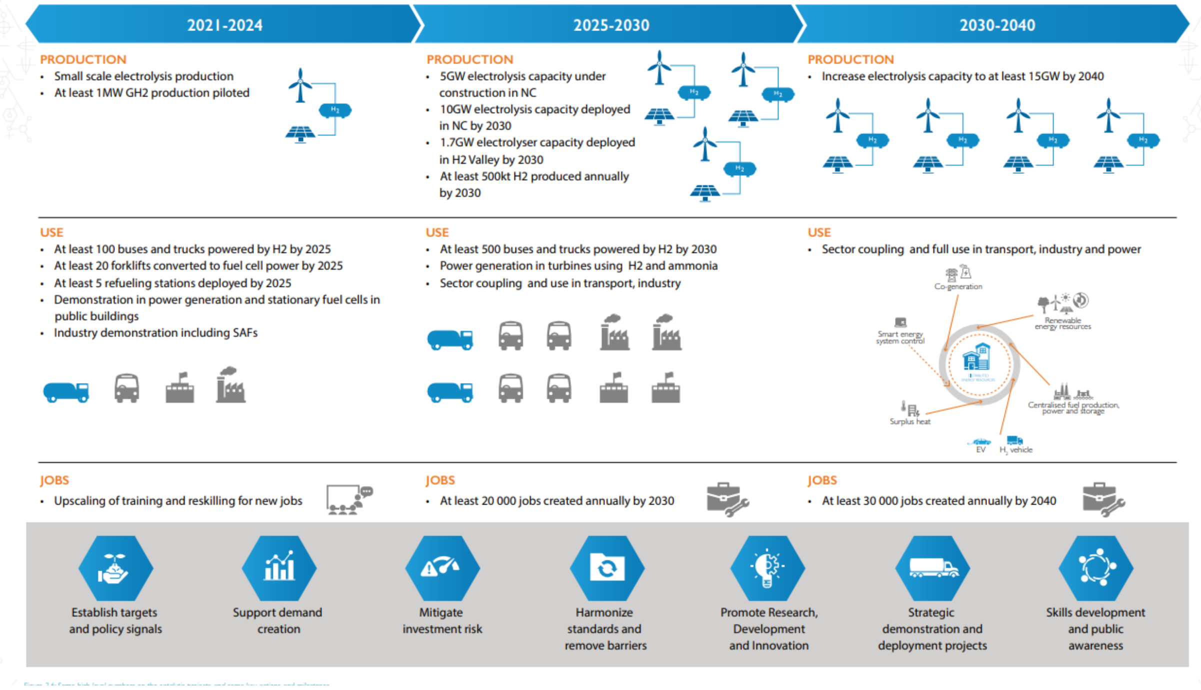

Figure 11: Timeline of the Hydrogen Society Roadmap in South Africa

3.3.2. Morocco hydrogen roadmap

The Green H2 plan of Morocco includes a strategy considers in 3 phases of development:

1. In the short term (2020-2030) the main priorities are Green H2 exports (MoU Germany), local usage for national industry, especially phosphates, and exploration of natural hydrogen deposits.
2. In the medium term (2030-2040) Morocco will focus on developing hydrogen projects and using Green h2 as an energy storage vector.
3. In the long term (2040-2050), the roadmap foresees higher levels of exports and ammonia production.

The National Roadmap outlines also an implementation pathway revolving around three main axes:

a. Technological developments and cost savings;
b. Investment and procurement, including the establishment of an industrial cluster and the elaboration of a Master Plan for the corresponding infrastructure;
c. Market and demand, referring to the realization of demand opportunities, giving rise to new markets

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Also, eight actions were identified for the development of Green H2 in Morocco: Cost Reduction; Research & Innovation; Local content; Industrial Cluster; Domestic markets; Storage; Exports; Financing. Especially on export, the proximity with the European continent makes Morocco a strategic partner of the first rank. Several European countries, including Germany, have expressed their willingness to consolidate their energy partnership with Morocco. Indeed, Morocco could rely on its gas and port infrastructure well connected to the Atlantic and the Mediterranean to the Atlantic and the Mediterranean to set up a logistics platform for exporting green hydrogen and hydrogen and its products to Europe.

3.3.3 Namibia hydrogen roadmap

With its world-class renewable energy sources, Namibia is poised to help fill the anticipated global H2 demand-supply gap and lower the cost of the net-zero transition. Namibia will be able to produce hydrogen ((LCOH) of just US$1.2-1.3/kg for production by 2030) and its derivatives at highly competitive costs thanks to unique mix of wind and solar resources which could provide a stable supply of very low-cost clean power for H2 production.

Namibia is well placed to serve markets in Europe, China, Japan and South Korea and other parts of the world. Namibia aspires to create an at-scale green fuels industry with a production target of 10- 12 Mtpa H2 equivalent by 2050 with an intermediary goal of 1-2 Mtpa of H2 equivalent in 2030.

To this end, it will develop three hydrogen valleys; in the southern region of Kharas, the central region including Walvis Bay port and the capital Windhoek, and the northern region of Kunene.

Many countries, particularly in Europe, will not be able to meet their demand fully and/or cost-effectively through domestic production. To secure sufficient supply at low cost they will have to form energy partnerships with countries that have abundant renewable energy resources, e.g., the European Commission's REPowerEU programme sets an import target of 10 Mt of green hydrogen by 2030.

Indeed, The European Hydrogen Strategy has identified the African Union as partner for research and innovation, technological development, transport infrastructure and regulatory policy.

It has already signed memoranda of understanding (MoUs) with Germany, Belgium, the Netherlands and Japanese companies and another is in the pipeline with the European Union.

Also, Namibia aspires to establish an integrated, thriving green ecosystem across Southern Africa by creating synergies in infrastructure (e.g., shared ports, pipelines and transmission networks) green transport corridors and job opportunities across borders – particularly with South Africa, Botswana, Zambia and Angola.

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3.4 Synthesis of the first AU green hydrogen policies assessment

Available strategies have been gathered in a similar tables as the ones built for European countries for 2030 and 2050 perspectives. It is expected that as the Just Green AfrH2ica project will progress, these tables will get more and more documented.

Table 11: Synthesis quantified data related to Hydrogen plans of AU countries by 2030

AU 2030 [Mtpa]	Demand	Production	Export	Import	Comments / hypothesis
South Africa	0,2	0,5	n/a	n/a	
Algeria	n/a	n/a	2	n/a	Assuming 10% of REPowerEU's demand in 2030
Tunisia	n/a	0,4	2,1	2	Assuming all Algerian H2 exports via South corridor A
Marocco	0,1	0,3 - 0,5	0,2 - 0,5	n/a	
Mauritania	n/a	1,7	n/a	n/a	
Namibia	n/a	0,3	n/a	n/a	
Egypt	n/a	0,2	n/a	n/a	
Angola	n/a	0,7	0,3	n/a	
Kenya	0,005	0,05	0,045	n/a	Assuming that the excess production is 100% exported
Congo (Democratic Republic of)	n/a	n/a	n/a	n/a	No existing data / no data found
Ghana	n/a	n/a	n/a	n/a	No existing data / no data found
Mali	n/a	n/a	n/a	n/a	No existing data / no data found
Mozambic	n/a	n/a	n/a	n/a	No existing data / no data found
Niger	n/a	n/a	n/a	n/a	No existing data / no data found
Senegal	n/a	n/a	n/a	n/a	No existing data / no data found
Tanzania	n/a	n/a	n/a	n/a	No existing data / no data found
Zimbabwe	n/a	n/a	n/a	n/a	No existing data / no data found
Total AU	n/a	n/a	n/a	n/a	No existing data / no data found

Legend 0,1 - 0,2 National roadmap data (min – max) 0,2 EHB data 2,5 Other industry reports *2,5* Estimation

Table 12: Synthesis quantified data related to Hydrogen plans of AU countries by 2050

AU 2050 [Mtpa]	Demand	Production	Export	Import	Comments / hypothesis
South Africa	1,9	4,0	1,9	n/a	
Algeria	n/a	n/a	n/a	n/a	No existing data / no data found
Tunisia	0,5 - 2,5	n/a	n/a	n/a	
Marocco	1,2	n/a	3,5	n/a	
Mauritania	n/a	n/a	n/a	n/a	No existing data / no data found
Namibia	n/a	10 - 15	n/a	n/a	
Egypt	n/a	n/a	n/a	n/a	No existing data / no data found
Angola	n/a	n/a	n/a	n/a	No existing data / no data found
Kenya	n/a	0,5	n/a	n/a	
Congo (Democratic Republic of)	n/a	n/a	n/a	n/a	No existing data / no data found
Ghana	n/a	n/a	n/a	n/a	No existing data / no data found
Mali	n/a	n/a	n/a	n/a	No existing data / no data found
Mozambic	n/a	n/a	n/a	n/a	No existing data / no data found
Niger	n/a	n/a	n/a	n/a	No existing data / no data found
Senegal	n/a	n/a	n/a	n/a	No existing data / no data found
Tanzania	n/a	n/a	n/a	n/a	No existing data / no data found
Zimbabwe	n/a	n/a	n/a	n/a	No existing data / no data found
Total AU	n/a	n/a	n/a	n/a	No existing data / no data found

Legend 0,1 - 0,2 National roadmap data (min – max) 0,2 EHB data 2,5 Other industry reports *2,5* Estimation

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4. OTHER ON-GOING HYDROGEN INITIATIVES FOR AU-EU INTERACTION

4.1 Introduction and context

Looking at the potential market impact of a "Green Hydrogen Revolution" in Africa (supportive to EU Hydrogen transition an vice-versa), the following three major markets are considered:

1) Demand in Africa - Local Markets as presented in chapter 3 ((e.g. green ammonia and fertilizer for the African agricultural sector or green hydrogen for decarbonizing the mining/chemical industry – *SHORT TERM*),
2) Attracting Foreign Direct Investments (e.g. attracting heavy and other energy intensive industries or providing ammonia for refueling of maritime vessels – *MEDIUM TERM*),
3) Exporting low carbon MoleculesH2-derivatives (e.g. exporting green hydrogen from North Africa via pipelines to EU or low carbon ammonia/molecules from Africa to Europe or Japan – *LONG TERM*).

It's worth highlighting that an African-H2 revolution could have a strong impact not only on African economy, but also on its agriculture (short term) and infrastructures (mid-long term).

Despite its huge potential, renewable hydrogen has not played a significant role in the African continent until recently. Out of the 604 projects in the IEA low-carbon hydrogen project database[12], only 7 were in 2022 being developed in the African continent (3 in Morocco, 2 in Egypt, 1 in Mauritania and 1 in South Africa). The picture is however moving rather rapidly as described after.

The goal of this chapter is therefore to present on-going hydrogen initiatives for AU-EU interaction and to map announced renewable hydrogen projects in Africa mostly promoted by industrial consortia.

A number of 86 low carbon hydrogen production projects are reported as of July 2023. The vast majority of these projects is still in predevelopment phase (pre-FID). Most projects do not communicate any information on planned production capacity and/or deployment phasing. Thus, the aggregated figures only account for a fraction of the African project pipeline. These projects are illustrated in Figure 12. Most of them are dedicated entirely or almost entirely to exportation.

[12] https://www.iea.org/data-and-statistics/data-product/hydrogen-projects-database

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Summing up all currently available information and assuming that all reported projects will reach commercialization by 2050, the annual output of the current pipeline of projects amounts to 21Mtpa by 2050 (Figure 13) .

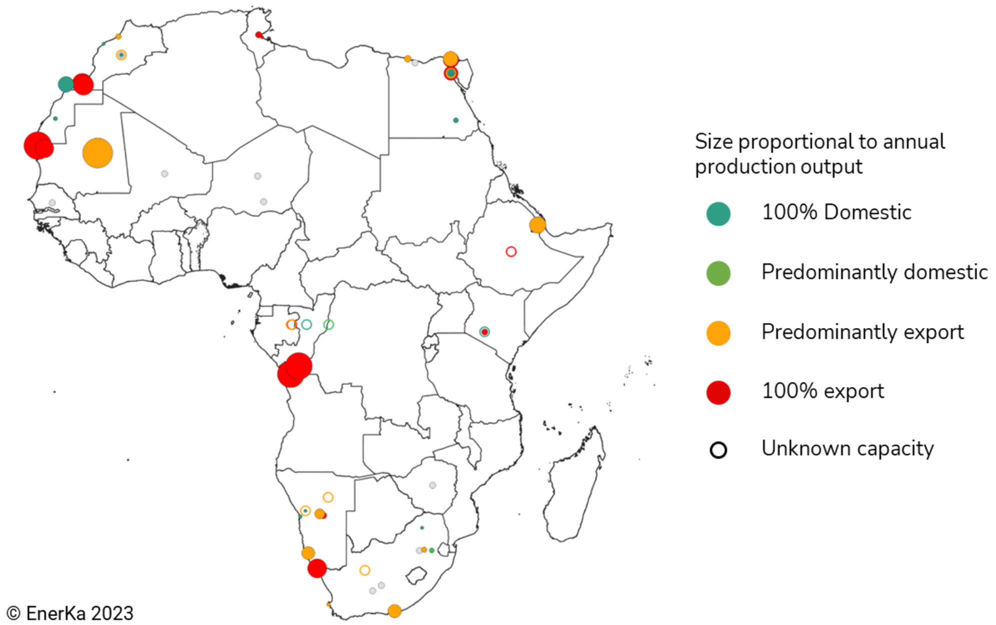

Figure 12: mapping of announced renewable hydrogen production projects in Africa as of July 2023.

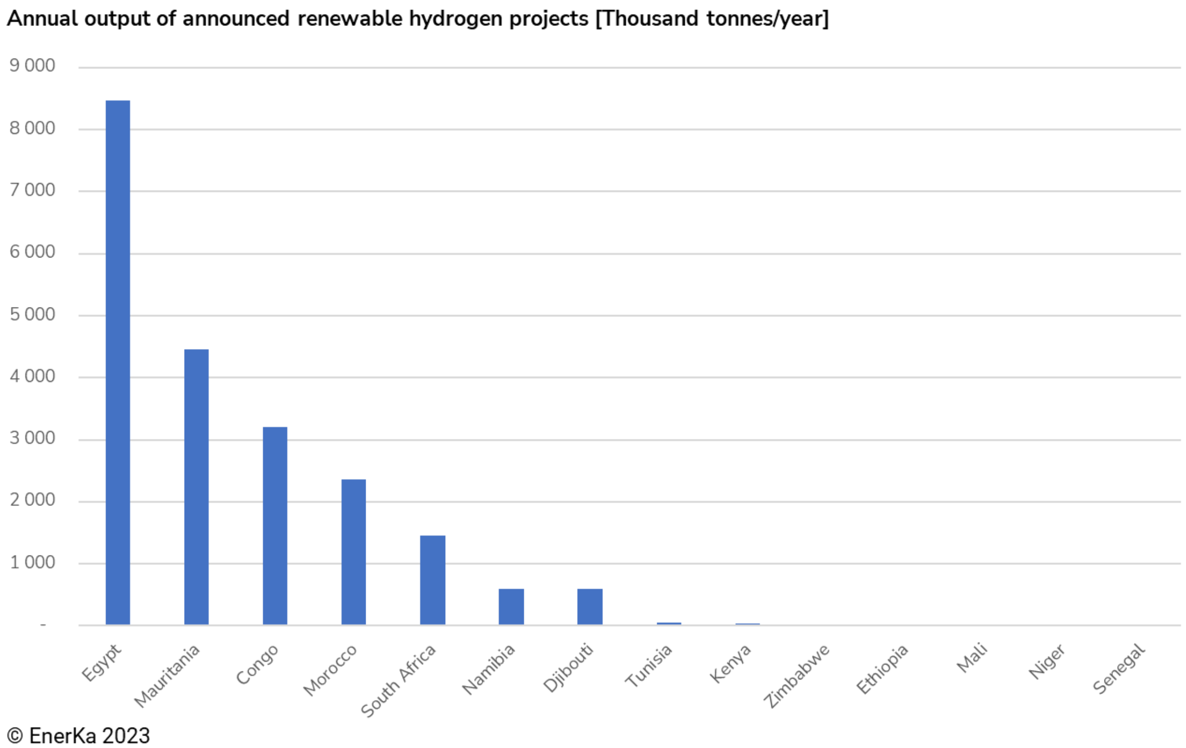

Figure 13: Estimated annual output of announced renewable hydrogen production projects by 2050

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4.2 Analysis of announced projects in several African countries

4.2.1. Egypt

Egypt stands ahead as top future producer and exporter of green hydrogen in Africa and is home to 24 active large-size projects (1 to 3GW electrolytic capacity), representing 28% of all reported renewable hydrogen projects in Africa. Unlike other African countries, Egypt's future renewable hydrogen production relies on a diversified base of producers selected through a competitive bidding process with several auction rounds. Given its strategic position with the Suez Canal, Egypt's hydrogen production is mainly oriented towards ammonia exports to Europe (Rotterdam, Antwerp, Germany) and methanol or e-fuels for ship bunkering.

Excluding projects with little/no information available, only a fraction of projects have disclosed plans to start commercialization before 2030: in the current state of development, the Egyptian project pipeline is expected to have an annual output of ca. 3Mtpa by 2030 (or 35% of total Egyptian projects pipeline).

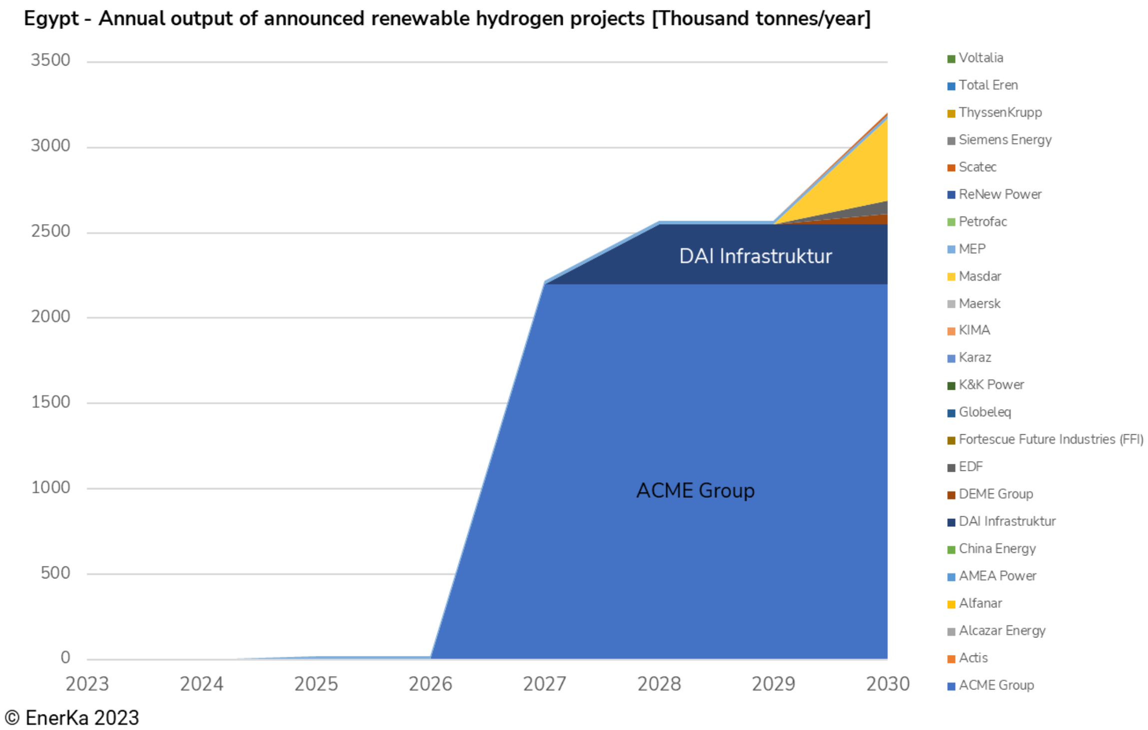

Figure 14: Estimated ramp-up of announced renewable hydrogen production projects in Egypt by 2050 in Mt per year

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4.2.2. Mauritania, Morocco and Congo

Mauritania, Congo or Morocco stand behind Egypt in terms of absolute hydrogen output but their production pipeline is concentrated in a small number of mega-projects (>10GW, >USD 10billion). Mauritania and Morocco can leverage vast areas of land with exceptional solar and wind resources and are home to some of the largest renewable hydrogen projects on the planet (Nour, Aman, Amun, Tilemzoune …) led by a handful of "big pockets" companies (CWP Global, Shell, TotalEnergies). These projects are located in very sparsely populated areas with vast areas of barren land, requiring building all the necessary ancillary infrastructures from scratch and only marginally benefiting local communities. Except for one project by ArcelorMittal (production of pre-reduced iron ore and/or steel through the direct reducing process with hydrogen) leveraging Mauritania's iron resources, most projects plan to produce green ammonia for export to European markets.

Unlike Mauritania and Morocco, Congo intends to develop its vast hydroelectric potential on the Congo river for export as hydrogen and derivatives with Australian company Fortescue Future Industries (FFI) as main hydrogen developer. With the current development plan, a lot of question arise as to whether these projects (Inga III, Grand Inga) will generate proportional side-benefits for Congo and local communities.

Austral African countries (South Africa, Namibia, Botswana, Zimbabwe) are also developing significant project pipelines. Yet very little information is available regarding any intermediate commercialization milestones before 2030. Although projects in South Africa and Namibia are mainly oriented towards green ammonia exports, they also include significant local ecosystem developments.

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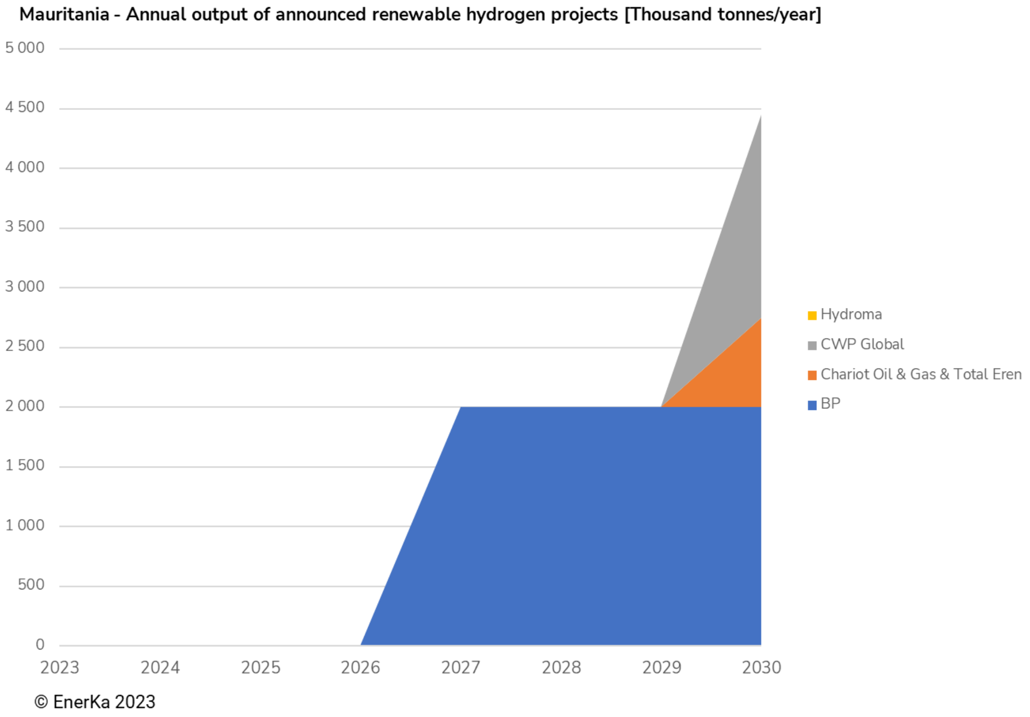

Figure 15: Estimated ramp-up of announced renewable hydrogen production projects in Mauritania by 2050 in Mt per year

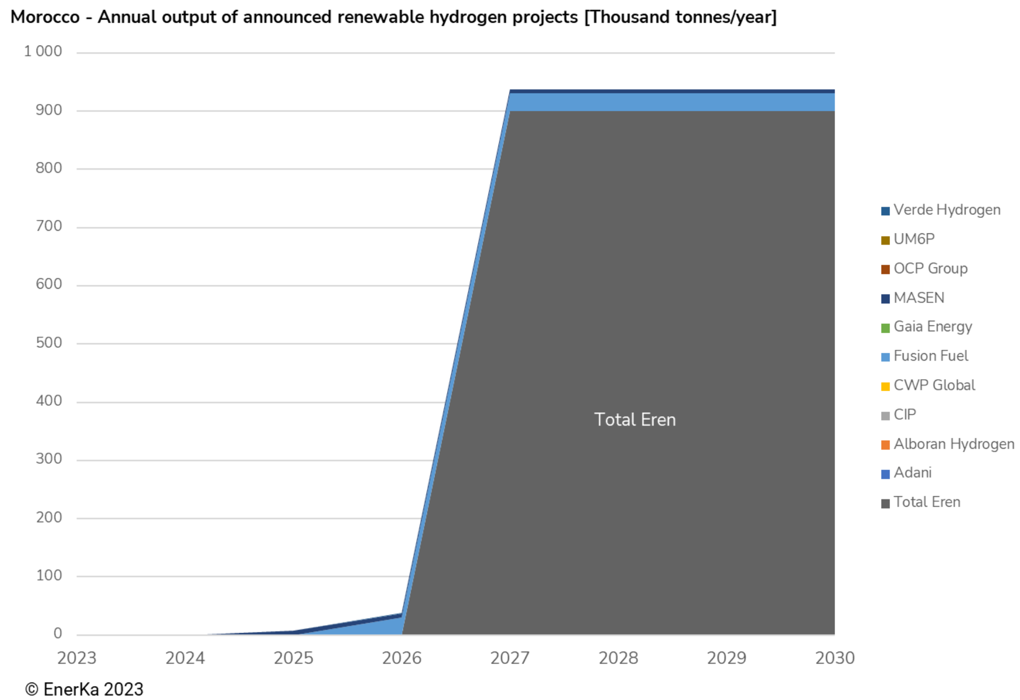

Figure 16: Estimated ramp-up of announced renewable hydrogen production projects in Morocco by 2050 in Mt per year

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T4.2.3. Other projects

his section should be updated during the course of JUST GREEN AFRH2ICA as new projects continuously arrive on the public area. It is in particular the case for Namibia and South Africa where different EU driven projects are currently announced.

One example could be the case for the "Daures Green Hydrogen Village"[13] project in Namibia supported by German funds (project delegates participated to Madrid Stakeholders Workshop in June 2023), where a production of renewable hydrogen and ammonia is scheduled to start very soon and to ramp-up until 2032 up to 60 Mtpa H2 and 352 Mtpa ammonia (Figure 17).

Figure 17: Time line and ambition of the project "Daures Green Hydrogen Village" in Namibia

[13] www.daures.green

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5. TRANSATIONAL ASSOCIATIONS CONTINENTAL VISIONS

In order to promote low carbon hydrogen at National level in both EU and AU, it is relevant that transnational associations encourage Member States to develop their own hydrogen plans and policies.

At this purpose, the vision of Clean Hydrogen Partnership (who promotes and funds JUST GREEN AFRH2ICA project) is quite clear and aligned with European Commission "RePowerEU Plan": establish a privileged mutual benefit collaboration between Europe and Africa, taking advantage of existing energy (NG) infrastructure and established shipping routes to facilitate an export of green hydrogen locally produced in Africa (also leveraging in a first moment European electrolysis R&D and industrial know how to be then transferred to African entrepreneurs and scientists).

This perspective is well aligned with AHP vision of Africa as global low carbon hydrogen and low carbon ammonia exporter both to global Western and Eastern economies, taking advantage again of existing shipping routes, consolidated commercial and industrial partnership with key countries in Europe and Asia where Africa is already exporting products and raw materials (figure 19).

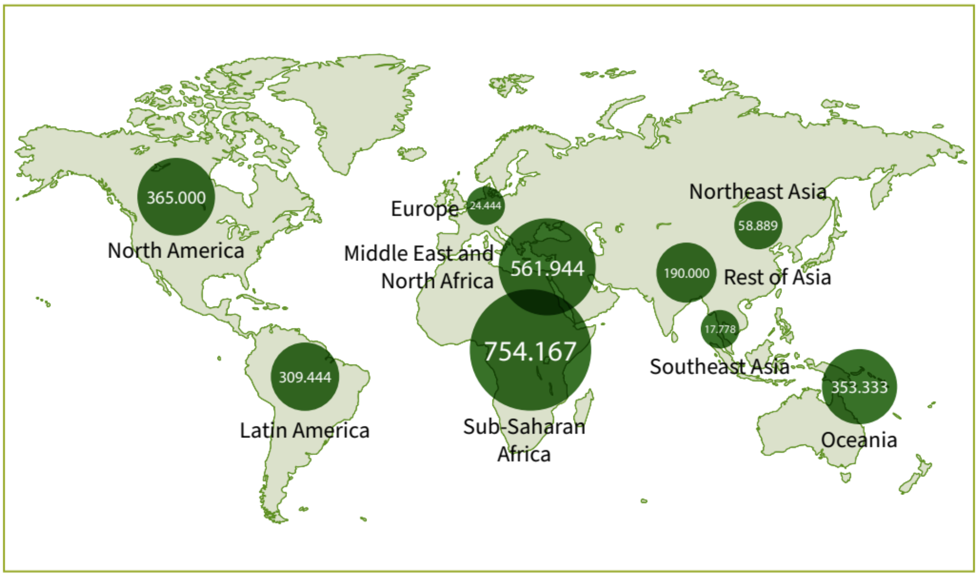

Figure 18: Technical potential for producing green hydrogen under USD 1.5/kg by 2050, in TWh[14]

[14] IRENA, 2022; Geopolitics of the Energy Transformation; The Hydrogen Factor https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jan/%20IRENA_Geopolitics_Hydrogen_2022.pdf?rev=1cfe49eee979409686f101ce24ffd71a)

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Further to these perspectives, other transational initiatives are currently in place to promote low carbon hydrogen in Africa as well as its collaboration with EU. In the following sub-chapters, some of them are presented.

5.1 Africa Green Hydrogen Alliance

In May 2022, six African countries formally launched the Africa Green Hydrogen Alliance[15] , aiming to make their continent a frontrunner in the race to develop green hydrogen, accelerating the transition from reliance on fossil fuels and shift to new to new energy technologies that open up access to clean, affordable energy supplies to all.

In forming this Alliance, Kenya, South Africa, Namibia, Egypt, Morocco and Mauritania (six of Tier-1 countries mentioned in Chapter 3) intend to foster collaboration on creating a sustainable enabling environment to supercharge green hydrogen development. This includes development of public and regulatory policy, capacity building, financing and certification needs to mobilize low carbon hydrogen production for domestic use and export. Following initial discussions at COP26 and the official launch in May 2022, the Alliance is now inviting more countries to join in this effort, responding to the opportunities presented by lower cost renewables, fast-developing electrolyser technology, and signals in some major markets that green hydrogen demand is likely to emerge at scale this decade.

The countries formally launched the Africa Green Hydrogen Alliance (which is part of a larger Green Hydrogen Organisation[16]), with support from the UN Climate Change High-Level Champions, the African Development Bank and the UN Economic Commission for Africa.

A broad base of mission-aligned public and private sector partners interested in pre-competitive collaboration are currently part of Green Africa Hydrogen Alliance and they can send a strong signal to policymakers in AU and EU countries of broad intention to work towards equitable, lasting industrial development outcomes with adoption of green hydrogen.

The list of members of the Alliance is the following:

- Egypt: Ministry of Electricity and Renewable Energy (MOERE)
- Kenya: Ministry of Energy
- Mauritania: Ministry of Petroleum, Energy & Mines
- Morocco: IRESEN
- Namibia: Green Hydrogen Commission
- South Africa: Industrial Development Corporation

In addition, the following entities are observers of the Alliance:

[15] https://climatechampions.unfccc.int/africa-green-hydrogen-alliance/
[16] https://gh2.org/countries

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- Africa Development Bank (AfDB)
- The United Nations Economic Commission for Africa (UNECA)
- African Union Development Agency-NEPAD (AUDA-NEPAD)
- UN Climate Change High Level Champions
- United Nations Economic Commission for Africa
- Green Hydrogen Organization

5.2 Mediterranean Green Hydrogen Partnership (MGHP)

During recent COP27 conference, the possibility to setup a Mediterranean Green Hydrogen Partnership (MGHP) to promote interaction particularly between North Africa and Eastern Europe as well as some Middle East countries was encouraged particularly by Egypt (who was hosting the conference).

The Mediterranean Green Hydrogen Partnership (MGHP) could provide stepping stones to the future structuring and governance of the global hydrogen market, considering that in envisaged area some key shipping routes (like Red Sea) and key Natural Gas Global actor are active.

The MGHP should therefore be designed in a manner that is both relevant to members on both the African and European sides of the Mediterranean and potentially be an inspiration for other parts of the world. The key notion for the MGHP should be "supra-nationalism" in its structure, its decision-making, and its policy implementation.

Hydrogen Europe supported the view that an MGHP which functions supra-nationally will not only be capable of organizing intercontinental hydrogen exchange, it will also form the embryo of a globally viable hydrogen agency governing the promotion, production and distribution of clean hydrogen.

When preparing this deliverable the MGHP initiative is not yet established but it should be officially launched at the COP 28 in the UAE at the end of 2023.

5.3 European Investment Bank (EIB)

European Investment Bank has put its focus on supporting African low carbon hydrogen promotion since late 2022 targeting a potential production of up to 50 Mt of low carbon hydrogen per year, with a total investment needed estimated of 1000 B€. Different potential investments are being considered all around the continent, but particularly in Morocco, Mauritania, Egypt, Namibia and South Africa. An analysis publication[17] suggests three requirements to enable producing these 50 million tons of green hydrogen in Africa by 2035:

[17] https://www.eib.org/attachments/press/africa-green-hydrogen-flyer.pdf, December 2022

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- National planning, regulation and incentive schemes are required to mobilise private sector investment.
- Pilot projects need to show successful low carbon hydrogen production, storage, distribution and use at both demonstration and commercial scale.
- Market-based partnerships are needed to enable mass-scale domestic and international off-take and demand for low carbon hydrogen, and increase cooperation to design, finance, build and operate low carbon hydrogen production, storage and distribution infrastructure.

According to EIB, 1000 B€ low carbon hydrogen investment would deliver the equivalent of more than one third of Africa's current energy consumption, boost GDP, improve clean water supply and empower communities.

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6. RESULTS OF FIRST STAKEHOLDERS' ACTIVITIES : ASPECTS RELATED TO EU-AU INTERACTIONS

JUST GREEN AFRH2ICA is a stakeholders driven project: along the full project lifetime, stakeholders' inputs will be collected via different initiatives like workshops, surveys, questionnaires in order to take advantage of key actors' insights on all project topics.

In the first six months of the project, the following workshops have been organized

- Brussels (BE), Launching Event - 15th February 2023
- Milan (IT), Green Hydrogen Project Developer Workshop (in the framework of World Hydrogen Leader Conference) – 2nd May 2023
- Genova (IT), Italian Stakeholders Workshop – 21st June 2023
- Madrid (ES), Spanish Stakeholders Workshop – 27th June 2023

In all of them a specific session was dedicated to analyze on-going and future "EU-AU green H2 potential interaction" and to collect guidelines on this topic.

Also in the first project M3-M6 stakeholders' survey and questionnaire, which collected relevant inputs for all WP1 activities (ANNEX 1), some specific questions were dedicated to provide suggestions to encourage EU-AU interaction starting from most strategic countries.

In the following sections, some key insights on the topic of the deliverable are presented from each of these stakeholders interaction opportunities (which will be further and more in details described in WP1 and WP5 deliverables).

6.1 Summery of main outcomes of the first Stakeholders workshops

6.1.1 Brussels Workshop

Starting from Bart Biebuyck's introduction speech (where he highlighted the possibility to promote EU Hydrogen Valley approach to African context), attendees had the chance to share their thoughts about EU-AU contact points for the promotion of green hydrogen. At this purpose, the afternoon working session has been beneficial to highlight one key aspect that will become a guide for next WP1-WP2 activities of the project: EU Hydrogen Valley approach cannot be fully replicated, but "**Hydrogen Hub**" approach with significant local demand of low carbon hydrogen from industry or export hubs (e.g. a NG grid injection point) could become perfect location where to develop green hydrogen projects.

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6.1.2 Milan Workshop

During the workshop, the role of project developers (and their drivers, inspired by renewable energy project development strategies) and of EU-AU **Natural gas Infrastructure** has been deeply investigated, highlighting the relevance of taking advantage of the existing above mentioned asset as key "carrier of exported hydrogen" with investments to make it "H2 ready" that should be driven not only by Italian/Spanish Natural TSO, but or by the European Commission as a whole or by a pool of EU Natural Gas TSO/Energy utilities aiming to promote/distribute hydrogen in Europe. Furthermore, the peculiarities of African context (e.g. absence of feed-ins and local National Supporting measures) in comparison with EU context were highlighted, to show the importance for low carbon hydrogen project developers to identify different market strategy/business models for projects more dedicated to "local H2 market" or to "H2 export".

6.1.3 Italy Workshop

As in Milan workshop, the workshop highlighted the pivotal **role of Italy** in the AU-EU Hydrogen collaboration scenario, particularly related to the existing NG infrastructure that connects Italy with Northern Africa. Furthermore, the importance of promoting Mediterranean low carbon hydrogen initiatives in terms of joint R&D and knowledge sharing were discussed, also to share with neighbours best practices and lessons learnt from the different hydrogen projects that will be supported by Italian PNRR (NextGen EU funds).

6.1.4 Spain Workshop

The workshop highlighted the pivotal **role of Spain** in the AU-EU Hydrogen collaboration scenario, particularly related to the existing NG infrastructure that connects Spain with Morocco and its connection (always via a specific H2 corridor) with central EU. Furthermore, the importance of promoting **knowledge sharing** related to i) fluctuating RES plants connection with electrolyzers and their implementation and control; ii) use of hydrogen in ports from Spanish stakeholder to AU ones was presented as key know-how asset of Spanish hydrogen actors.

6.2. Outcome of the Stakeholders' survey/questionnaire

Looking at the text of first project M3-M6 stakeholders' survey and questionnaire, the following sections and questions appear relevant to the topic of the deliverable:

2.5 In your opinion, which are the countries in Africa who are or should be frontrunners to promote African Green Hydrogen transition?
CURRENT FRONTRUNNERS:____

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MOST STRATEGIC FRONTRUNERS:____
3. FINAL INPUTS
3.1 How European hydrogen actors can support African green hydrogen transition? - Please provide your view and answer ____ ____
3.2 Which could be European countries and actors that can benefit from African green hydrogen transition? - Please provide your view and answer ____ ____
3.3 Which are the key competences/know-how that EU can "export" to Africa to promote its green hydrogen transition? - Please provide your view and answer ____ ____
3.4 Would "EU Hydrogen Valley approach" be replicable in Africa to promote first green hydrogen projects? Why? Where? - Please provide your view and answer ____ ____

For what it concerns answer to §2.5, the following countries received the highest preferences

- CURRENT FRONTRUNNERS: South Africa (>40% of respondents[18]), Morocco and Namibia (>30%), Northern Africa countries generally speaking (>40%) with Egypt and Kenya often mentioned but not recurrent (around 10%)
- STRATEGIC FRONTRUNNERS: also looking at strategic frontrunners who could develop high potential green hydrogen projects, further than above mentioned countries (with South Africa, Morocco and Namibia always highlighted with highest preferences), it is worthy to highlight the mention of countries like Ethiopia and DRC Congo, two countries with a high hydropower potential. Algeria as well, considering its current "lower penetration of RES", is highlighted as a country with an untapped renewables (and therefore green hydrogen as well) potential.

Stakeholders' surveys somehow confirm the analysis presented in Chapter 3 and Tier-1, Tier-2, Tier-3 classification proposed by AHP.

Looking at questions of section 3 of the survey, some key insights could be collected question per question. In the following lines, some relevant inputs are reported per each question.

3.1 How European hydrogen actors can support African green hydrogen transition? - Please provide your view and answer

More than half of respondents' highlighted the importance for EU not only to divert private investments to Africa Green Hydrogen projects, but also public funding.

Investment for the enhancement of energy infrastructure, sharing of know-how and technology transfer are key peculiarities to be promoted too.

[18] So far we have collected 103 feedbacks: 41 answers via the on-line surveys and 62 answers via printed questionnaire distributed during stakeholders' events. Around 30% of respondents are coming from Africa, 65% from Europe and 5% from other continents. Percentage presented in this sub-chapter are referred to above respondents number.

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It's tricky that just few stakeholders' highlighted the importance for EU actors to commit via signed contracts and specific agreement to become official off-taker (and therefore somehow promoter/investor) of the proposed green hydrogen investment.

This is aligned with what presented in chapter 4, where so far it seems that EU actors are more interested to move to Africa to setup new electrolysis installations (even dedicated to local market) more than create the full value chain (from a technological and market/business point of view) to guarantee the export of locally produced hydrogen.

3.2 Which could be European countries and actors that can benefit from African green hydrogen transition? - Please provide your view and answer

More than 40% of respondents' highlighted Germany as one of the key benefit recipients of low carbon hydrogen promotion in Africa, together with other Central EU countries like The Netherlands, Switzerland, or France.

Despite their existing Natural Gas Infrastructure (and potential future ones looking at Hydrogen Backbone initiative) Spain and Italy are mentioned just by 25% of respondents and Greece is really hardly mentioned.

This stakeholders' vision is partially aligned the EU National plans described in Chapter 2.

3.3 Which are the key competences/know-how that EU can "export" to Africa to promote its green hydrogen transition? - Please provide your view and answer

What is interesting to highlight here is that many Stakeholders seem not to acknowledge EU technological leadership in electrolysers' technologies: only 25% of respondents talked indeed about "TECHNOLOGICAL/ELECTROLYSER" know-how to be shared, while different respondents mentioned energy policy making, energy modelling, regulatory support and coherence as a key know-how to be shared.

3.4 Would "EU Hydrogen Valley approach" be replicable in Africa to promote first green hydrogen projects? Why? Where? - Please provide your view and answer

This question received a "50-50" feedback with different visions on the possible replicability of "hydrogen valley" approach to African contexts: generally speaking, all the stakeholders acknowledge the lack of energy infrastructure and transport infrastructure that could benefit from an "hydrogen valley approach", but at the same time the possibility to setup "industrial driven" H2 valley particularly in specific industrial hub in Morocco or South Africa are well presented. Also following the outcomes of Brussels launching workshop, it seems in any case from stakeholders' inputs that the approach of EU alone will not be applicable for Africa and should be modified to fit the African needs. Africa has its own unique challenges which are much deeper than those of EU, therefore, the potential "African hydrogen valley" (or Hydrogen Hub as called in Brussels) should be "truly African" and not a direct copy and paste of EU ways of promoting renewable hydrogen.

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7. ANALYSIS OF THE CONTACT POINTS BETWEEN THE DIFFERENT H2 PLANS

Wrapping up the results and the main outcomes of previous chapters, the following aspects could be highlighted:

The analysis of **low carbon hydrogen strategies in EU-countries** shows clear intention to deploy hydrogen relying on importations with a target of 10Mtpa of non-EU hydrogen imports by 2030.

- EU countries have set **production targets** so far, for hydrogen market to organize around flagship projects until the next policy planning rounds.
- EU countries hydrogen roadmaps mainly set objectives for 2030. Only Belgium and the United Kingdom (non-EU) have 2050 targets in terms of **domestic consumption** and/or exports.
- **Export** from EU-countries is assumed to be intra-EU only. However, no consistent plan can be found among EU countries.
- EU has set a **2030 target of 10Mtpa for non-EU hydrogen imports** but there is no consistent breakdown of the share of this import among EU countries.
- Large discrepancies remain in the evaluation of future domestic demand for hydrogen among EU countries.

Concerning **hydrogen corridors**, while the EU-27 low carbon hydrogen demand is expected to massively increase in the next decades, the amplification of 2030 objectives suggests that even more ambitious African green H2 import volumes could be reached by 2050.
Existing prospective studies tend to suggest that 2050 glow carbon H2 import volumes from Africa could generally be handled through **the repurposing of strategic cross-Mediterranean natural gas pipelines** as well as **ship transportation of liquefied hydrogen or ammonia.**

However, most ambitious import scenarios may lead to a strong concentration of hydrogen flows around a few Member States, which suggests **the need for significant adaptations in the deployment of a trans-European hydrogen infrastructure.**

The analysis of hydrogen strategy in African country show that only a limited number of countries, gathered in so called “Tier-1 countries” have a well defined strategy. It is the case for Algeria, Egypt, Kenya, Mauritania, Morocco, Namibia and South Africa. It is worth noting that it is not always a low carbon hydrogen that is targeted (e.g. Algeria). A large number of

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countries have some elements of hydrogen strategy (e.g. Tunisia, Ethiopia, ...) and numerous country have no hydrogen ambition expressed.
Gathering these strategies and the initiatives that can be found such as industrial projects or alliances, a certain number of lessons can be drawn:

- Most African renewable hydrogen projects plan to mainly export green ammonia to Europe (mostly Germany) via shipping.
- There is only a handful of projects aiming at developing further added value locally. The most notorious examples include Morocco's OCP to cut ammonia imports with locally-produced green ammonia and South Africa's Sasol to progressively replace its fossil-based synthetic fuel industry with renewable molecules.
- In the current state of information, the pipeline of African hydrogen projects together with the claimed ambition of several countries appear not mature enough to provide the EU with 100% of its projected import quantities: the annual output of announced projects amounts to ca. **9Mtpa by 2030**. This quantity has to be compared with the EU target of Repower EU of 10 Mtpa in 2030 .
- Therefore assuming that EU countries buy all the available green ammonia production by 2030, 1Mtpa of complementary volumes need to be sourced from other exporting regions (e.g. Chile, Australia, middle-East ...). Besides, African countries are being courted by other importing countries, namely Eastern countries, and one cannot reasonably assume that 100% of Africa's renewable hydrogen output will be shipped over to Europe. Consequently, **the share of African H2 in EU import should be much below 90%**.
- By 2030, the southern hydrogen corridors across the Mediterranean sea will most probably not be ready to supply hydrogen to Europe. Furthermore, the pipeline of low-carbon/renewable hydrogen projects from northern African countries such as Algeria or Tunisia remains to be built. Consequently, the EU shall essentially rely on green ammonia imports via its major import hubs (Rotterdam, Antwerp, Hamburg, Bremerhaven) where projects of ammonia cracking units are being developed.
- By 2050, Africa's hydrogen & derivatives production output is expected to significantly increase, potentially reaching well over 20Mtpa available for export. However, EU's import needs/objectives are not yet specified this far in time.

The way most low carbon hydrogen production projects can be deployed cannot be directly derived from the European "hydrogen valley" model. **Specific African Hydrogen Hubs** appear to be the most relevant option. They have also to be coupled to a careful analysis of the water resource.

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CONCLUSION

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This Deliverable "D1.1 Assessment of EU-AU green H2 potential interaction", developed within WP1 aims to provide an overview of on-going low carbon and/or renewable hydrogen collaboration and initiatives between Europe and Africa in order to understand the potential "space of collaboration" between the two continents on low carbon hydrogen import/export.

A review of EU-countries low carbon hydrogen policies and strategies has been presented. Similarly, a preliminary review of African renewable hydrogen policies and strategies (to be further integrated in D1.2) has been introduced complemented by the presentation of on-going/promoted projects (co-funded by EU and AU institutions and governments or industries) for large scale low carbon hydrogen projects. In addition to these reviews, the results of M1-M6 stakeholders' activities (surveys and events) has provided some qualitative indications on specific questions/topics related to this AU-EU space of collaboration.

Some first conclusions can be drawn:

- The **low carbon hydrogen strategies in EU-countries** foresees a target of 10Mtpa of non-EU hydrogen imports by 2030, mostly driven by RePowerEU plan.
- H2 import volumes from Africa could generally be handled through **the repurposing of strategic cross-Mediterranean natural gas pipelines** as well as **ship transportation of liquefied hydrogen or ammonia.**
- Import scenarios may lead to a strong concentration of hydrogen flows around a few Member States, which suggests **the need for significant adaptations in the deployment of a trans-European hydrogen infrastructure as well as to specific hydrogen plans at EU level, in such countries and in respective "African sisters exporting countries".**
- Only a limited number of AU-countries have a well-defined hydrogen strategy and many African renewable hydrogen projects (particularly in countries where NG infrastructure is not present) are considering to mainly **export green ammonia** to EU (mostly Germany) **via shipping.**
- Several AU-countries with no clear hydrogen strategy present a high renewable energy potential, significant water resource and large export potential (e.g. Algeria or Tunisia). Some support from this project could help them to develop a strategy
- In the current state of information, the pipeline of African hydrogen projects together with the claimed ambition of several countries appear not mature enough to provide the EU with 100% of its projected import quantities: **the share of African H2 in EU import should be much below 90%.**
- The way most low carbon hydrogen production projects can be deployed cannot be directly derived from EU "hydrogen valley" model. Also following stakeholders' guidelines, the identification of **specific African Hydrogen Hubs** (with a significant local hydrogen demand) appears to be the most relevant option, driven by a **careful analysis of the water resources too.**

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The analysis presented in this document reflects the current situation and could be updated during the course of the JUST GREEN AFRH2ICA project.

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ANNEX: First Project Stakeholders' Survey questionnaire – M3-M6

Promoting a JUST transition to GREEN hydrogen in AFRICA

STAKEHOLDERS QUESTIONNAIRE

1. GENERAL INFORMATION

1.1 YOUR COUNTRY:______________________________

1.2 WHICH TYPE OF INSTITUTION ARE YOU BELONGING TO

Technology manufacturer ☐
Energy utility ☐
Policy Maker/NGO/government body ☐
Engineering and consulting ☐
Academia ☐
Clean Energy/Hydrogen Financing ☐
OTHER: (please specify)______________________

2. YOUR INPUTS FOR GREEN HYDROGEN PROMOTION IN AFRICA

2.1 In your opinion, what are the most relevant aspects that can facilitate green hydrogen projects development in Africa? *(Please rank them from 1 – the less relevant – to 8 – the most one)*

ASPECT	Ranking score
Presence of an adequate policy/Hydrogen plan at country level	
Country electrification and electric interconnection with neighbour countries	
Large Renewable Energy potential	
Presence of industrial hydrogen off-takers in the country	
Presence of relevant energy infrastructure (e.g. gas pipeline)	
Presence of relevant infrastructures (e.g. ports, highway...)	
Presence of investors ready to promote projects in the country	
Political stability	

OTHER ASPECTS TO BE CONSIDERED: ____

____

2.2 In your opinion, what are the most promising application that can boost green hydrogen promotion in Africa? *(Please rank them from 1 – the less relevant – to 8 – the most one)*

APPLICATION	Ranking score
Industrial application in Refineries	
Industrial application in the Chemical Sector	
Industrial application in the Mining Sector	
Industrial application in the Cement Sector	
Industrial application in Fertilizers companies	
Use in agricultural sector	
Use in land transport	
Use in maritime transport	

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OTHER SECTORS TO BE CONSIDERED: ____
____

2.3 In your opinion, what is the level of severity of the following barriers (from 1 – not relevant - to 5 – very relevant) to green hydrogen promotion in Africa? *(Please rate each line)*

BARRIER	Rate (1 to 5)
Absence of regulation and policies at local level	
Lack of interested investors	
Absence of a local manufacturing value chain for electrolysers, H2 storage...	
Lack of skilled workforce and competences	
Significant investments/costs of green hydrogen projects	
Dependency from out of Africa (for skills and technologies)	
Lack local hydrogen off-takers	

OTHER BARRIERS TO BE CONSIDERED: ____

2.4 In your opinion, who are the first stakeholders who should act to promote green hydrogen projects in Africa *(Please rank them from 1 – the less relevant – to 8 – the most one)***?**

APPLICATION	Ranking score
Renewable Energy projects promoter	
Energy and gas utilities/grid managers	
Donors (World Bank, African Development Bank...)	
Governments	
Technology manufacturers to showcase product reliability and attract investors	
Hard to abate industries	
African Hydrogen Partnership and relevant African associations	
African Union setting a clear roadmap as done by European Commission	

OTHER STAKEHOLDERS TO BE CONSIDERED: ____
____

2.5 In your opinion, which are the countries in Africa who are or should be frontrunners to promote African Green Hydrogen transition?

CURRENT FRONTRUNNERS:____

MOST STRATEGIC FRONTRUNERS:____

3. FINAL INPUTS

3.1 How European hydrogen actors can support African green hydrogen transition? - Please provide your view and answer ____
____
____
____

3.2 Which could be European countries and actors that can benefit from African green hydrogen transition? - Please provide your view and answer _____________________________________
____
____
____

3.3 Which are the key competences/know-how that EU can "export" to Africa to promote its green hydrogen transition? - Please provide your view and answer ___________________________
____
____

3.4 Would "EU Hydrogen Valley approach" be replicable in Africa to promote first green hydrogen projects? Why? Where? - Please provide your view and answer ____________________
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