The Future of Renewable Hydrogen in the European Union

Market and geopolitical implications

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Florence School of Regulation, April 27, 2022

HARVARD Kennedy School
BELFER CENTER

Photo by JJ Ying on Unsplash

The present and future of hydrogen

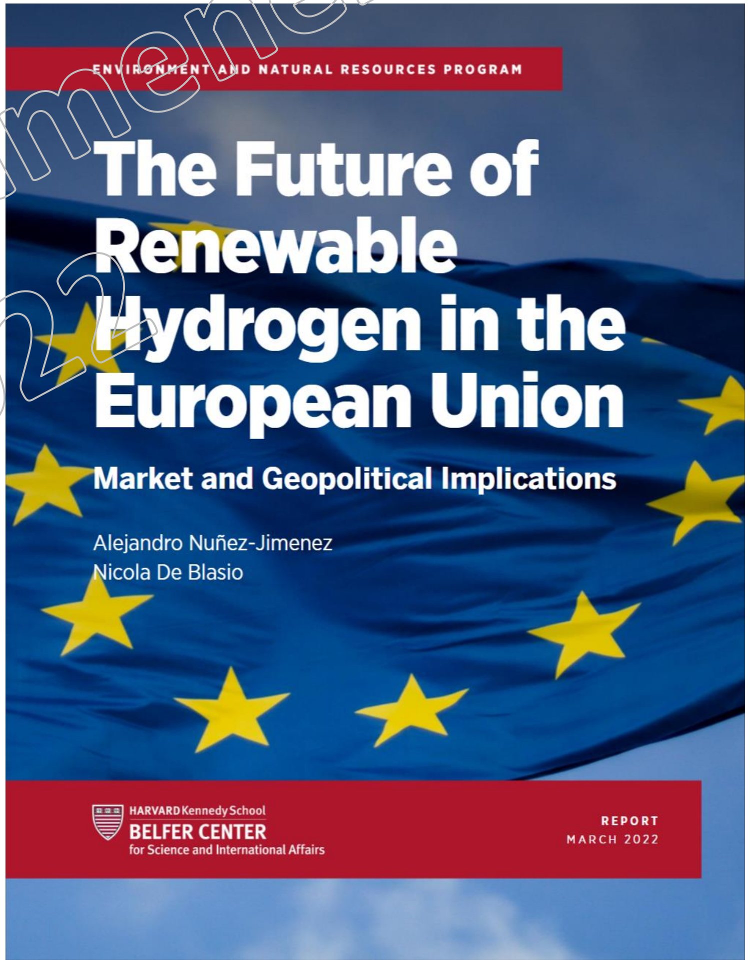
What is the picture today?

- Hydrogen in the world

Where will the European Union get competitive and secure renewable hydrogen from?

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

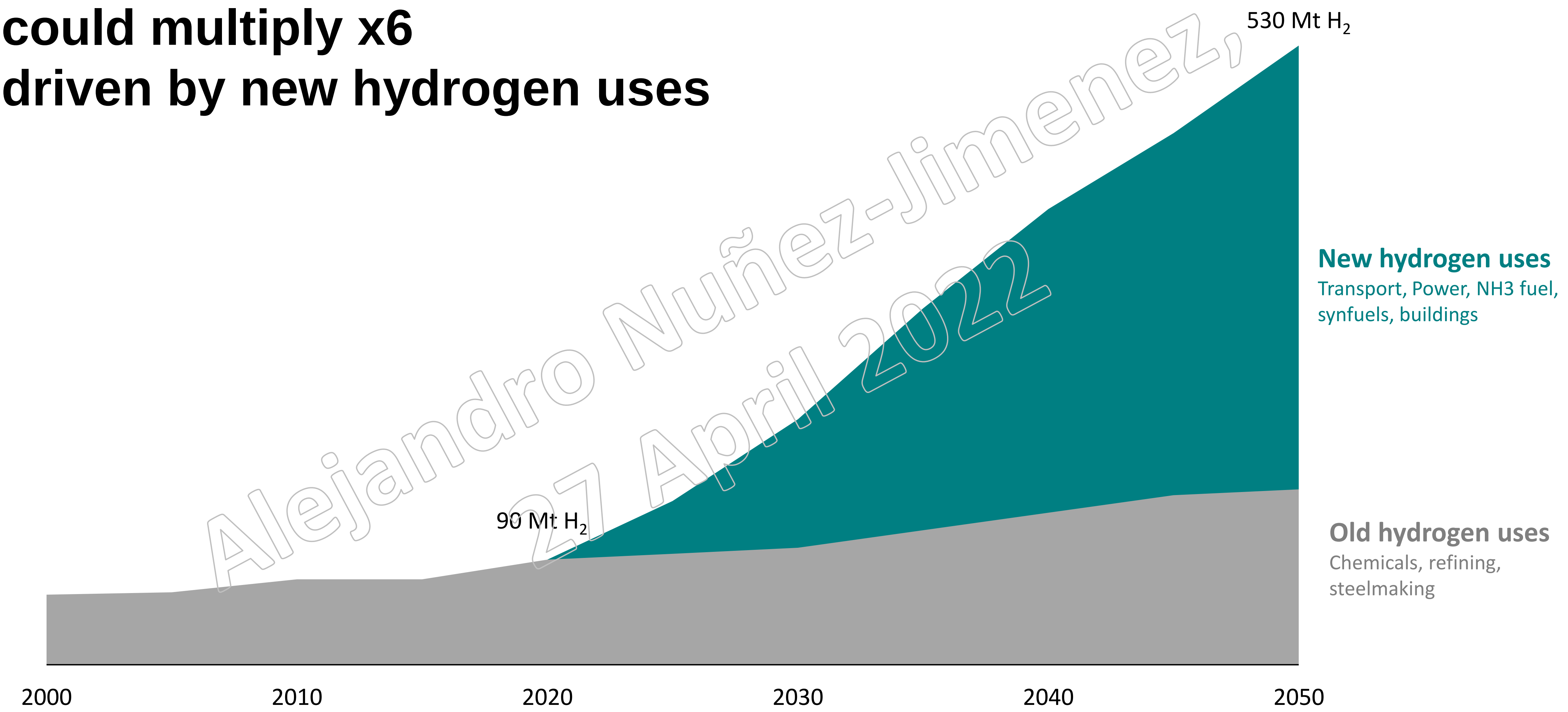
Q&A



Why there is so much excitement about hydrogen?

- Expectations for high demand
- Clean hydrogen production gap

Global hydrogen demand could multiply x6 driven by new hydrogen uses

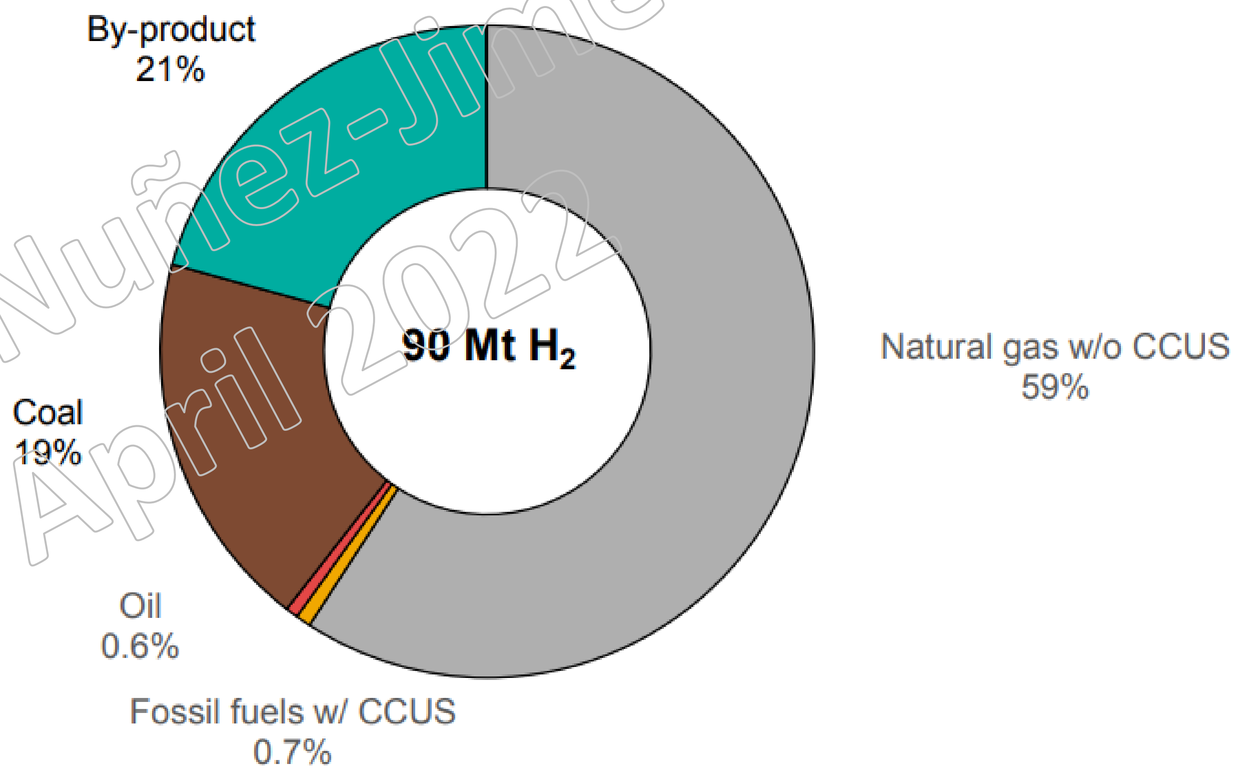


Data: IEA GHR 2021, Net Zero Emissions scenario.

Hydrogen production today is part of the problem

Equivalent to the combined emissions of Indonesia and the UK (900 Mt CO_2)

Sources of hydrogen production, 2020

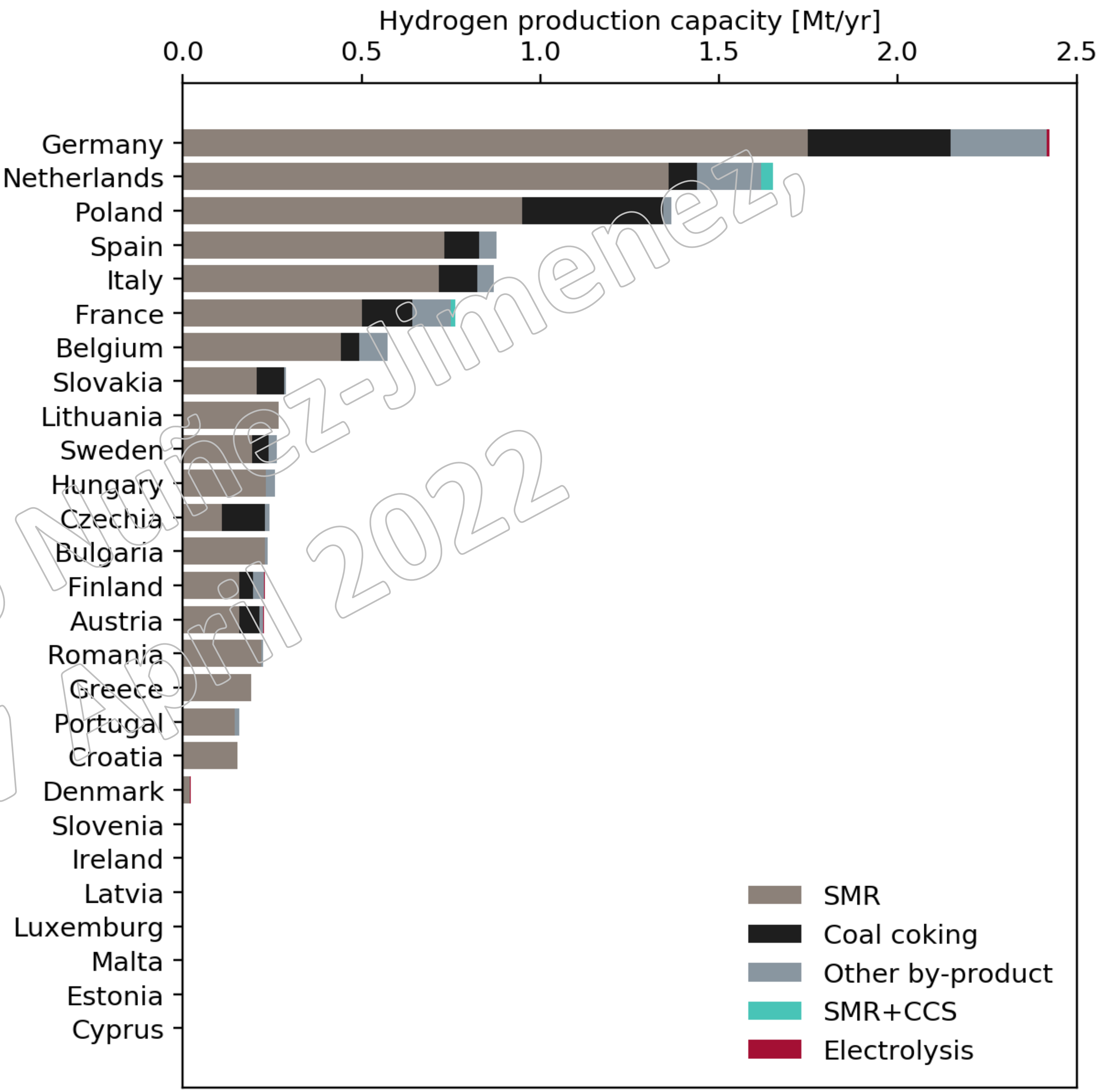


Note: CCUS = carbon capture, utilisation and storage.

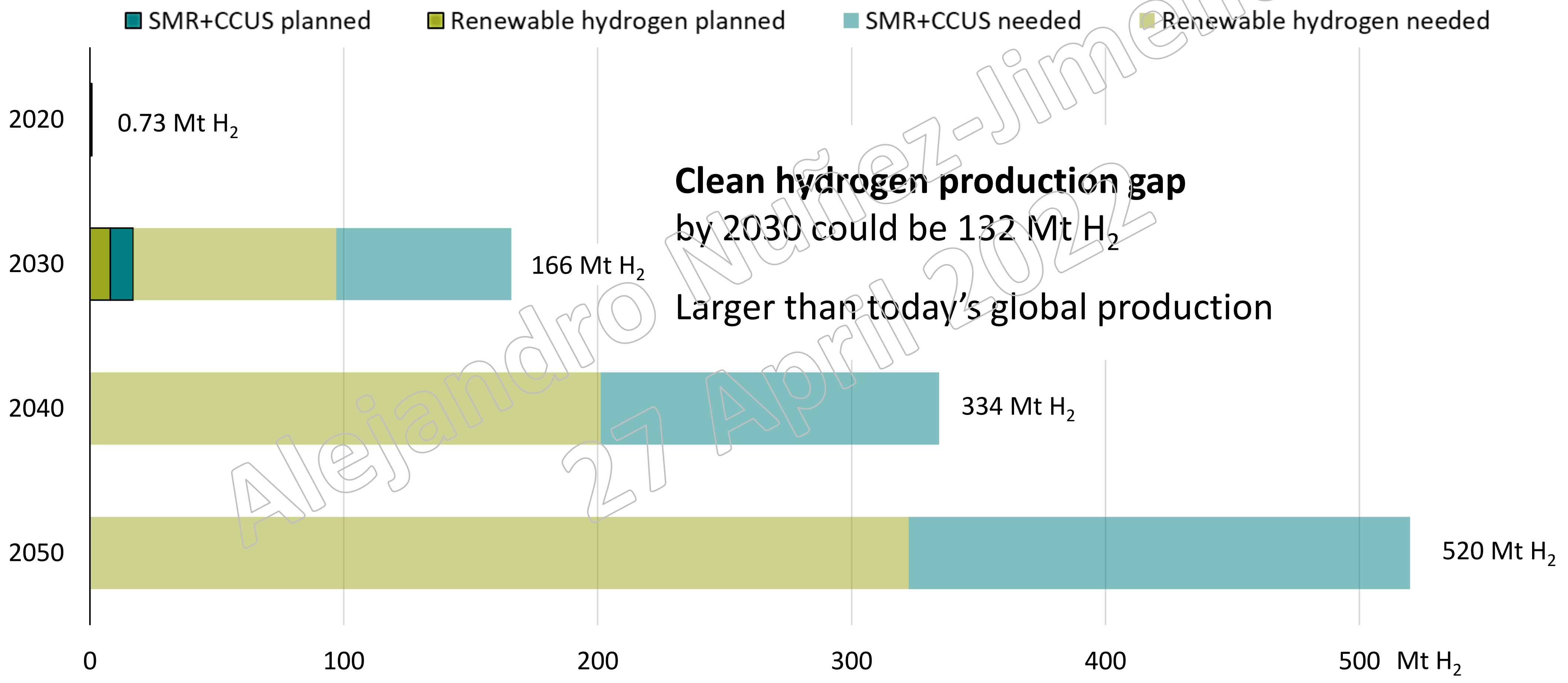
Also in the European Union

EU production capacity 11.3 Mt/yr

- **SMR:** 77%
- **Coal coking:** 14%
- **SMR+CCS:** 0.4%
- **Electrolysis:** 0.1%
- **Other by-product:** 8%



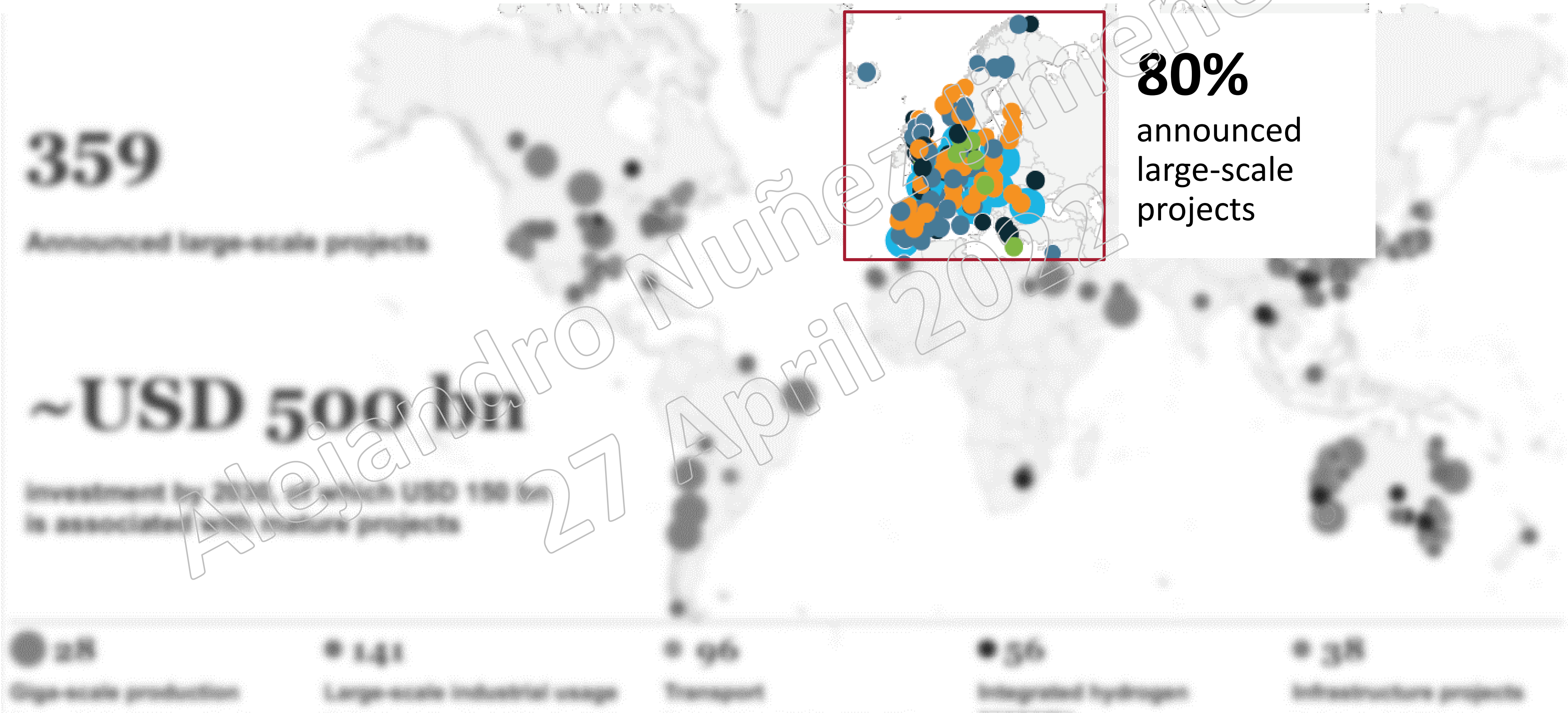
Clean hydrogen production Is not growing fast enough



Data: IEA GHR 2021, Net Zero Emissions scenario.

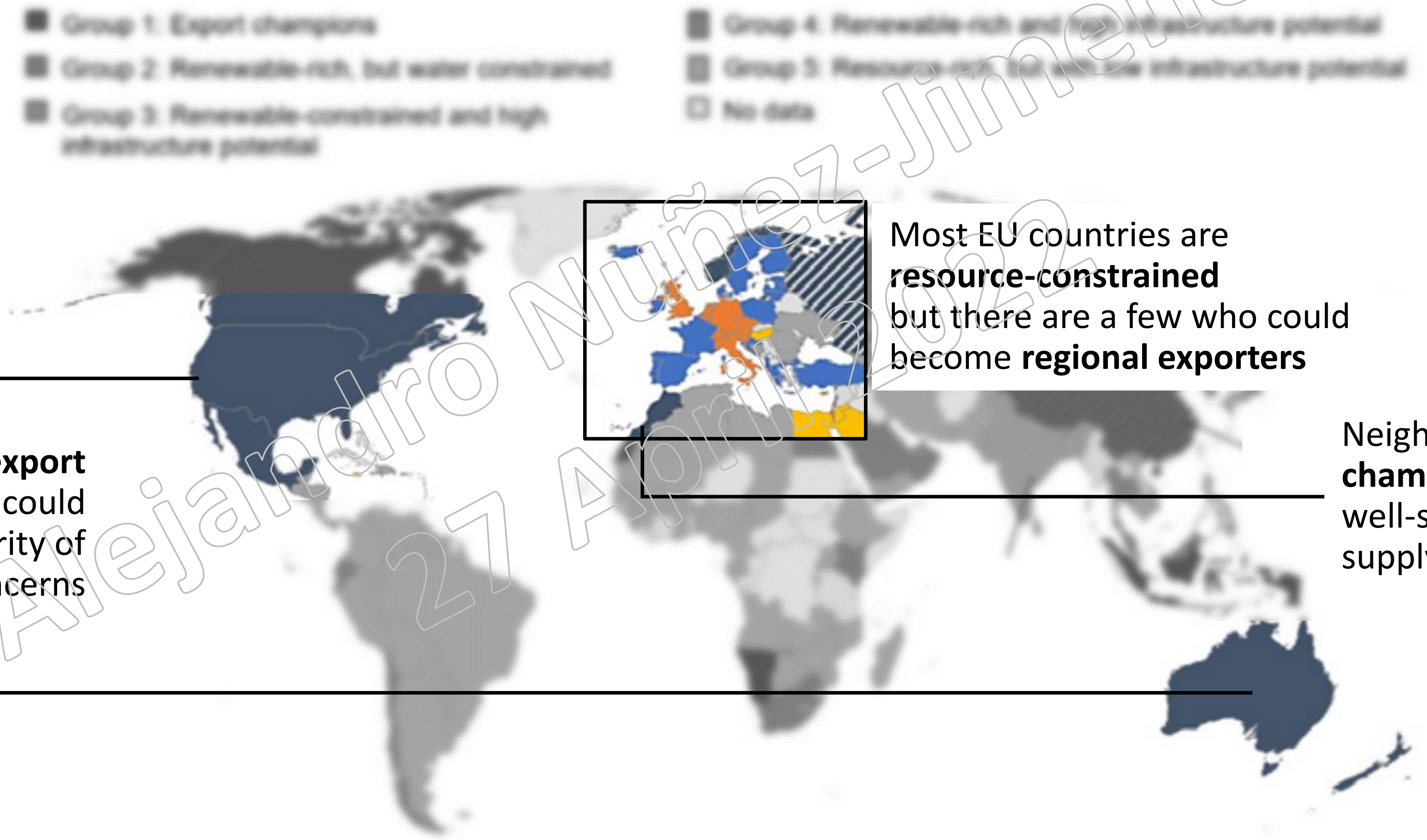
Where will the EU obtain competitive and secure renewable hydrogen supplies from in the long term?

Hydrogen enjoys unprecedented momentum worldwide, and Europe is at the forefront of the global hydrogen race



McKinsey & Company, 2021, Hydrogen Insights, for the Hydrogen Council, July 2021, https://hydrogencouncil.com/en/hydrogen-insights-2021/

To stay ahead, the European Union (EU) needs a cohesive long-term strategy for competitive, secure hydrogen markets



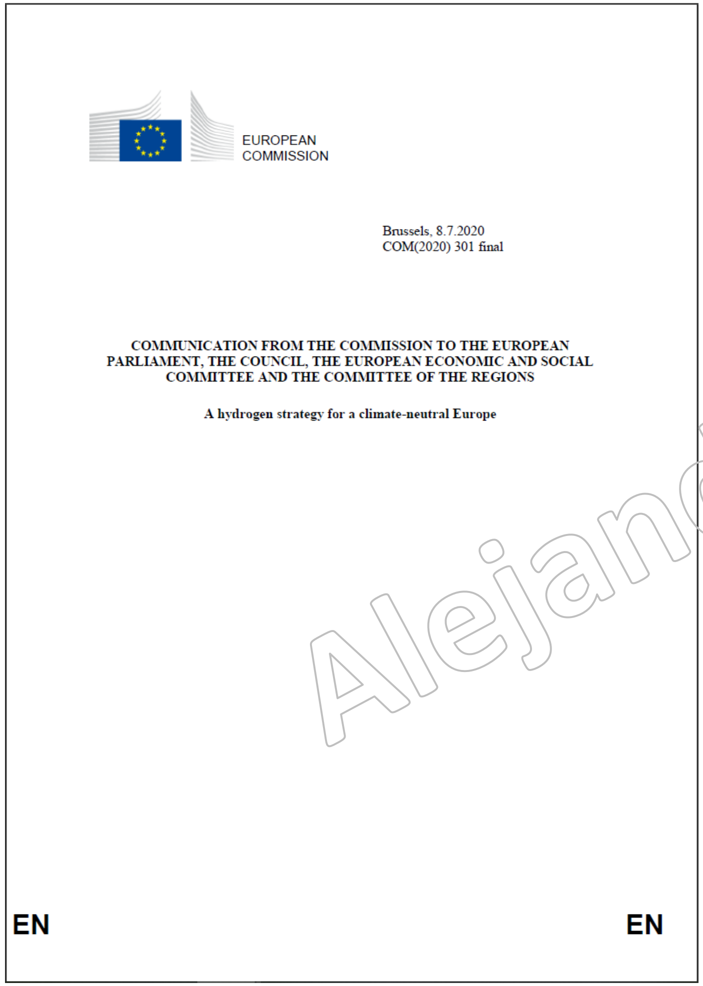
Most EU countries are **resource-constrained** but there are a few who could become **regional exporters**

Long-distance export champions could mitigate security of supply concerns

Neighbor **export champions** are well-situated to supply the EU

Pflugmann, F., De Blasio, N. 2020. The Geopolitics of Renewable Hydrogen in Low-Carbon Energy Markets, Geo., Hist., and Int. Rel. doi:10.22381/GHIR12120201

In July 2020, the EU hydrogen strategy presented renewable hydrogen as key for reaching climate neutrality in 2050


EUROPEAN COMMISSION

Brussels, 8.7.2020
COM(2020) 301 final

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

A hydrogen strategy for a climate-neutral Europe

EN EN

- **Renewable hydrogen** (water electrolysis using wind and solar) is the **key priority**
- **Deployment targets for electrolyzers** are set (6GW 2024, 40GW 2030) to produce about 10 Mt H_2 by 2030
- After 2030, no targets
- Aspirations for "an **open and competitive EU hydrogen market**"
- Recognition of "**new opportunities for re-designing Europe's energy partnerships**"

European Commission (EC) (2020), 'A hydrogen strategy for a climate-neutral Europe', COM(2020) 301 final, 8 July 2020. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0301

On March 8, 2022, the European Commission raised its ambition on renewable hydrogen with the RepowerEU plan

20 Mt H2 of renewable hydrogen by 2030 (vs. 5.6 Mt H2 in Fit for 55)

Of the 15 Mt H2 added: 5 Mt H2 in EU + 10 Mt H2 imports

All new gas infrastructure must be hydrogen-ready

Incuding cross-border connections

Accelerate switch to hydrogen in industry

EU-wide scheme of carbon contracts-for-difference

While the EU strategy lays the foundations for an EU hydrogen economy, it leaves the door open to different views on what future hydrogen markets may look like after 2030

Our research analyzes three scenarios in which the EU prioritizes different strategic variables

Scenario	Priority	Description	Countries
Hydrogen Independence	***Energy independence***	EU internal production only	**EU member states**
Regional Imports	***Cost optimization***	EU internal production with imports from regional neighbors	**EU + Regional partners**: neighboring export champions (Morocco, Norway) + renewable-rich, high infrastructure potential countries (Albania, Egypt, Iceland, Turkey)
Long-Distance Imports	***Energy security***	Long-distance imports complement EU and regional supplies	**EU + Regional neighbors + Long-distance partners**: long-distance export champions (Australia, United States)

Each scenario is investigated in three steps

1. Feasibility assessment

Is there enough renewable hydrogen to meet demand?

2. Production cost-competitiveness analysis

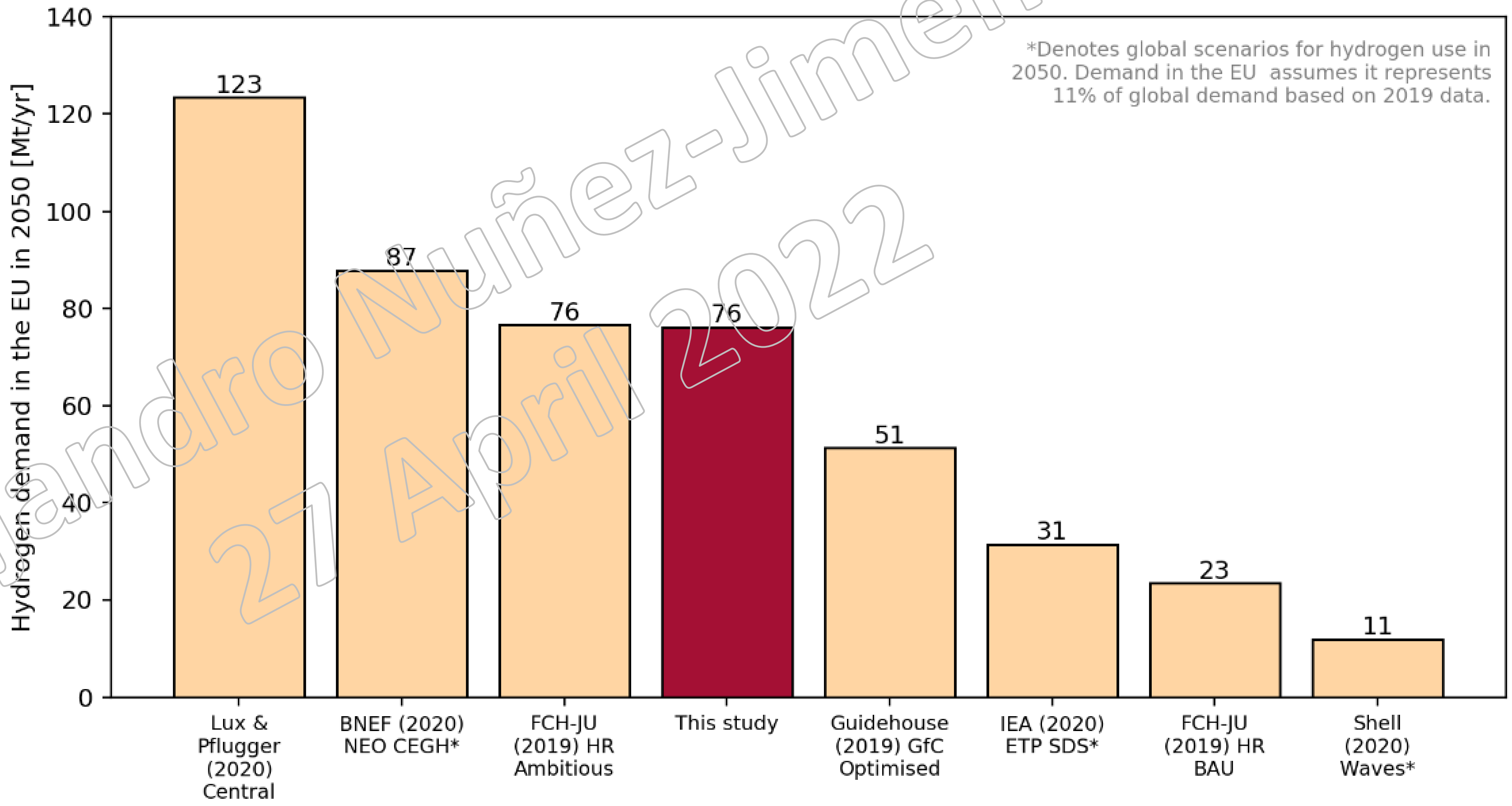
How costly is renewable hydrogen production?

3. Trade optimization

What are key trade routes to keep supply costs lows?

Future EU hydrogen demand was projected because no consumption target is set in the EU strategy

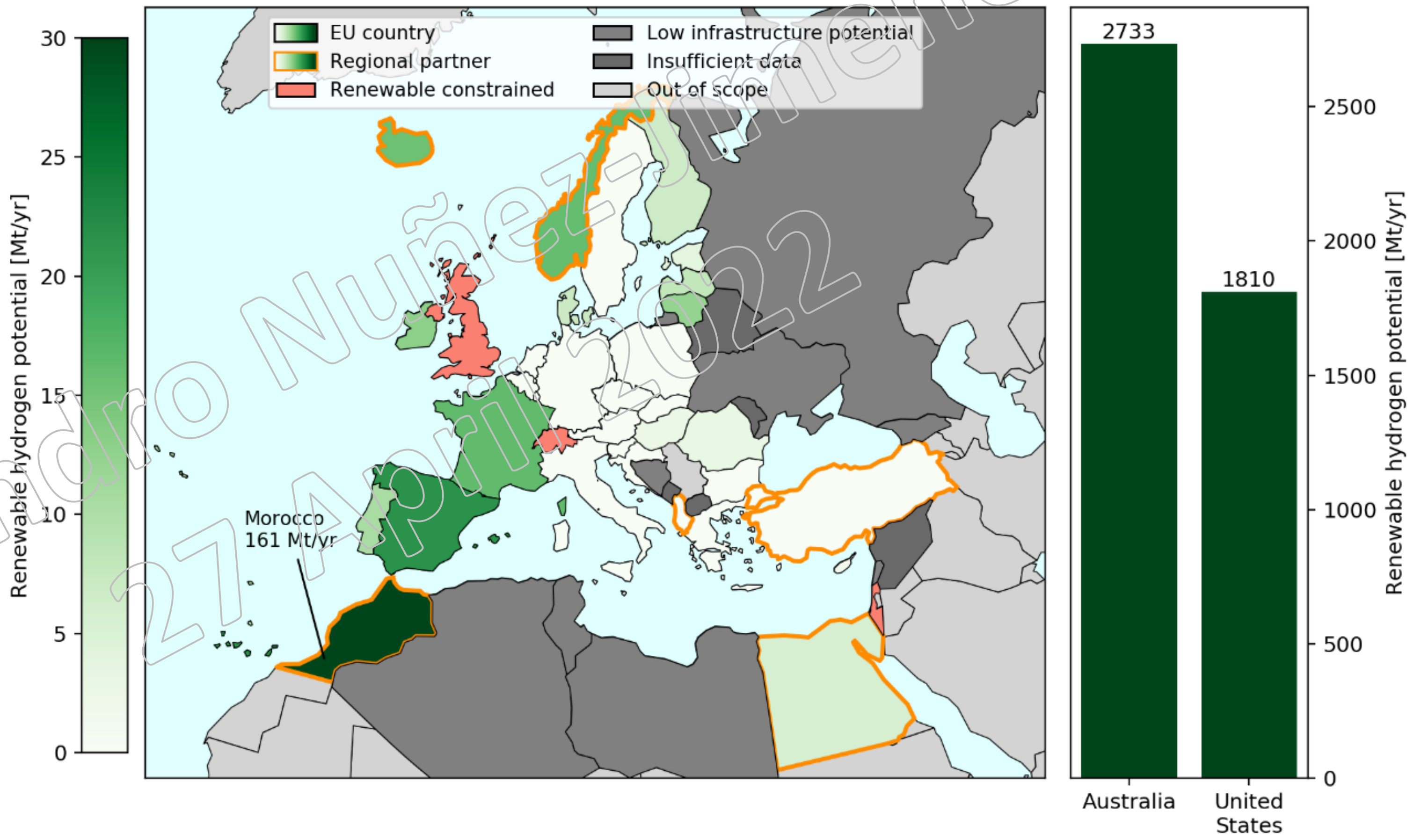
- 2050 EU hydrogen demand based on national hydrogen targets **in key EU countries**
- Hydrogen demand in 2050 in each EU country **equivalent to 15% of current primary energy**



Own elaboration based on a review of recent literature. Conversion using lower heating value of hydrogen when required.

1. All scenarios are viable pathways to meet long-term EU hydrogen demand

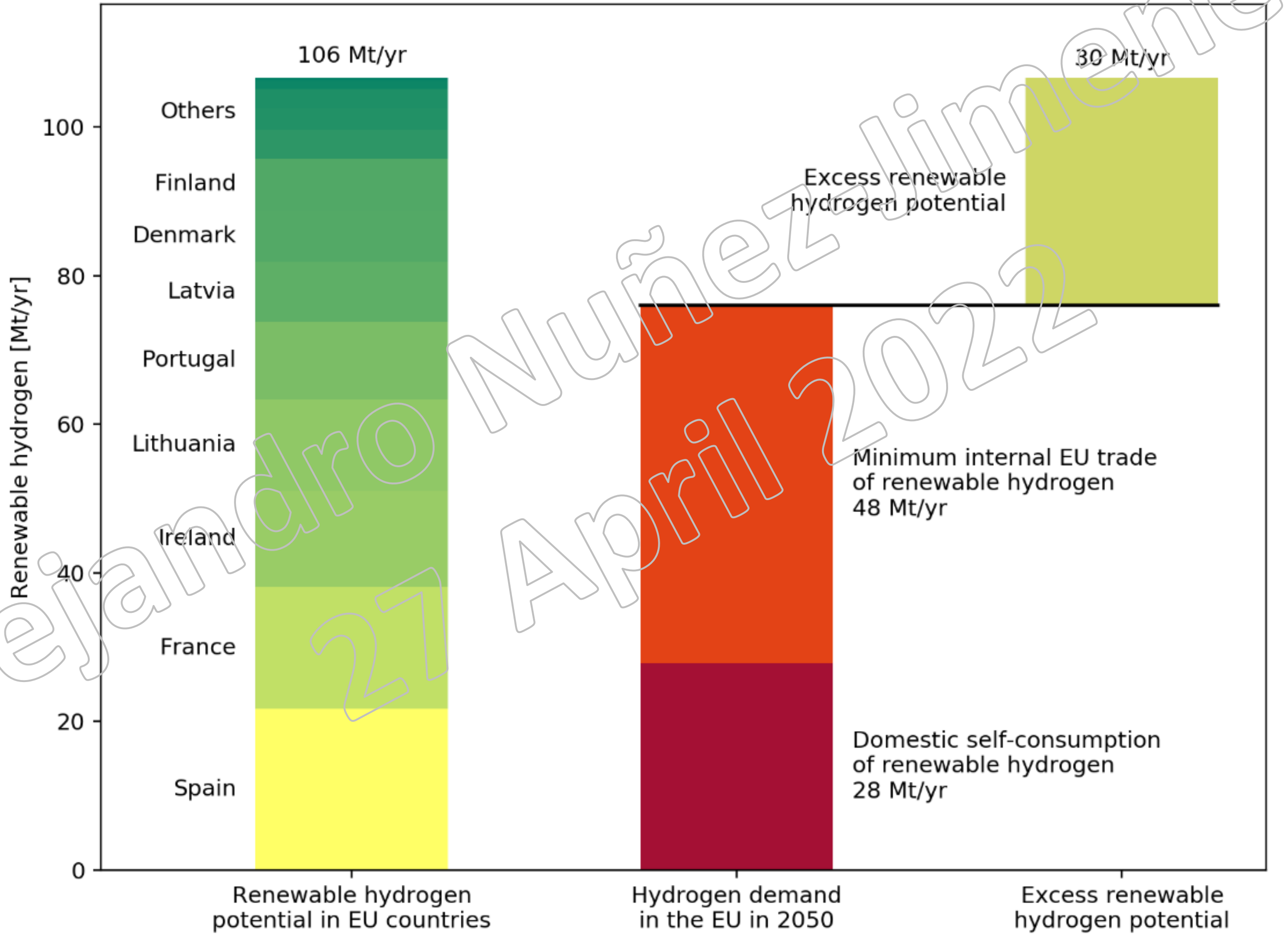
- **No EU country can become an export champion**
- Member states in the **EU periphery** have high potentials
- Regional and long-distance partners have much larger potentials than EU countries



Authors' own analysis.

But to become Hydrogen Independent by 2050, a vast EU internal market for hydrogen has to emerge

8 EU countries account for **80% of EU renewable hydrogen potential**

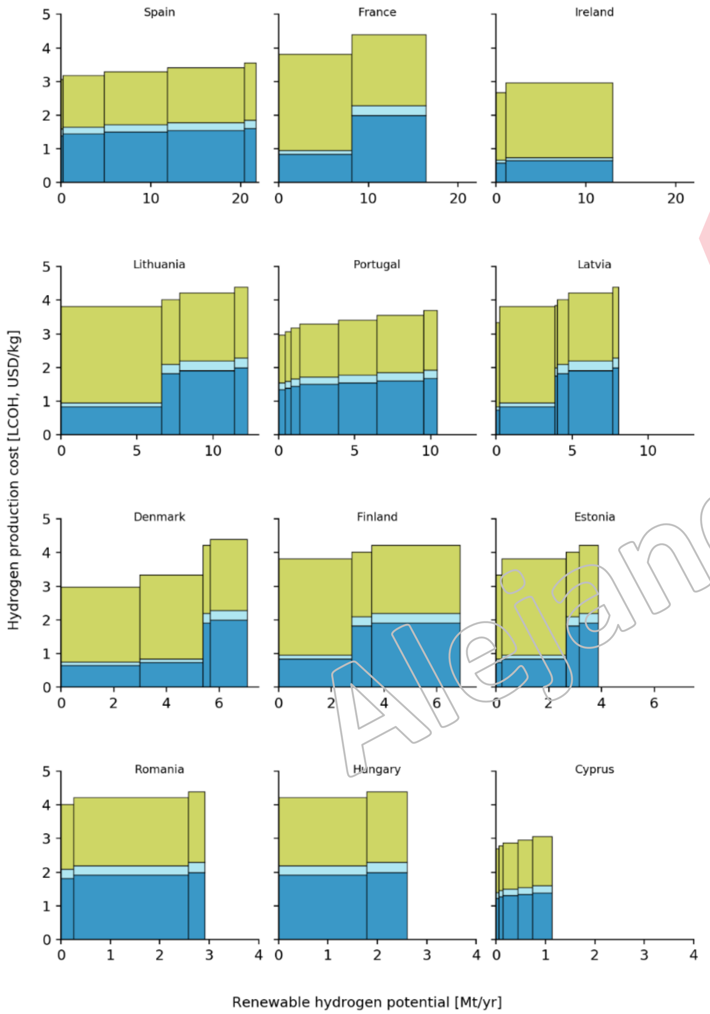


Internal EU trade must cover at least **two-third of hydrogen demand**

15 EU countries would face **"production gaps"**

Authors' own analysis. Domestic self-consumption refers to renewable hydrogen produced and consumed within the same country.

2. Production cost depends on renewable hydrogen production scale

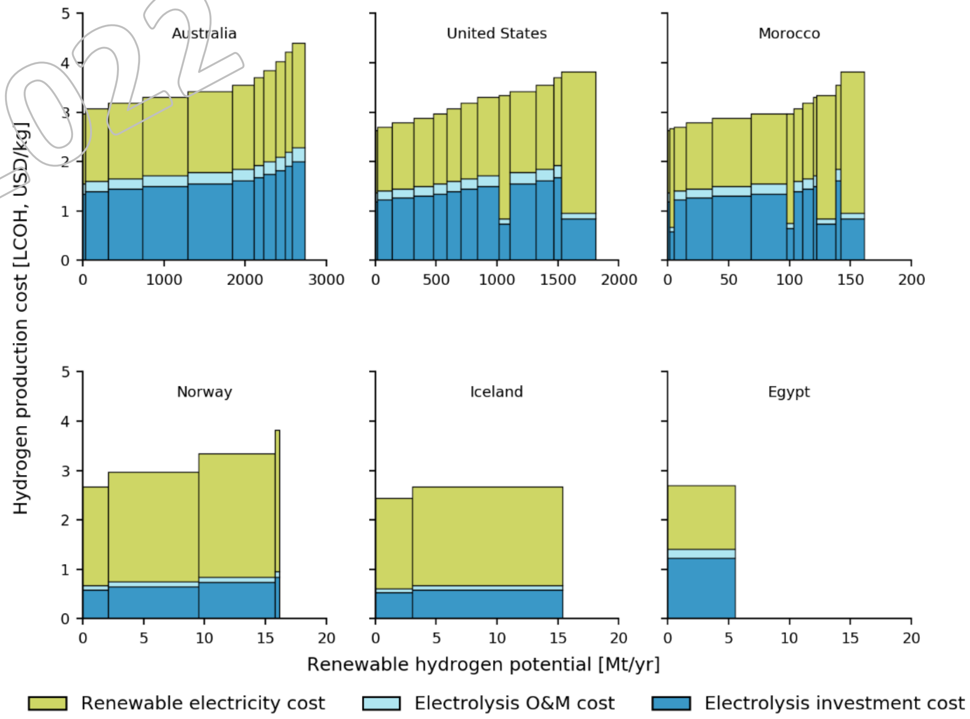


EU production costs range 2.7-4.4 USD/kg

3.5 USD/kg WAHC* to meet 2050 EU demand

Outside the EU, similar cost ranges but larger potentials at lower costs

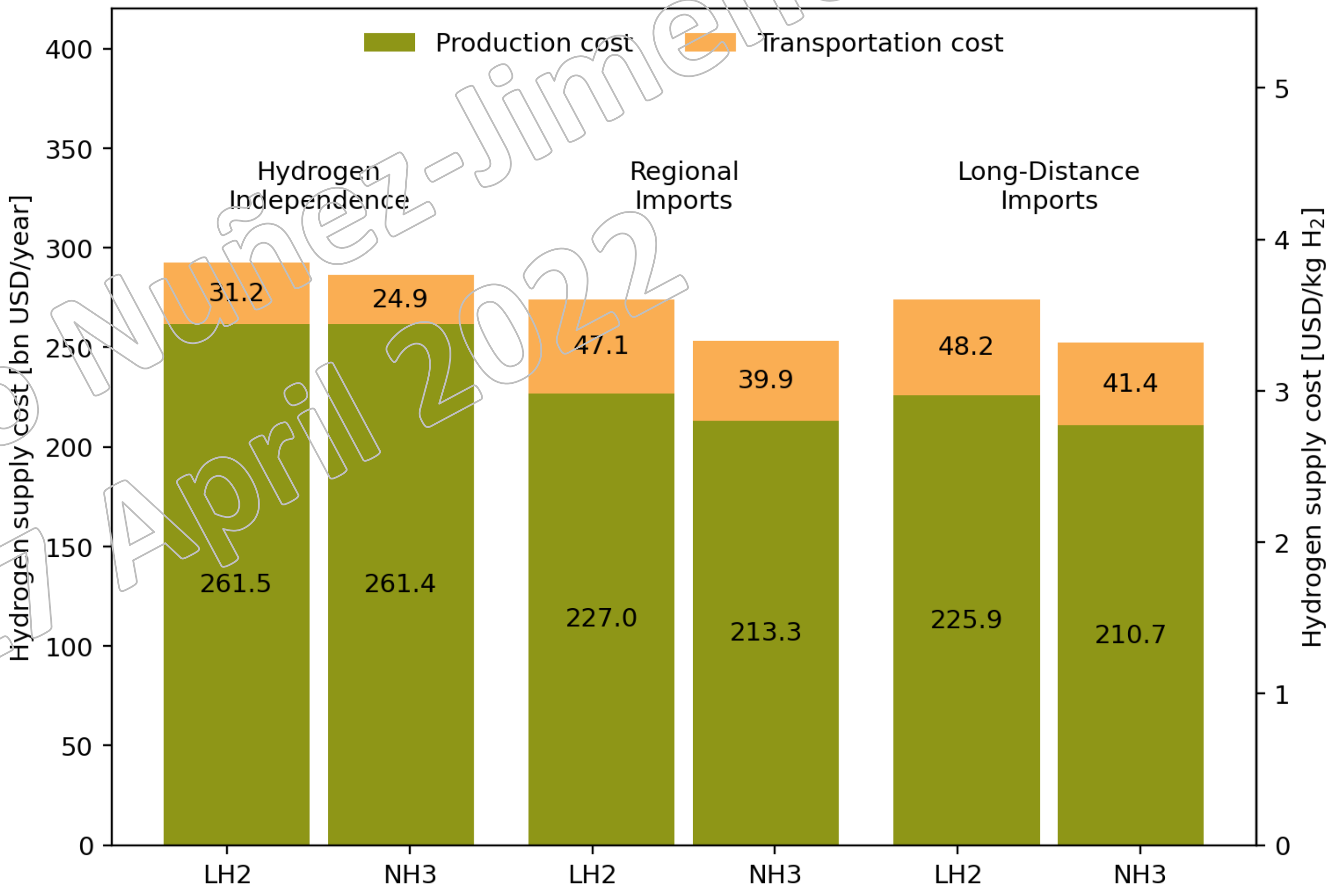
2.7 USD/kg WAHC* to meet 2050 EU demand



WAHC stands for weighted average hydrogen cost based on renewable hydrogen production cost as a function of produced quantity in each country excluding transportation costs and making use of lowest-cost resources

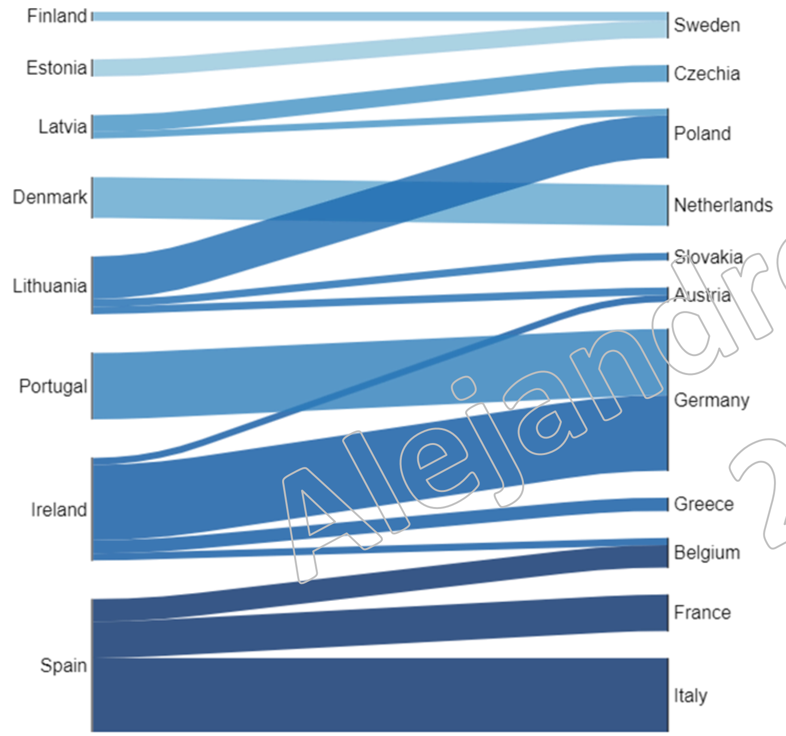
3. Imports could lower supply costs by 6% to 12%

- Between **253 and 294 bn USD/yr supply costs**, equivalent to 3.3 to 3.9 USD/kg
- **Long-Distance Imports** provide **no** additional **costs reduction opportunities**
- **Ammonia shipping lowers supply costs** thanks to lower transportation costs and access to cheaper imports

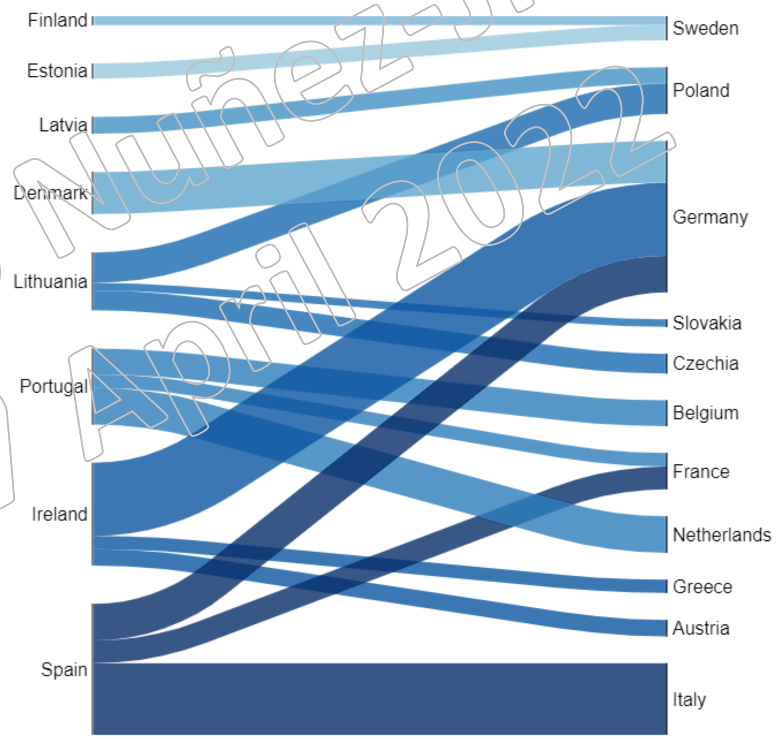


Hydrogen Independence relies on countries in the EU's periphery bridging production gaps in Central Europe

Hydrogen Independence scenario with hydrogen gas pipelines and **liquefied hydrogen shipping**



Hydrogen Independence scenario with hydrogen gas pipelines and **ammonia shipping**

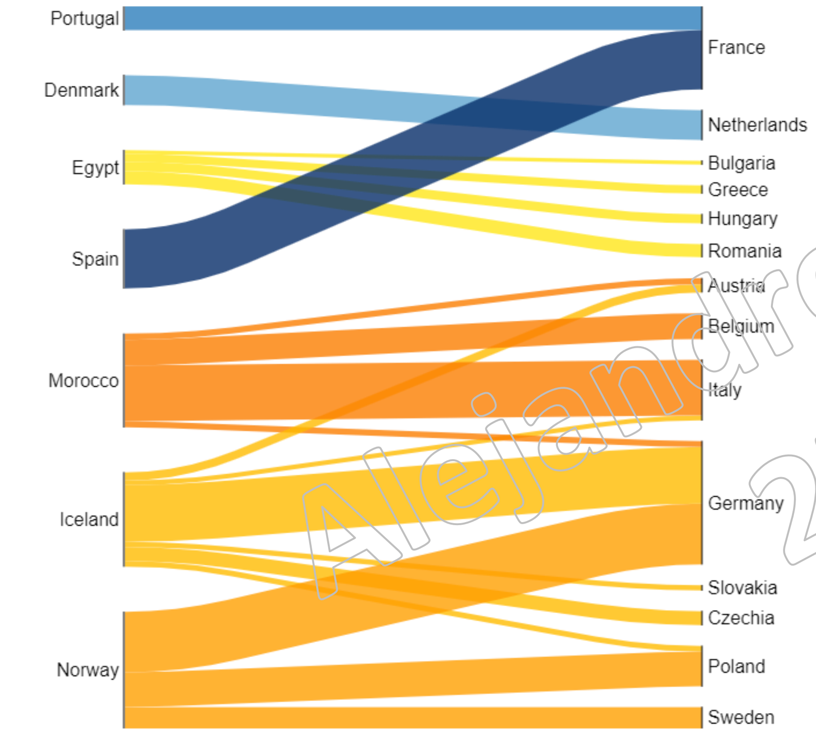


Authors' analysis. Flows below 0.5 Mt/yr and domestic self-consumption excluded for clarity.

- **70% of EU demand** would be met by **internal EU trade**
- **Pipelines** from Spain and Portugal, the Baltic states (Estonia, Latvia, Lithuania), and Denmark would cross the continent to supply resource- constrained EU countries

Regional Imports lower supply costs by importing over 60% of EU hydrogen demand from North Africa and North Europe

Regional Imports scenario with hydrogen gas pipelines and **liquefied hydrogen shipping**



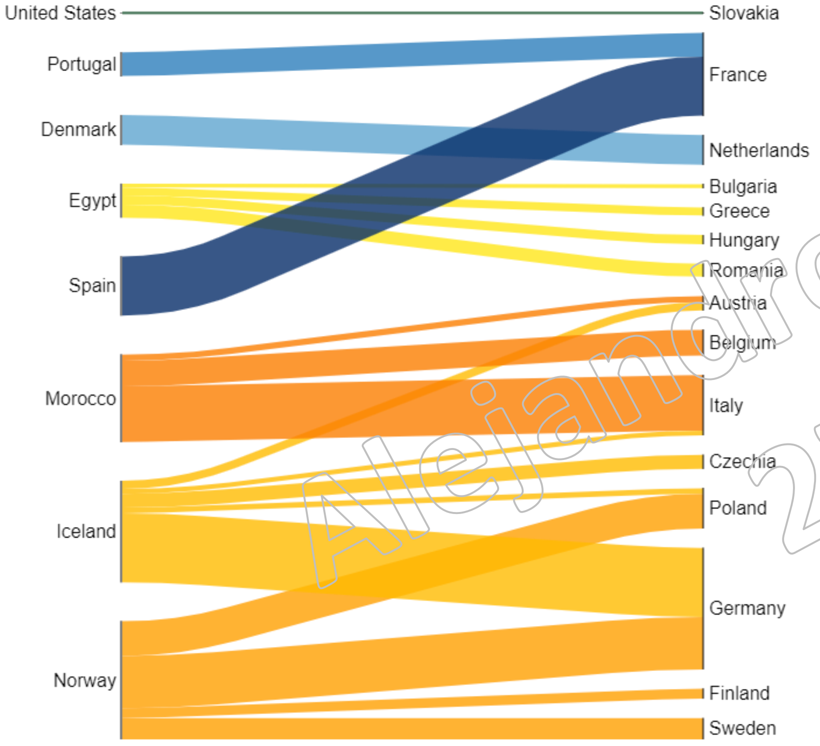
Regional Imports scenario with hydrogen gas pipelines and **ammonia shipping**

Authors' analysis. Flows below 0.5 Mt/yr and domestic self-consumption excluded for clarity.

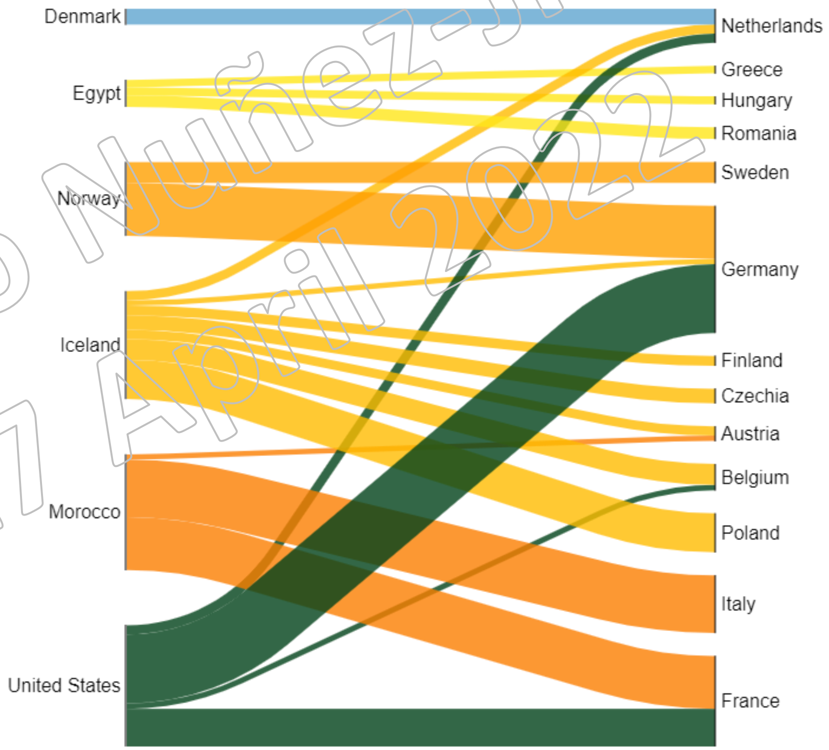
- **Imports supply 62% of EU demand** with **liquefied hydrogen shipping**
- **Imports** rise to **84%** if **ammonia shipping** is available
- **Norway and Morocco** would be the **largest suppliers to the EU**
- Reliance on a few regional suppliers could reproduce past patterns of **energy dependence**

Long-Distance Imports help diversify imports cost-effectively but only if shipping hydrogen becomes competitive

Long-Distance Imports scenario with hydrogen gas pipelines and **liquefied hydrogen shipping**



Long-Distance Imports scenario with hydrogen gas pipelines and **ammonia shipping**

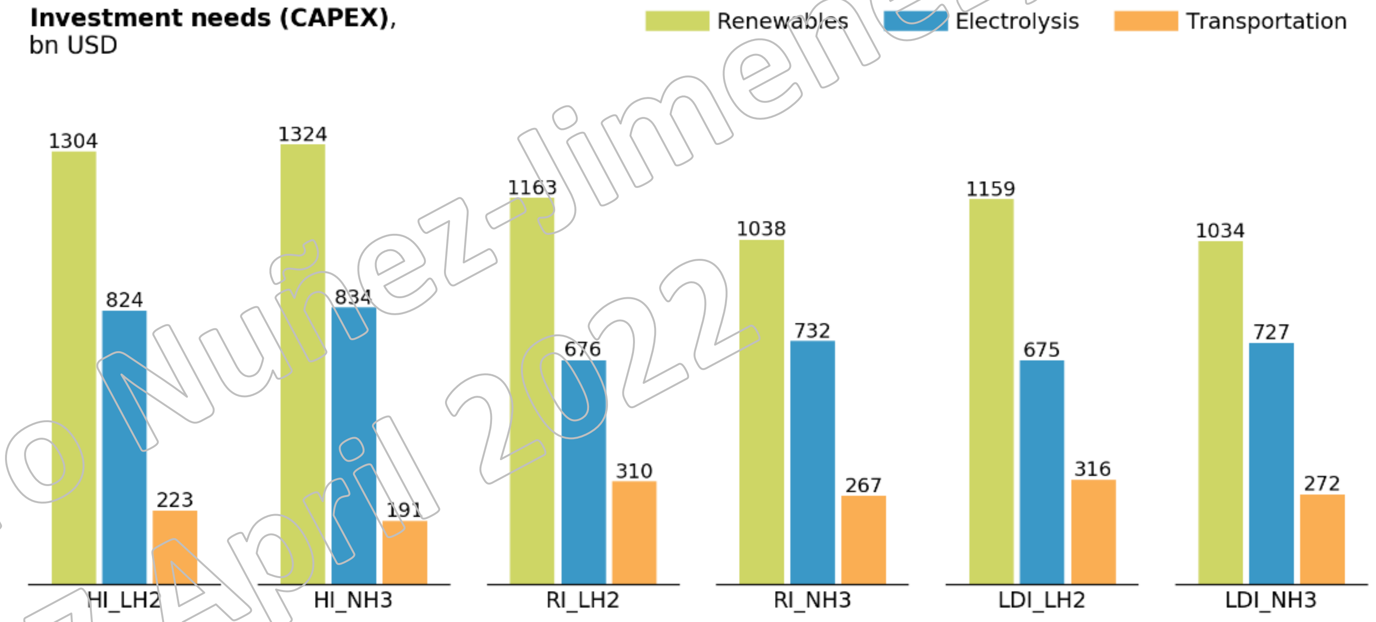


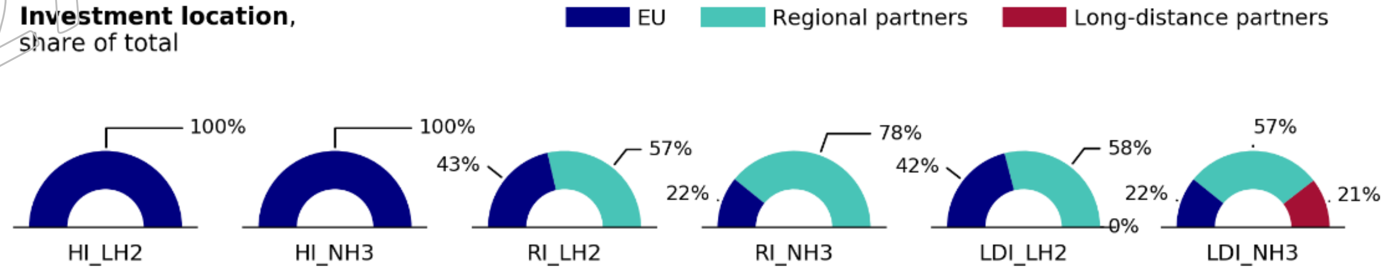
Authors' analysis. Flows below 0.5 Mt/yr (except from the United States on the left graph) and domestic self-consumption excluded for clarity.

- **Imports cover 63% to 83% of EU demand**
- Ammonia shipments from the **United States could limit EU dependence on any single producer to 20%** of overall demand

To make any of these scenarios a reality, at least between 2.0 and 2.4 trillion USD need to be invested until 2050

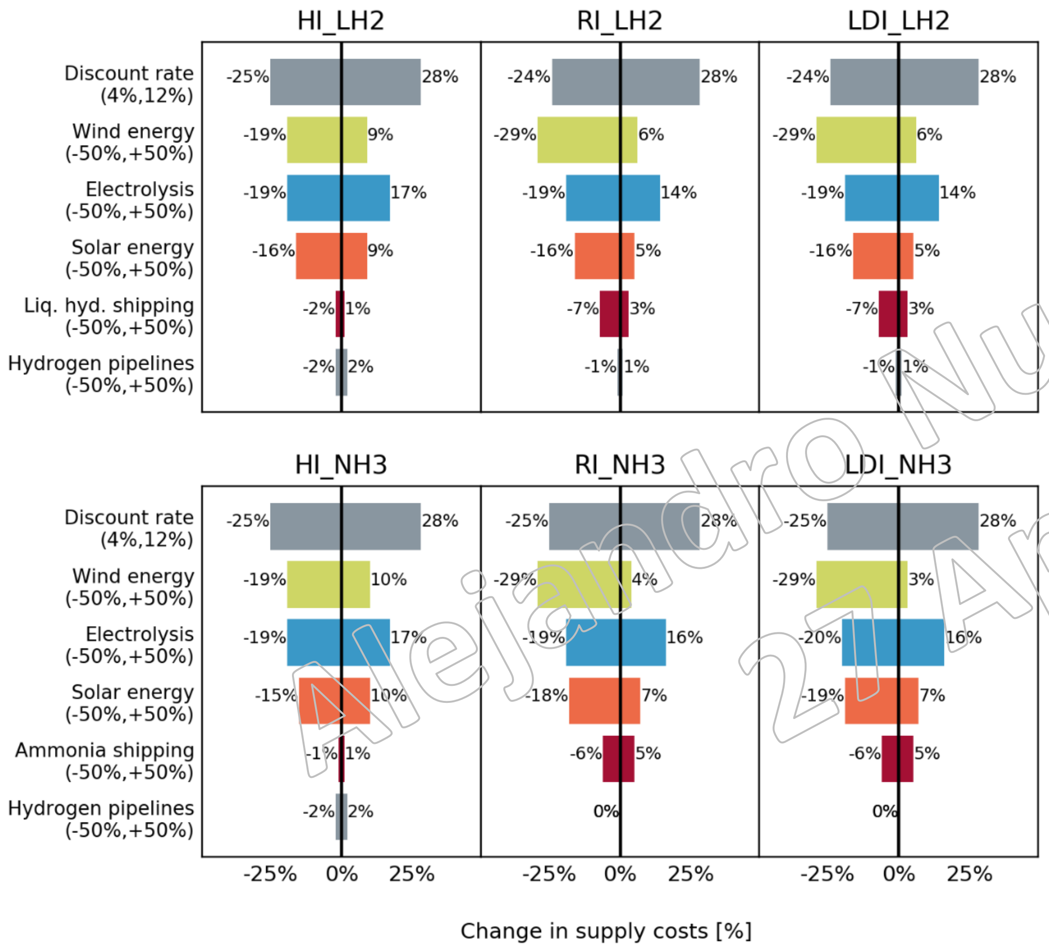
- **Over 80% of investment** needs are for **renewable electricity** generation and **electrolyzers**
- **Imports lower total investment** needs by 9% to 13% **despite** requiring **higher investments in transportation** infrastructure
- With imports **57% to 78% of investments** vital for the EU's long-term hydrogen strategy **outside the EU**





Scenario labels: HI: Hydrogen Independence, RI: Regional Imports, LDI: Long-Distance Imports. Transportation scenario labels: LH2: hydrogen gas pipelines and liquefied hydrogen shipping, NH3: hydrogen gas pipelines and ammonia shipping.

4. Scenario rankings remain the same under very different technology cost assumptions



Scenario labels: HI: Hydrogen Independence, RI: Regional Imports, LDI: Long-Distance Imports. Transportation scenario labels: LH2: hydrogen gas pipelines and liquefied hydrogen shipping, NH3: hydrogen gas pipelines and ammonia shipping.

- **Lower cost of capital** (4%) reduces supply costs by one-fourth to between **2.5 and 2.9 USD/kg** compared to 3.3 to 3.9 USD/kg in the reference case (8%)
- **A "switch effect"** would **limit the impact of costlier-than-anticipated renewables**
- Changes in **transportation infrastructure costs** have only **minor impacts**

Policy implications

Renewable hydrogen adoption at scale in the EU will require to:

- **Lower market risk** and remove commercialization barriers to achieve the required economies of scale
- Define **clear policies to stimulate strong renewable sources growth**, particularly in those member states that can become regional exporters
- **Fund innovation** and pilot projects to accelerate progress towards cost-competitive renewable hydrogen technologies
- **Coordinate the enabling infrastructure development** and deployment across the continent, based on optimized flows
- **Harmonize standards and regulations**, including certificates of origin, to ensure renewable hydrogen flows seamlessly across borders

Regional Imports or Long-Distance Imports will also require:

- **Long-term contracts and direct investments** to help reduce market risk for producing nations
- **Transparent regulations** and long-term investments in enabling infrastructure to send strong signals to investors in producing nations
- **International standards** for renewable hydrogen production, transportation, and use

Future of Hydrogen Initiative is a project at the Belfer Center of the Harvard Kennedy School led by Dr. Nicola de Blasio and Prof. Henry Lee

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Thanks for your attention!

I look forward to your questions