Hydrogen hype

Why the EU should be cautious about uncertain imports from far-flung places

January 2024

Summary

Following the EU's ambition to mitigate climate change and reduce the bloc's dependence on fossil energy from third countries, the EU's RePowerEU plan aimed for 10 Mt of renewable hydrogen produced in the EU and 10 Mt of imports by 2030.

While trade discussions with potential exporting countries keep being announced, it is not yet clear what the impacts of hydrogen imports could be. T&E commissioned Ricardo to assess the EU's needs for hydrogen imports and evaluate their potential risks and benefits, through six case-studies of ambitious exporting countries: Chile, Egypt, Morocco, Namibia, Norway and Oman.

Unrealistic ambition vs potential for EU production

While the revised Renewable Energy Directive adopted a slightly higher binding target for hydrogen and e-fuels of around 4 Mt, Agora Energiewende modelling suggests that only 3.5 Mt of hydrogen would be needed by 2030. Hastily decided following the Russian invasion of Ukraine, **RePowerEU objectives thus appear around five times higher than what is legally mandated and effectively needed in 2030.**

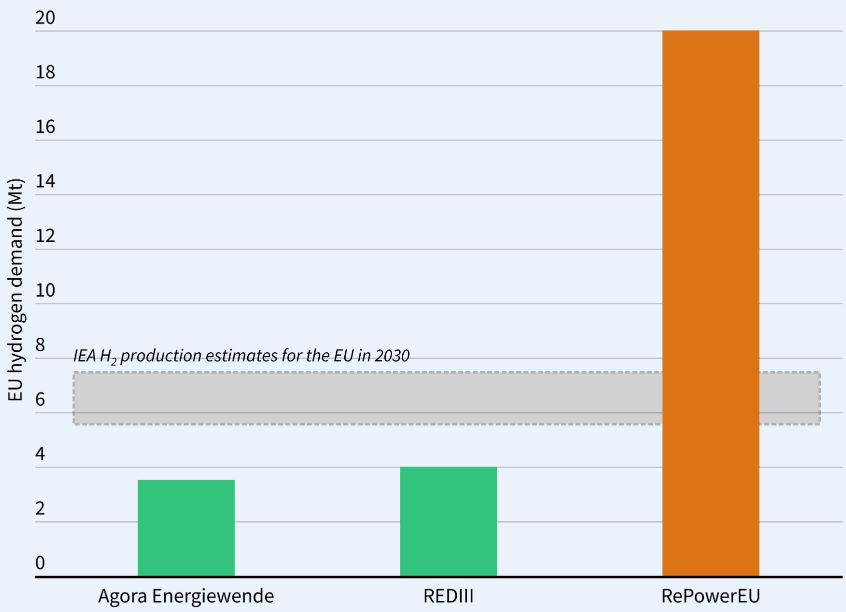
Moreover, Ricardo's analysis of scenarios from the International Energy Agency (IEA) indicates that the EU could produce between 5.8 and 7.5 Mt of renewable hydrogen by 2030, depending on the uptake of renewable electricity sources. **The EU could thus potentially produce enough hydrogen domestically for its actual needs and legally binding mandates by 2030** although there is likely to be a large gap between what is theoretically possible and what will actually happen.

Uncertain projects in exporting countries

While the IEA estimates that only 4% of announced hydrogen projects globally reached a final investment decision, the **Ricardo study finds that 99% of the planned H_2 capacity in the six promising exporting countries is still at the technical feasibility stage.** Based on national hydrogen strategies of the six front-running countries and announced projects, Ricardo estimates that 2.6 Mt of renewable hydrogen could be exported from the selected countries to the EU by

2030, well below the import ambition foreseen in the RePowerEU plan. It is important to stress that as there is currently no infrastructure for hydrogen to be transported in a pure form, the only viable export pathways rely on hydrogen derivatives such as ammonia or methanol which can be transported by ship.

Other countries could also host projects that export hydrogen and e-fuels to the EU, but time is running out to manage scaling up a renewable hydrogen and e-fuel industry. It is unlikely that large volumes of renewable hydrogen will be exported to the EU by 2030 from countries beyond the scope of this study.



Source: Transport & Environment, based on Ricardo analysis (2023)

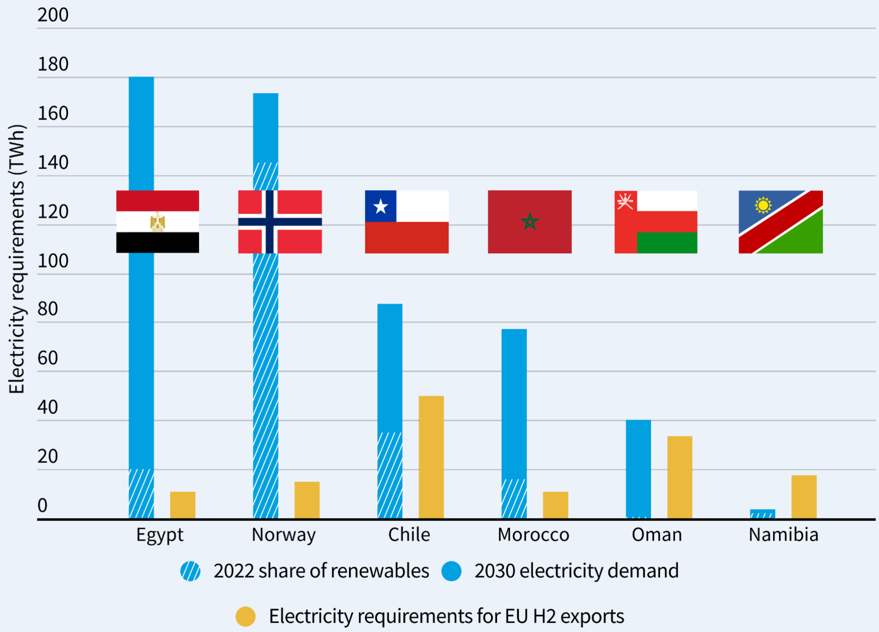
Potential for EU H_2 production could be enough to meet realistic targets

Risks of competition with local grid decarbonisation
Hydrogen production will require massive deployment of renewable electricity in the EU or in exporting countries. While EU rules clearly specify that hydrogen and e-fuels need to be produced from additional and unsubsidised renewable electricity, Ricardo estimates that **the equivalent amount of renewable electricity planned for H_2 exports to Europe could decarbonise a significant share of those countries' grids.**

Chile and Oman could meet 57% and 84% of their projected electricity demand respectively, while in the most extreme case, **Namibia could meet more than ten times its electricity demand with the renewables needed for the planned hydrogen exports to the EU in 2030.** In addition, only half of the population has access to electricity and the country is heavily dependent on imports of dirty electricity from South Africa. Countries such as Oman, almost exclusively relying on fossil fuels in their power sector, could reduce their grid emissions by up to 90%. In case hydrogen production for exports occurs, it is key that national grids clean up in parallel, as the result of these investments.

Limited focus on scalable carbon sources

The EU does not allow the use of any fossil carbon for e-fuel production from 2041 (with a deadline already from 2036 for carbon from fossil power generation). Ricardo analysis shows that **most of the studied countries do not have an alternative non-fossil source of carbon available** for synthetic fuels production or for hydrogen transport through synthetic hydrocarbons and alcohols. While the availability of biogenic CO_2 sources appears to be limited especially in desert countries, direct air capture could then be used as a carbon source for e-fuels production but only a few projects could be found. As a result, **high hopes for liquid e-hydrocarbons imports to the EU seem questionable at least in the short term.** Alternatively, e-fuels that do not require carbon, such as e-ammonia, could also be developed and imported to the EU, especially for the shipping sector that could use them directly.



Source: Ricardo (2023)

H_2 exports to the EU from announced projects would require significant renewable electricity compared to local demand and decarbonisation needs

Significant water needs in already water-stressed countries

While water needed for H_2 production appears relatively low compared to current water uses in the selected countries, **such additional water consumption would happen in a context where most of the studied countries are increasingly facing water scarcity issues**. These countries indeed already suffer from the effects of climate change, such as mega-droughts in Chile, low-recharge rates in Morocco and seawater intrusion in Oman.

Desalination could enable the use of seawater instead of freshwater for H_2 production. However, **such technology could face environmental challenges** if brine residues are released into the ocean, putting pressure on biodiversity and thus local populations. Oversizing the desalination plants could supply additional freshwater supply to local populations and should be promoted.

Land use, environmental and social impacts

Because of the massive renewables deployment needed, hydrogen production will require vast areas of land. While relatively limited compared to the size of the exporting countries, such projects could have high impacts on local ecosystems and compete with current land uses. Some projects announced in Namibia are planned inside national parks and **clearly do not demonstrate that environmental impacts have been properly considered and that local communities have been consulted**

Prioritising domestic H_2 could be cheaper and bring benefits to the EU industry

Ricardo finally looked at the cost of H_2 imports and showed that **depending on how hydrogen will be transported and distributed to the EU, the costs entailed might not offset the reduced production costs from exporting countries.** Finally, according to current investments already announced, between one and two million jobs could potentially be created by hydrogen supply chains by 2030 in the EU.

1. Introduction

While hydrogen represented less than 2% of the European Union's energy consumption in 2022 and was almost exclusively produced from fossil fuels, green hydrogen is seen as a key energy carrier to decarbonise hard-to-abate sectors such as heavy industry as well as aviation and shipping transport[1].

Following the EU's ambition to mitigate climate change, European policies have set different renewable hydrogen objectives, for instance through its Fit for 55 legislative package or the Renewable Energy Directive (RED III). In May 2022, the RePowerEU plan promoted hydrogen among other solutions to reduce the bloc's dependency on fossil energy from third-countries, in particular Russia[2]. Aiming at 10 million tonnes of renewable hydrogen produced in the EU by 2030, this plan also mentions the need for imports of equivalent volumes from non-EU regions.

While trade agreements with potential exporting countries and hydrogen projects keep being announced, it is not clear whether hydrogen imports into the EU would be needed to cover the EU's demand, but also if they would be truly sustainable as well as beneficial for the population in those countries.

With the objective to contribute to this discussion, T&E commissioned Ricardo consultancy to analyse the EU's needs for hydrogen imports and evaluate potential risks and benefits associated with such imports. This briefing also draws on other sources analysed by T&E.

To do so, T&E and Ricardo identified six case-study countries with ambitious plans to export hydrogen to the EU before 2030. These countries include Chile, Egypt, Morocco, Namibia, Norway and Oman, which were selected to cover the most diverse country profiles possible. For each country, an assessment of the announced projects as well as an analysis of the local electricity demand and supply context and a review of potential environmental impacts on water and land use have been conducted.

[1] European Commission. (2023). *Hydrogen*. (Link).
[2] European Commission. (May 2022). *RePowerEU: A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition.* (Link).

2. Does the EU need to import hydrogen?

2.1. RePowerEU ambitions grossly overestimate 2030 H_2 demand

Mostly used in oil refineries and in the fertiliser and chemical industry, EU H_2 demand was just below 9 million tonnes (Mt) in 2020. RePowerEU set up very ambitious objectives to decarbonise the current production of hydrogen (H_2) and expand its use in sectors where it can replace fossil fuels. In total 20 Mt of renewable H_2 are being targeted in this plan: half being produced domestically in the EU and half imported from other regions by 2030. Among the 10 Mt foreseen for imports, around 4 Mt would be imported in the form of synthetic derivatives such as ammonia. However, it is not clear on which basis such goals in RePowerEU have been defined and it is important to mention that these objectives are not legally binding. Despite this, these targets continue to be referenced when discussing the EU's ambition on renewable hydrogen and they remain a key reason for the multiplication of hydrogen trade partnerships.

In April 2023, the revision of the Renewable Energy Directive adopted an overall renewable energy target of 42.5% by 2030 in the EU. For the first time, a specific binding target for Renewable Fuels of Non Biological Origin (RFNBOs), i.e. renewable H_2 and synthetic fuels, is mandated and should at least reach 42% of the industry and 1% of the transport energy consumption by 2030. Taking into account different incentives to reach this target[3], **these RED targets effectively convert into around 4 Mt of H_2 being legally mandated**, most of it being needed in the industry (Figure 1).

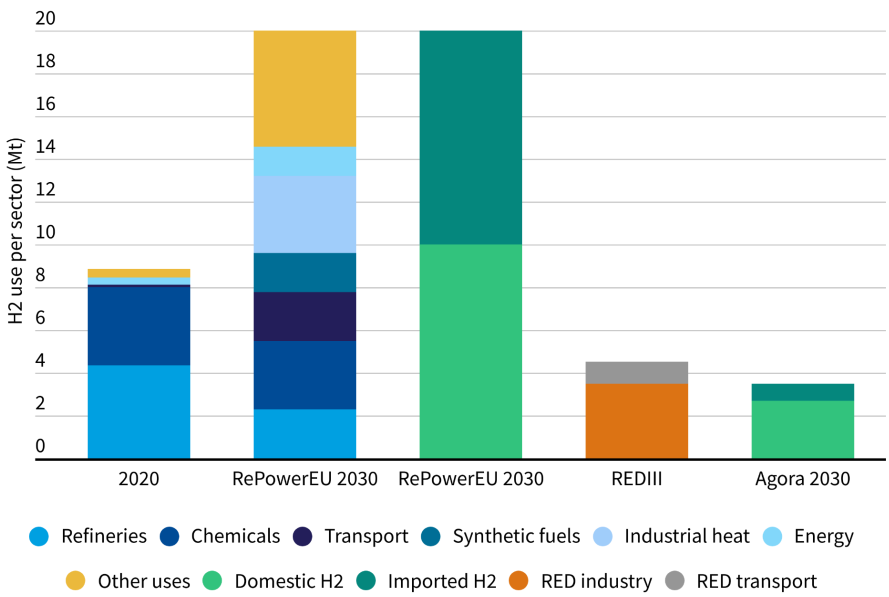


Figure 1: EU 2030 hydrogen objectives and targets

[3] Such as double-counting mechanism and multipliers to prioritise RFNBO used in aviation and shipping sectors.

In addition, modelling done by Agora Energiewende[4] estimated that only 3.5 Mt of H_2 would be needed to achieve similar emissions reduction as the RePowerEU plan but with a more efficient use of resources. Taking into account more energy savings and direct electrification where it can be done, **their EU Gas Exit Pathway only sees the needs for 0.7 Mt of H_2 imports by 2030, 14 times less than RePowerEU.** Finally, modelling from other organisations and research institutes similarly indicate that H_2 demand could be significantly lower to decarbonise the EU with limited H_2 imports[5], while market analysts such as Bloomberg NEF showed that meeting the 20 Mt H_2 objective defined in RePowerEU is not necessary to achieve net zero emissions by 2050[6].

The objectives listed in the RePowerEU plan for 2030 therefore are unrealistically high compared to the legally binding targets contained in the RED or to the decarbonisation modelling done by Agora.

2.2. EU domestic H_2 production could meet realistic 2030 demand

In parallel to demand targets and objectives, the potential for H_2 production in the EU seems to vary largely between sources. While the European Hydrogen Backbone foresees a theoretical feasibility potential of 13.5 Mt of H_2, **Ricardo analysis of scenarios from the International Energy Agency (IEA)[7] estimates that between 5.8 Mt and 7.5 Mt could be produced in 2030 in the EU.** The IEA base case assumes current renewables ramp-up continue as it is, while the accelerated case considers an increased deployment of renewables where all EU countries do as good as current best-in-class.

Figure 2 shows how these production potentials compare to the demand targets and objectives described in the previous section. It can be seen that **in any case the REDIII RFNBO target could be reached by EU's projected hydrogen production in 2030**.

4 Agora Energiewende. (May 2023). *Breaking free from fossil gas*. (Link).
5 CLEVER. (Jun 2023). *Climate neutrality, Energy security and Sustainability: A pathway to bridge the gap through Sufficiency, Efficiency and Renewables*. (Link).
6 BNEF. (Nov 2023). Hydrogen Market Outlook presented during the European Hydrogen Forum.
7 IEA. (Dec 2022). *Is the European Union on track to meet its REPowerEU goals?* (Link).

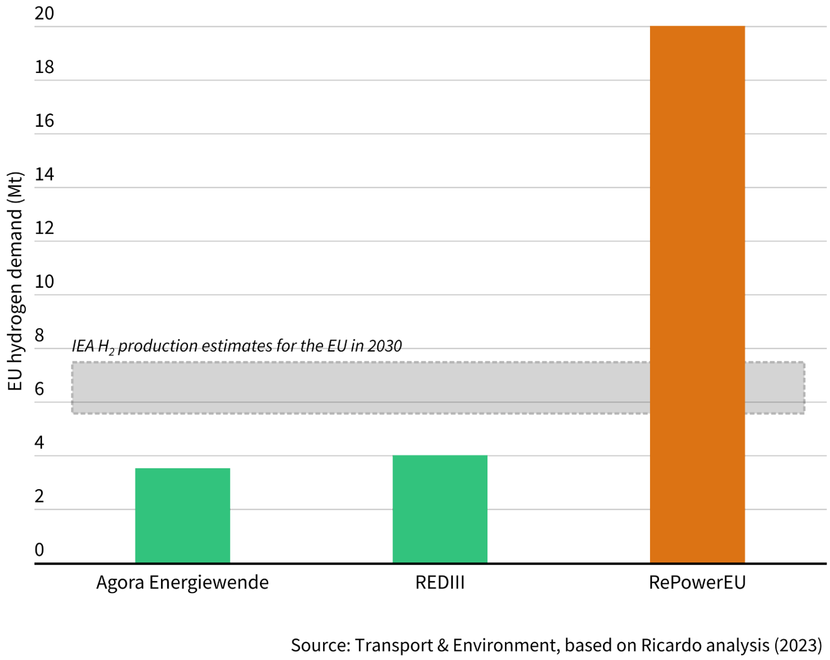


Figure 2: Potential for renewable hydrogen production in 2030 in the EU

However, if RePowerEU objectives were to be followed **between 12.5 and 14.2 Mt of H_2 imports would be required**, which could be even more than the 10 Mt of H_2 imports foreseen in the plan.

Other studies show the importance of a fast ramp-up not only for the renewable electricity generation but also for the electrolyser capacity installed. Analysis by research think tank Zenon for instance shows that the production of electrolytic hydrogen in the EU needs to reach a minimal 97% growth each year to reach the RePowerEU objectives by 2030[8].

2.3. H_2 export projects are mostly uncertain

In its 2023 hydrogen report, the IEA estimated that announced projects could reach a production of 27 Mt of electrolytic H_2 and 10 Mt of H_2 from fossil fuels coupled with carbon capture globally in 2030, almost 50% more than in its 2022 report[9]. However, **only 2 Mt, or 4% of these projects have reached Financial Investment Decision (FID) and are therefore almost certain to be realised.**

Looking at the six selected countries (Chile, Egypt, Morocco, Namibia, Norway and Oman), Ricardo study found that projects announced in 2022 totalled 3.9 Mt of renewable H_2 potential capacity by 2030[10]. Based on national strategies and announcements, it has been estimated that out of this total planned capacity, **2.6 Mt could be used for exports to the EU**. While this only looks at six promising exporting countries, it still falls short of the RePowerEU 10 Mt import objective. Other countries, such as Brazil, South Africa or

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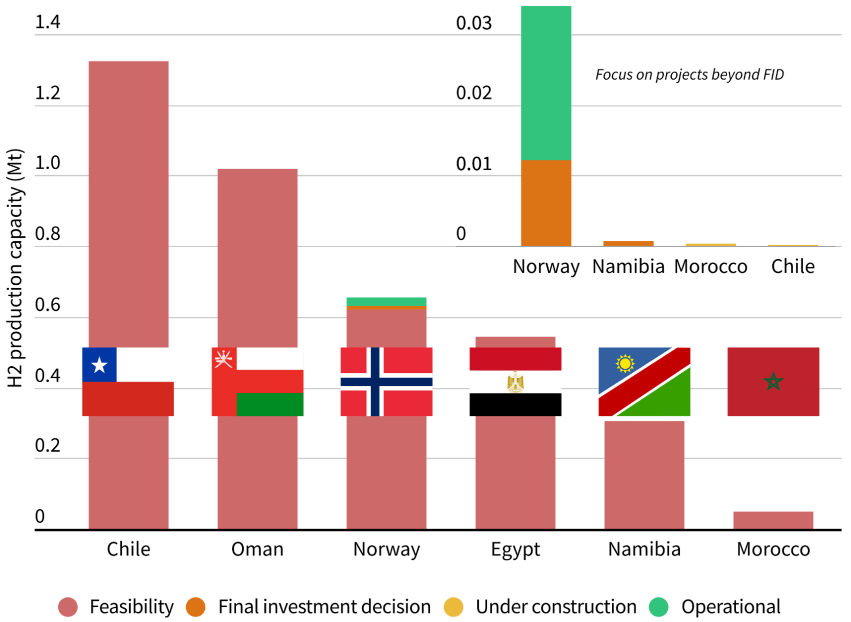
[8] Zenon. (Nov 2023). *Low-carbon hydrogen production in the EU: are 2030 targets achievable?* (Link).
[9] IEA. (Oct 2023). *Global Hydrogen Review 2023*. (Link).
[10] T&E analysis of the updated 2023 IEA hydrogen database suggests that the total planned capacity of H_2 projects that reached development stages beyond feasibility study increased to around 5 Mt in the six selected countries.

Australia, could also be potential hydrogen exporters but these countries could also produce hydrogen for other demanding regions, such as the United States of Japan. However, it is unlikely that large quantities of renewable hydrogen will be exported to the EU by 2030 from countries beyond the scope of this study given time is running out to develop renewable hydrogen and e-fuel projects at the industrial scale.

As at the global scale, **the analysis shows that 80% of projects in these countries, equivalent to 99% of the planned capacity, were still at the feasibility stage in 2022** (Figure 3). While only two projects were operational in Norway in 2022, two were under construction in Chile and Morocco but with a limited projected capacity, some more reached FID in Norway and Namibia.



Source: Transport & Environment, based on Ricardo analysis (2023)

Figure 3: Announced projects by stage and projected nameplate capacity in the six selected countries

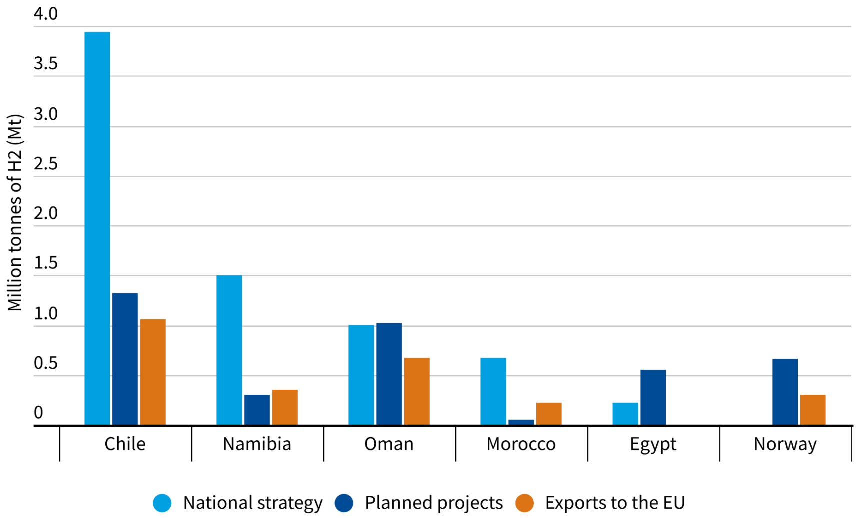
Despite the H_2 market evolving fast, it is hard to say whether announced projects will materialise without firm final investment decisions. In addition, energy and infrastructure projects typically require a lead time of several years, which could significantly delay the announced H_2 projects. **Relying massively on imports of H_2 from these countries thus appears uncertain at least before 2030.**

3. Case studies: production potential and impacts

For each of the six selected countries, Ricardo conducted an analysis of the national H_2 strategies and announced projects with a focus on exports to the EU. They also assessed potential competition of H_2 projects with local decarbonisation as well as water use, land use and the availability of carbon feedstock for e-fuels production.

3.1. The EU is a key target market for the selected countries

The analysis of the respective national strategies indicates that the EU is clearly identified as a key market for H_2 exports (Figure 4). For instance, in the case of Oman more than two thirds of the national H_2 production could be exported to the EU in 2030. With the most ambitious H_2 strategy, Chile also foresees exports as a priority, with an objective of more than one million tonnes traded to the EU.



Norway did not publish a national hydrogen strategy at the time of this study, and Egypt's national strategy did not include precise objective on hydrogen exports to the EU.

Source: Ricardo, based on official national strategies and the IEA hydrogen database (2022)

Figure 4: 2030 hydrogen strategies and announced projects in the studied countries

However, each country has very different contexts, whether it is in terms of socioeconomic aspects such as unemployment rates, inequalities or growing population and more practically in terms of existing export infrastructures, distance to the EU and electricity supply.

3.2. Renewable electricity needed for hydrogen exports could make substantial contribution to local grid decarbonisation

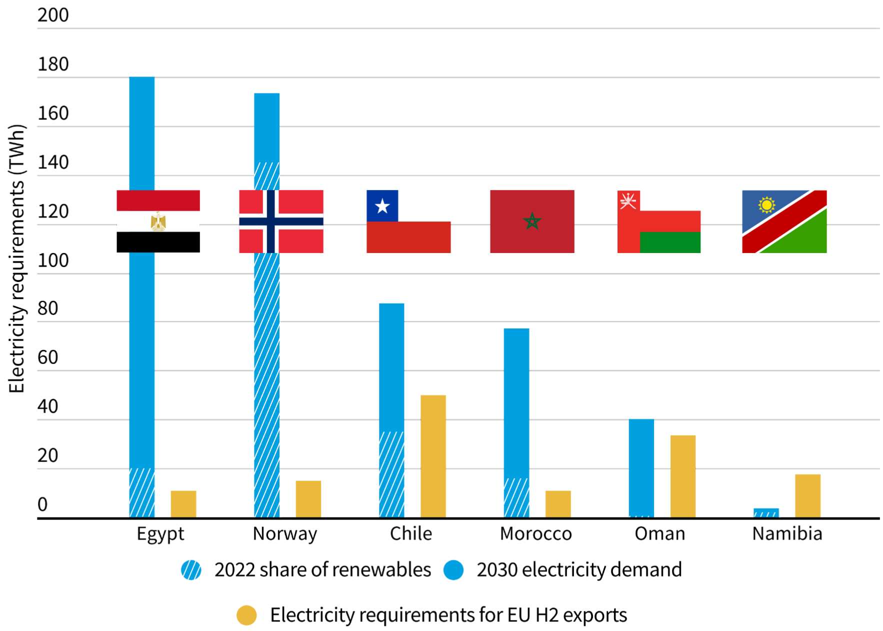
Hydrogen production will require massive deployment of renewable electricity, whether it is in the EU or in potential exporting countries. While EU rules clearly define RFNBOs as hydrogen and derivatives produced from additional renewable electricity[11], the use of very large quantities of renewables in countries with limited access to electricity or heavily relying on fossil fuels raises concerns. A massive roll-out of hydrogen projects could indeed compete with the decarbonisation of local grids, at a time when most countries need to meet the increasing demand from growing population and the electrification of uses.

In this study, Ricardo calculated the amount of electricity required for hydrogen exports from the

[11] European Commission. (Feb 2023). *Commission Delegated Regulation (EU) 2023/1184*. (Link).

case-studies to the EU in 2030. They compared such volumes with the projected electricity demand and the current renewable generation in each country.

Figure 5 shows that the results of such comparison depend largely on the country, their context and the planned exports to the EU. For instance, planned projects in Egypt, Norway and Morocco would require renewable electricity equivalent to 6% and 9% of the projected electricity demand of these countries by 2030. On the other hand, Chile and Oman would need relatively much more electricity compared to their demand (57% and 84% respectively), while **Namibia is the most extreme case with more than ten times of the projected 2030 electricity demand required for hydrogen export projects**.



Source: Ricardo (2023)

Figure 5: Electricity demand and requirements for EU H2 exports in the selected countries

Except Norway, other countries appear to have limited renewables capacity and thus need to decarbonise their grid. In the worst case, **countries such as Oman are currently almost exclusively relying on fossil fuels to power their grid**.

While Namibia's electricity production is mainly powered with hydroelectricity and thus almost fully renewable, the country imports more than 60% of its electricity from neighbouring countries with coal-based power such as South Africa. In addition, **Namibia's context is also particular because only half of the population has access to electricity today**.

Ricardo's counterfactual assessment therefore shows that in most of the studied countries, **the same amount of renewable electricity planned for H_2 exports to Europe could decarbonise a significant share of the selected countries' grid**[12]. Again, Namibia is the most extreme case and would only require

[12] Such analysis did not consider any consequential emissions that could happen if hydrogen was to be produced elsewhere, potentially from fossil fuels.

limited amounts of renewable electricity to decarbonise its demand, even taking into account imports from South Africa. Chile would also need less renewables than the total capacity needed for H_2 exports. Furthermore, using such renewable electricity would avoid almost 90% of Oman's current grid emissions, as well as 40% and 7% of Morocco's and Egypt's emissions respectively. Finally, while Norway's grid is already almost fully green, the country's decarbonisation of other sectors (e.g. electrification of road transports) is expected to increase the demand for additional renewables.

This counterfactual comparison therefore suggests that **the equivalent renewable capacity planned for hydrogen exports could help make a significant contribution to decarbonising the power sector of exporting countries**, underlying some potential competition between grid decarbonisation and H_2 exports. On the other hand, the reprioritisation of renewables could be contingent on the redirection of investments from hydrogen to renewables and the roll-out of renewables for hydrogen projects could instead promote the development of local renewables supply chains and benefit exporting countries.

3.3. Strong safeguards needed to prevent negative environmental impacts

Significant water needs in already water-stressed countries

Producing green hydrogen does not only require clean electricity but also water. Depending on the purity of the available water as well as the use or not of cooling systems, water consumption for H_2 production could be well above the theoretical value of 9 kg per kg of H_2 and reach 20 to 30 kg per kg of H_2[13].

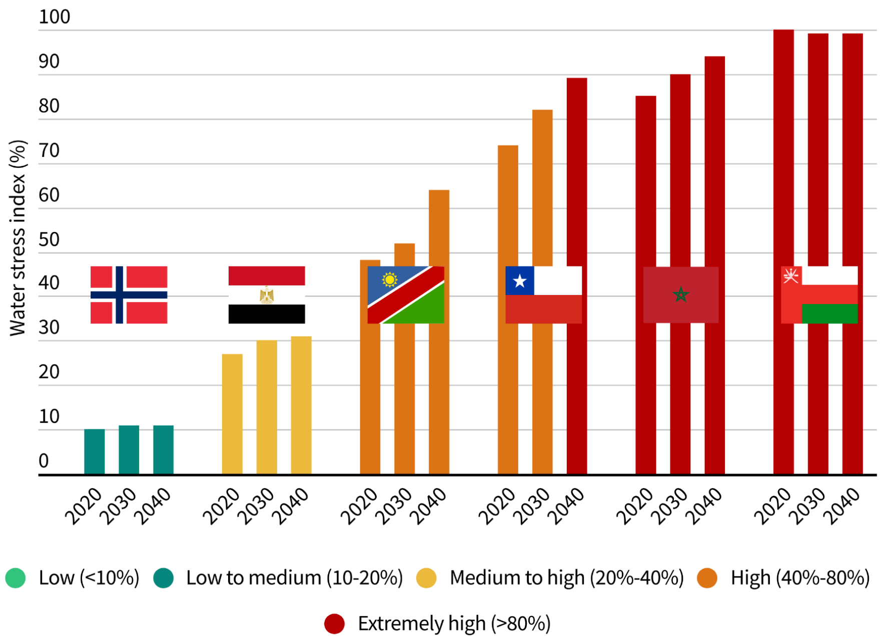
Ricardo estimates that **between 55 and 80 million tonnes of water would be required in the case-studies to produce the 2.6 Mt of H_2 planned to be exported to the EU in 2030**. This would convert into up to 32 thousand olympic swimming pools being used each year for hydrogen production. If the RePowerEU 10 Mt import objective was to be followed, between 200 and 300 million tonnes of water would be required, equivalent to 80-120 thousand olympic swimming pools.

While such values appear high, the absolute volumes could seem relatively low compared to the current water withdrawal of these countries. However, **such additional water consumption would happen in a context where most of the studied countries are increasingly facing water scarcity issues**. Except Norway, other countries are indeed already using most of their water resources for domestic agriculture or existing industries.

Combined with water over-abstraction, the effects of climate change can indeed also already be observed, with for instance mega-droughts in Chile, low-recharge rates in Morocco and seawater intrusion in Oman. Figure 6 shows the projected water stress index, i.e. the ratio of water demand to renewable supply, as modelled by the World Resource Institute[14] under a business-as-usual scenario[15]. It indicates that **all countries except Norway will face medium to extremely high water scarcity in the decades to come**, with Namibia and Chile expected to have the most severe surge.

[13] IRENA. (Dec 2023). *Water for hydrogen production*. (Link).
[14] WRI. (Aug 2023). *25 Countries, Housing One-quarter of the Population, Face Extremely High Water Stress.* (Link).
[15] Equivalent to the IPCC's RCP 7.0 scenario.

An alternative often promoted to avoid water issues in H_2 production is desalination, which could purify seawater before using it in electrolysers. While such technology already exists in countries such as Egypt, Oman or Chile for local populations' needs, Ricardo mentions that **desalination could face environmental and financial challenges**. If brine residues from desalination plants are disposed into the ocean, it may indeed increase the salt concentrations and pose risks to aquatic life, endangering local biodiversity and putting pressure on populations living from fishing (e.g. in Chile). Some H_2 projects, such as the OCP ammonia project in Morocco, promise to oversize their desalination plants for hydrogen so the local population benefits from additional freshwater supply.



Source: Transport & Environment, based on data from the World Resources Institute (2015)

Figure 6: Current and projected water scarcity in the selected countries

Land use and other impacts

In addition to water use, other impacts such as land use and loss of biodiversity are also important to assess. Because of the massive renewables deployment needed to power H_2 projects in potential exporting countries, a significant amount of land will be required to build electrolysers, export infrastructure and dedicated renewables.

Ricardo estimates that the assessed hydrogen exports to **the EU would require between 3,000 and 13,000 km^2 of land,** depending on whether solar panels, wind turbines or a mix of both are used. In the worst case, this would represent up to 40% of the size of a country such as Belgium, or more than 1.2 million football pitches.

While these areas are limited relatively to the size of the exporting countries, it could still have local impacts and competition with current land uses, as for instance in Egypt where industries and agriculture areas are concentrated alongside the Nile river and the Suez canal. Hydrogen projects could have impacts on local ecosystems, even in desert countries and disturb populations living in the chosen regions, especially during the construction part of the projects. Co-location of projects close to export infrastructures or other industries could minimise the impact while being more cost effective.

Some announced projects clearly do not demonstrate that impacts have been properly considered. For instance, the Hyphen Green Hydrogen project is planned to be developed in Tsau Khaeb national park in Namibia. With this project located in the most biodiverse region of the country, it will likely pose significant threats to local endangered species. Such plan also has a heavy symbolic weight for Namibian people since it will be located on land where Germany recognised to have committed a genocide during its occupation of Namibia[16].

Information, consultation and consent of local communities

In order to ensure public acceptance of such major industrial projects, proper information and consultation of the local communities, indigenous people and more broadly civil society is crucial. There are already indications that this is not how things have been organised in some countries. In Namibia for example, there seems to be an overall lack of information and consultation about the Hyphen project with civil society requesting more transparency[17]. In Chile, civil society is also mobilising, with more than 70 local environmental organisations openly opposing the government's plans to develop green hydrogen, expressing concern about the impacts on the environment and human rights[18]. In Africa, over 500 African civil society groups rejected green hydrogen for export as a “false solution”, within the African People’s Climate and Development Declaration[19].

Finally, some projects are also planned in countries with bad records regarding human rights’ protection in general according to Amnesty International, but also bad precedents regarding the protection of the environment linked to big industries like mining. That’s the case in Morocco or in Egypt, but also in Namibia[20]. Caution is needed in these countries as there is a high risk of future violations of human rights, potentially linked to hydrogen projects.

3.4. Limited focus on sustainable and scalable carbon sources for e-fuels production

Knowing that future hydrogen plans could partly be used for synthetic fuels production or that the transport of hydrogen could be more energy efficient and cost effective through hydrocarbon carriers[21], Ricardo also assessed potential carbon feedstock availability.

The analysis shows that most countries do not have an alternative non-fossil source of carbon available. Countries such as Morocco, Oman, Egypt or Chile either have existing carbon emitting industries or

[16] Climate Change News. (Nov 2023). *Shades of green hydrogen: EU demand set to transform Namibia*. (Link).
[17] The Namibian. (Oct 2023). *Civil society demands disclosure amid green hydrogen ‘secrecy’*. (Link).
[18] Ladera Sur. (Jul 2023). *Más de 70 organizaciones ambientales rechazan el modelo impulsado por el gobierno para el desarrollo del hidrógeno verde en Chile*. (Link).
[19] Real Africa Climate Summit (Sep 2023). *The African People's Climate and Development Declaration*. (Link).
[20] Amnesty International. *Report 2022/2023*. (Link)
[21] Ammonia could also be used as an energy carrier to transport hydrogen.

electricity generation, whose emissions could be captured and used for e-fuels production. However, EU rules only allow captured carbon from fossil electricity generation up to 2035 and from industries up to 2040, if an equivalent carbon price mechanism is implemented. Apart from Norway which is a member of the EU Emissions Trading System (ETS), none of the other 5 countries have a carbon price or emissions trading[22], meaning that **fossil carbon sources are currently not compliant with EU rules**.

Most of these countries being desert countries, the availability of biogenic CO_2 sources appear to be limited as well. Countries such as Morocco or Namibia could have some limited potential, but there is a risk of a competition with current biomass uses and doubts regarding the sustainability of potential feedstocks. While Norway could use biogenic CO_2 from its local wood industry for e-fuel synthesis, potential indirect impacts related to the competing uses for such feedstocks are not clear yet.

Direct air capture could then be used as a carbon source for e-fuels production, with only a few projects already mentioned in Chile. High cost and energy demand for such technology will likely be a challenge in the short term but should be the preferred option in the long-term.

As a result of this analysis, **high hopes for liquid e-hydrocarbons imports to the EU are questionable at least in the short and medium term**. However, some e-fuels do not require carbon, such as e-ammonia, and could also be developed and imported to the EU. These e-fuels could be used as hydrogen carriers and be converted back to hydrogen or used directly in certain sectors such as shipping.

4. EU domestic production could deliver cheaper hydrogen and jobs to EU workers

While the Ricardo analysis discussed different challenges related to potential hydrogen exports to the EU, they also looked at potential impacts and benefits of producing hydrogen domestically to give another perspective.

Costs of hydrogen imports vs domestic production

Cost will be an important factor determining whether hydrogen should be imported from third-countries or produced domestically. Higher renewable load factors in the six countries tend to decrease the levelised cost of hydrogen production (LCOH), while the importation cost could nullify that advantage.

Ricardo's analysis suggests that hydrogen produced from solar PV in Spain could range between \$2.1/kgH_2 and \$3.5/kgH_2 by 2030[23], based on a comparison of cost estimates from the IEA[24], Aurora

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[22] Chile does have a carbon tax of \$5/tCO_2, which is not an effective carbon price. Emissions from electricity generation have continued to increase in line with demand, which indicates that the carbon tax is not effective in changing the carbon intensity of the electricity mix.

[23] It is important to note that the Spanish case is one of the most optimistic cases with high renewable potential and does not reflect the cost of H_2 production in other EU countries. A comparison of the LCOH in other EU countries is detailed in Ricardo's report.

[24] International Energy Agency. (Apr 2023). *Towards hydrogen definitions based on their emissions intensity.* (Link).

Energy[25], Fraunhofer ISE[26] and the Oxford Institute for Energy Studies[27]. However, such production costs could be overly optimistic, given the favourable assumption around future electrolysers' prices, which have been assumed to decrease sharply before 2030 across the different studies analysed. For instance, the IEA estimates that renewable hydrogen production cost could range between \$2/kgH_2 and \$8/kgH_2 by 2030, depending on the cost of electricity and electrolysers[28].

In order to assess potential transport costs, Ricardo looked at imports from Morocco, as the closest non-European exporter country as part of the six study-cases. Three transport cases have been considered: pipeline imports of H_2, shipment of liquefied H_2 or shipment of ammonia to be reconverted to H_2. **Their analysis shows that transport costs alone could add a further \$1.8-3.9/kgH_2 if hydrogen is piped, \$0.8-4.1/kgH_2 if it is converted to ammonia and shipped, and \$1.2-4.9/kgH_2 if it is liquefied and shipped**[29]. In the two latter cases, the higher cost can be explained by the additional energy intensive liquefaction or the conversion to ammonia and the reconversion back to gaseous H_2.

The total cost for both producing and transporting hydrogen from Morocco could therefore range between \$2.6/kgH_2 and \$8.1/kgH_2, again highlighting the uncertainty around the hydrogen economics.

Depending on how hydrogen would be transported and distributed from EU areas with high renewables potential to other regions, **these results suggest that the reduced production costs from exporting countries could not be sufficient to compensate for the high transportation costs**. However, this comparison is limited to two countries only and a more granular analysis of cost estimates for additional countries and imports' options would give a more refined picture.

Other studies also estimated the cost of hydrogen imports to the EU and suggest that additional parameters such as the production scale will likely influence the total cost[30]. The IEA 2023 Global Hydrogen Review[31] also estimates that importing liquefied hydrogen or hydrogen through ammonia from North Africa would be more expensive than domestically produced hydrogen[32]. Finally, actual hydrogen prices are likely to be higher than just production and transport costs, due to profit margins and specific market conditions.

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[25] Aurora Energy Research. (May 2021). *Enabling the European hydrogen economy*. (Link).
[26] Fraunhofer ISE. (Aug 2023). *Site-specific, comparative analysis for suitable Power-to-X pathways and products in developing and emerging countries*. (Link).
[27] Oxford Institute for Energy Studies. (Mar 2021). *Contrasting European hydrogen pathways: An analysis of differing approaches in key markets*. (Link).
[28] International Energy Agency. (Oct 2023). Figure 3-11. *Global Hydrogen Review 2023*. (Link).
[29] Ricardo decided to focus on a theoretical case where hydrogen would be imported from the South of Morocco, where many hydrogen projects have been announced, to Marseille as one of the biggest EU ports in the Mediterranean sea. In the case of the hydrogen pipeline to be built between Morocco and Spain, Ricardo assumed that a European hydrogen grid could be used to transport hydrogen from Spain to other EU regions, which could be overly optimistic.
[30] Clean Air Task Force. (Sep 2023). *Techno-economic Realities of Long-Distance Hydrogen Transport*. (Link).
[31] International Energy Agency. (Oct 2023). *Global Hydrogen Review 2023*. (Link).
[32] Produced in North-West Europe in that case.

INFO BOX: Hydrogen vs e-fuels imports

While importing hydrogen could be more expensive than producing it domestically in the EU, imports of hydrogen derivatives such as e-hydrocarbons, e-alcohols or e-ammonia could lead to different total costs if they were to be used directly as final products in the EU and not converted back to H_2. Such e-fuels will be in particular needed in sectors such as aviation and shipping.

Potential e-ammonia trade appears to be particularly attractive: more than 80% of the global e-fuels capacity announced by 2030 is slated for e-ammonia production according to the IEA[33]. E-ammonia could for instance be used as a fuel in shipping, since in many cases it is the cheapest low-emission e-fuel when accounting for transport and storage costs.

Finally, unlike e-hydrocarbons, e-ammonia does not require any carbon source and could then be easier to develop in places where sustainable and scalable carbon cannot be sourced.

Jobs and other indirect benefits

Besides costs, Ricardo also assesses to what extent favouring hydrogen production in the EU could bring other benefits such as a decentralised energy production and a diversified energy supply, enhanced technological innovation, improved trade balance and job creation.

Looking at jobs, the EU Commission estimates that 20,000 jobs would be created per billion euros of investments. This converts **between one and two million jobs potentially created with regards to hydrogen supply chains by 2030 in the EU**, according to current investments already announced. Europe, as of the first quarter of 2023, was indeed the global leader of hydrogen investment at $117 billion announced to be spent by 2030[34]. Many areas of the hydrogen economy will indeed require skills development, whether it is for the conceptualisation of the projects, the construction, the upstream electricity generation, the operation of the plants or the distribution of the final product.

Locating the largest share of the hydrogen supply chain in Europe would also be in line with the EU's ambition for reindustrialisation through low-carbon technologies as foreseen in the Net-Zero Industry Act[35].

While one could argue that importing hydrogen could also lead to jobs creation in exporting countries, there is also a risk that hydrogen developers would be flying in international workers to build and operate plants, rather than developing local skills, or that local jobs would only be created for the construction phase.

[33] International Energy Agency. (Dec 2023). *The Role of E-fuels in Decarbonising Transport*. (Link).
[34] Hydrogen Council. (May 2023). *Hydrogen Insights 2023*. (Link).
[35] European Commission. (Mar 2023). *The Net-Zero Industry Act: Accelerating the transition to climate neutrality*. (Link).

5. Limitations of the study

The objective of this study was to put under a reality check the EU's ambition for hydrogen imports and assess potential impacts in exporting countries, as well as looking at possible benefits for domestic production in the EU. However, the scope of the study is limited to plans up to 2030, given the uncertainty of hydrogen projects beyond that time. Different results could appear in the longer term with increasing needs for hydrogen to decarbonise hard-to-abate sectors such as the industrial activities and aviation and shipping transport.

Also, projects analysed in the selected countries are based on announcements made by the end of 2022, while the IEA's Global Hydrogen Review - published in September 2023 - shows many more projects have been proposed since then. In addition, a further analysis of potential benefits in exporting countries could help assess to what extent hydrogen projects would help the countries' local economy.

Finally, only six case-studies have been considered when other countries also appear as potential candidates for hydrogen exports, such as Brazil, Mauritania, South Africa or Australia for instance. These countries could also produce and export hydrogen towards other regions, such as the United States or Japan. However, it is unlikely that large volumes of renewable hydrogen will be exported to the EU by 2030 from countries beyond the scope of this study given time is running out to scale up a renewable hydrogen and e-fuel industry.

6. Policy recommendations

More realism is needed on the quantities of renewable hydrogen that the EU will need to decarbonise its economy and transport in particular. A more realistic and fairer vision of EU's hydrogen demand will define whether the EU needs to rely on small or big quantities of imports to decarbonise in the long run. Prioritising EU production could bring several environmental and economic benefits and avoid relying on uncertain imports from places with poor records when it comes to human rights or environmental protection.

Regardless of the exact role of hydrogen and e-fuels in helping the EU to reach net-zero emissions by 2050, strict conditions need to be attached to ensure that EU's imports of green hydrogen do not have negative impacts in the producing countries. The EU's biofuels policy has been a terrible example - it triggered huge amounts of imports with negative environmental, social and climate impacts. The EU should avoid repeating the same scenario this time with renewable hydrogen. T&E presents its key recommendations below.

#1. Urgently needed: A reality check on 2030 hydrogen (import) ambitions

The EU's high **ambitions for 10 Mt of green hydrogen imports by 2030 and 10 Mt produced domestically - as included in the communication RePowerEU plans - should be revised downwards**, as these targets are unrealistically high. Even if non-binding, these targets continue to be the reference for

EU's ambition on renewable hydrogen and they remain a key reason for the multiplication of hydrogen trade partnerships. Several reports indicate that meeting the 20 Mt objective is not necessary to achieve net zero by 2050.

Guided by the 'energy efficiency first' principle, **the EU needs a new, bottom-up assessment of a targeted use of hydrogen and e-fuels in decarbonising the sectors that are hard to electrify.** The focus must be on meeting the renewable hydrogen targets for industry, maritime and aviation sectors while avoiding the waste of renewable hydrogen in sectors like residential heating or e-fuels in cars and trucks. For the transport sector, the binding 2030 targets set in the Renewable Energy Directive and the ReFuelEU and FuelEU Maritime regulations are key. This is an important task for the next European Commission, when deciding on the level of ambition of the EU's 2040 climate targets.

In combination with **ambitious demand management policies** (resulting in e.g. flying less or modal shift), a targeted use of H_2 and e-fuels will make the EU less reliant on imports.

#2. Until 2030: Prioritise EU support for domestic production

The hydrogen and e-fuel export volumes projected for 2030 from the six countries reviewed are subject to a high level of uncertainty, with very few having achieved the stage when a final investment decision is made. Other countries outside of the six studied here are also planning to produce hydrogen for export to the EU but the situation is not so different. The EU has theoretically sufficient renewables potential to produce the necessary quantities for a more realistic target for RFNBO in 2030. But that also remains uncertain, in view of competing uses for additional renewable electricity capacity and questions around costs. T&E recommends that the **EU or national financial support for producing hydrogen/e-fuels** (European Hydrogen Bank, German H2Global initiative) **should be targeted in priority at domestic production**.

The EU must also ensure that the hydrogen and e-fuels production that is financially supported by the EU also benefits the development of a homegrown industry. To achieve this, **the EU could consider attaching a 'made in Europe' criteria to all financial support it offers to the hydrogen industry**. The strong financial and regulatory support offered to the hydrogen industry could be combined with an obligation to produce key technologies like electrolysers in the EU27, delivering European excellence in R&D, manufacturing jobs and more broadly industrial leadership in crucial net-zero technologies. In addition, the EU should consider introducing a maximum carbon footprint for the manufacturing of electrolysers, sustainable sourcing of raw materials and recycling obligations. Such requirements will not only decrease the lifecycle emissions of hydrogen and e-fuels, but also offer a competitive advantage to European companies. Apart from environmental criteria, strict compliance with social criteria (see EU Battery Regulation on human rights, labour rights and industrial relations) and governance criteria (e.g. newly adopted EU due diligence rules) should also be a precondition for qualifying for EU support.

It is not clear whether the EU will manage to deploy sufficient renewables to produce hydrogen or e-fuels for those sectors that are hard to electrify in the period after 2030. That's why, by 2030, **the role of imports may need to be re-evaluated in view of 2040 and 2050 targets**. The current high level of uncertainty about hydrogen and e-fuel imports and the potential risks associated with the production in non-EU countries does not rule out a more significant role in the longer term.

#3. Respect the principle of Free, Prior & Informed Consent from local population and Indigenous Peoples

Countries and project developers must commit to the principles of Free, Prior & Informed Consent[36] of local population and the respect of the ILO's Indigenous and Tribal Peoples Convention[37]. Exporting countries must establish a legal framework to ensure this principle is fully respected, especially with an objective to avoid land grabbing. There seems to be an overall lack of information and consultation of the population, for example in the case of Namibia. Feedback from local populations and Indigenous Peoples needs to be taken into account when it comes to land use, social as well as broader environmental impacts.

As proposed in several industry standards under elaboration, project developers shall also commit to and implement international standards on social impacts, workers' rights, anti-corruption & good governance. The EU should also carefully consider its partner countries, avoiding countries with bad track records when it comes to human rights or environmental protection.

#4. H_2 and e-fuel exports to the EU must benefit local populations by creating synergies with local grid decarbonisation and energy access

There is ample historical evidence of neocolonial practices by extractive industries (fossil fuels, agro-industry) that benefit the EU's economy. Before promoting large-scale exports of renewable hydrogen/efuels, the EU has a responsibility to create the conditions under which history does not repeat itself.

Insofar as exporting countries and project developers manage to export hydrogen or e-fuels to the EU by 2030, these **imports into the EU should only be allowed if the industrial-scale deployment of renewable sources like wind and solar is undertaken simultaneously with local grid decarbonisation**. To advance this objective, the EU should provide support for scaling up clean energy sources and infrastructure via capacity building, through its development policy and the Global Gateway initiative.

Furthermore, for EU companies considering investment in these projects, it is essential that they commit to facilitating proper technology transfer, ensuring long-lasting added value creation and the generation of high-quality jobs. If hydrogen or e-fuel exports are to become a reality in Europe by 2030, these trade relationships must be mutually beneficial.

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[36] United Nations. *Declaration on the rights of Indigenous Peoples*. Article 32.2. "States shall consult and cooperate in good faith with the indigenous peoples concerned through their own representative institutions in order to obtain their free and informed consent prior to the approval of any project affecting their lands or territories and other resources, particularly in connection with the development, utilisation or exploitation of mineral, water or other resources." (Link).

[37] International Labour Organization (1989). *The Indigenous and Tribal Peoples Convention*. Convention 169. (Link).

Countries wishing to export hydrogen and e-fuels to the EU should undertake a legally binding commitment to progressively reduce reliance on fossil fuels in their local electricity grid mix.

A **sovereign wealth fund financed by royalties from H2 and e-fuel exports** - modelled after the Norwegian pension funds, funded by royalties from oil & gas - should be introduced by exporting countries. This could mitigate some of the issues seen in the past with extractive industries. The use of such a sovereign wealth fund will be best decided by the people of the country. Such a fund could be dedicated to grid decarbonisation and improving electricity access (e.g. only 50% of the population has access to electricity in Namibia).

#5. Prevent negative impacts on water and land use

Every hydrogen and e-fuel project must be conditional to an Environmental Impact Assessment which includes assessment of water availability, wastewater disposal (e.g. brine disposal from desalination), biodiversity and land use impacts in the region. If water assessments show that the hydrogen and e-fuel production will exacerbate water scarcity in the area, access to freshwater resources for the local population should be prioritised. Where **desalination** is needed due to water scarcity, local governments should oblige project developers to oversize their desalination plants to deliver some benefits like an additional freshwater supply to the local population.

Rules already apply in the EU regarding environmental and water impact assessments but it's not always the case abroad. Whilst the recently agreed Corporate Sustainability Due Diligence Directive may address some of these concerns, as companies will be held responsible for their impacts in the EU and abroad, it unfortunately falls short of ensuring businesses outside of the EU adequately respect the environment and address impacts in their supply chains. Specific criteria on environmental indicators should be included by certification schemes, project developers and decision-makers more broadly as seen for example in the EU Critical Raw Materials Act and in the EU Battery Regulation due diligence rules. At the latest in its review of the RFNBO rules by mid-2028, the EU should include binding requirements for water, biodiversity and land use. Already before, auctions by the European Hydrogen Bank should include such an obligation.

Large-scale hydrogen/e-fuels exports will require only a fraction of the land that biofuel production occupies. Nevertheless, if export ambitions are realised, 100s and sometimes 1000s of km2 will be used and may not always be available for other uses. **Exporting countries must identify no-go zones before permitting H2/e-fuels projects. These criteria should be also added to the EU sustainability framework for RFNBOs.** For example, natural ecosystems (forests and key biodiversity areas) or contested territories (e.g. reserves for Indigenous peoples) shall not be used. Project developers also have a responsibility to avoid sensitive areas.

#6. Prepare a switch to sustainable carbon sourcing

By 2041, **the EU's RFNBO rules do not allow fossil carbon to be used for the production of liquid e-fuels**. And before that date, the EU's rules require a form of "effective carbon pricing", if fossil carbon is used to produce various e-fuels. Except for Norway as a member of the ETS, none of the countries reviewed have priced fossil carbon in what could be considered "effective". Most of them have no carbon price or a very low one (e.g. Chile). Introducing a stringent cap & trade system or high carbon tax will be necessary to be able to export carbon-based e-fuels to the EU.

The available supply of biogenic carbon must be analysed and the sustainability of its feedstock assessed, especially in arid areas where available biomass is more scarce. Sourcing biogenic carbon from crops or forest biomass must be avoided, prioritising instead only biogenic carbon from true and sustainable waste and residues.

The use of **Direct Air Capture must be incentivised in the longer term**, as demand for liquid e-fuels will increase especially after 2030 when most fossil carbon sources - especially from the power sector - will be phased out. The challenge of longer-term sourcing of sufficient volumes of sustainable carbon at a low cost underpins T&E's analysis that green ammonia will likely be the most cost-competitive e-fuel suitable for the shipping sector[38]. Another reason for its cost-competitiveness is that green ammonia can be easily transported and be directly used as a shipping fuel, without any prior recracking into hydrogen to make other e-fuels.

#7. Strong monitoring & verification of certification of H2/e-fuels, based on the rules of the EU delegated act

Imports of hydrogen and e-fuels must comply with the rules specified under the delegated act on additionality[39]. But that might not be sufficient to ensure that imports are fully compliant with EU rules. Lessons must be learnt from how certification efforts have failed so far to check some sustainability claims, especially with the long supply chains of imported advanced biofuels[40]. Relying on significant imports of green hydrogen/e-fuels must be combined with stronger monitoring & verification of certification of H_2 and e-fuels.

Further information

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