At the dawn of a new era

ECONOMY OF HYDROGEN

France Hydrogène
Engagée pour la transition écologique

GIIGNL

Marseille 15. April 2024

Philippe BOUCLY, Président

12 - 2020

France Hydrogène enjoys a strong dynamics

Key figures of the Association*

460
Stakeholders

121
Large & intermediate groups

208
SMEs

71
Local authorities

11
Competitiveness clusters

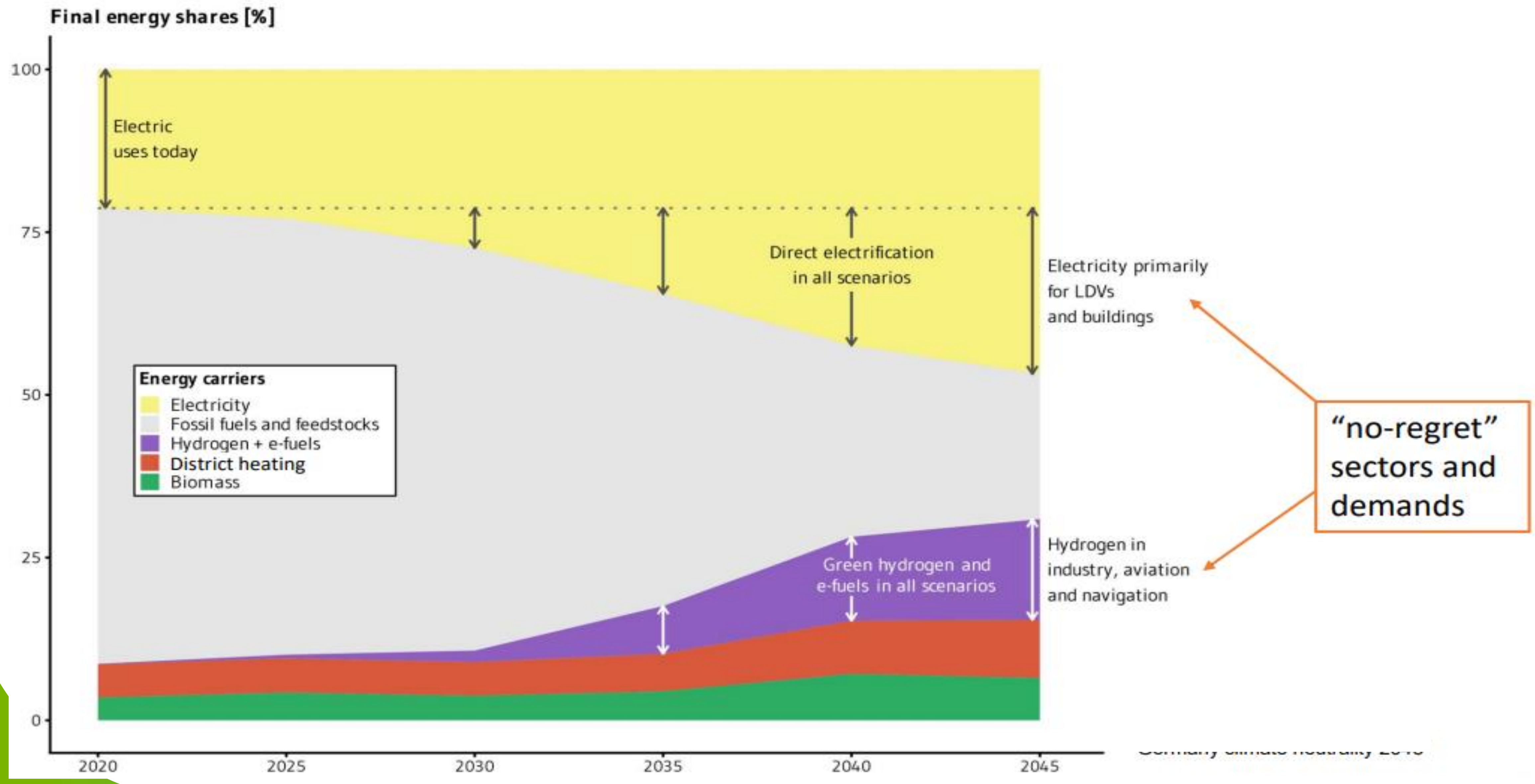
22
Research, Academia, Education actor

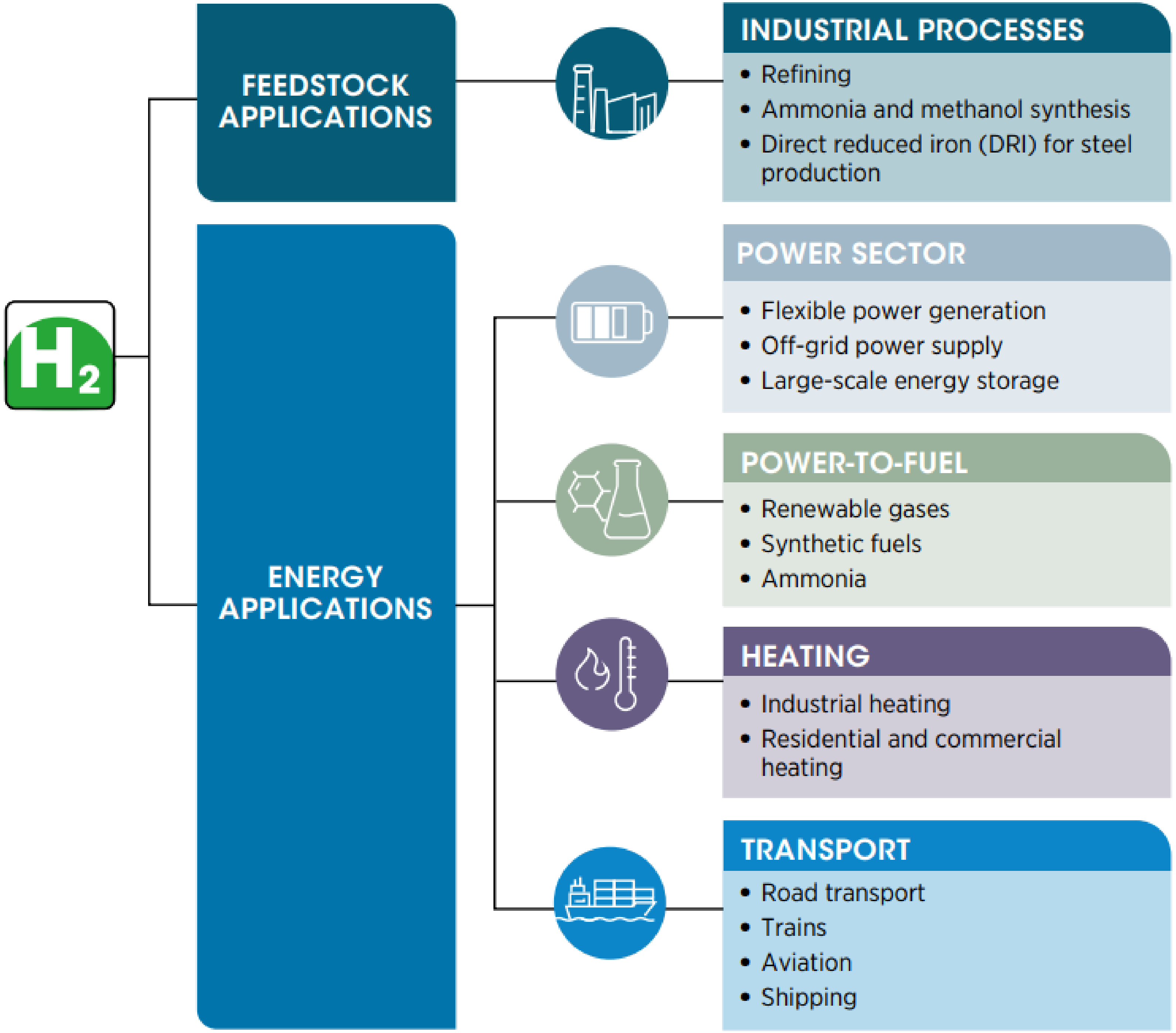
27
Associations, federations, …

*January 2024

Member of the **National Hydrogen Council**
Member of **Hydrogen Europe** and of the **European Clean Hydrogen Alliance**

Why hydrogen ?





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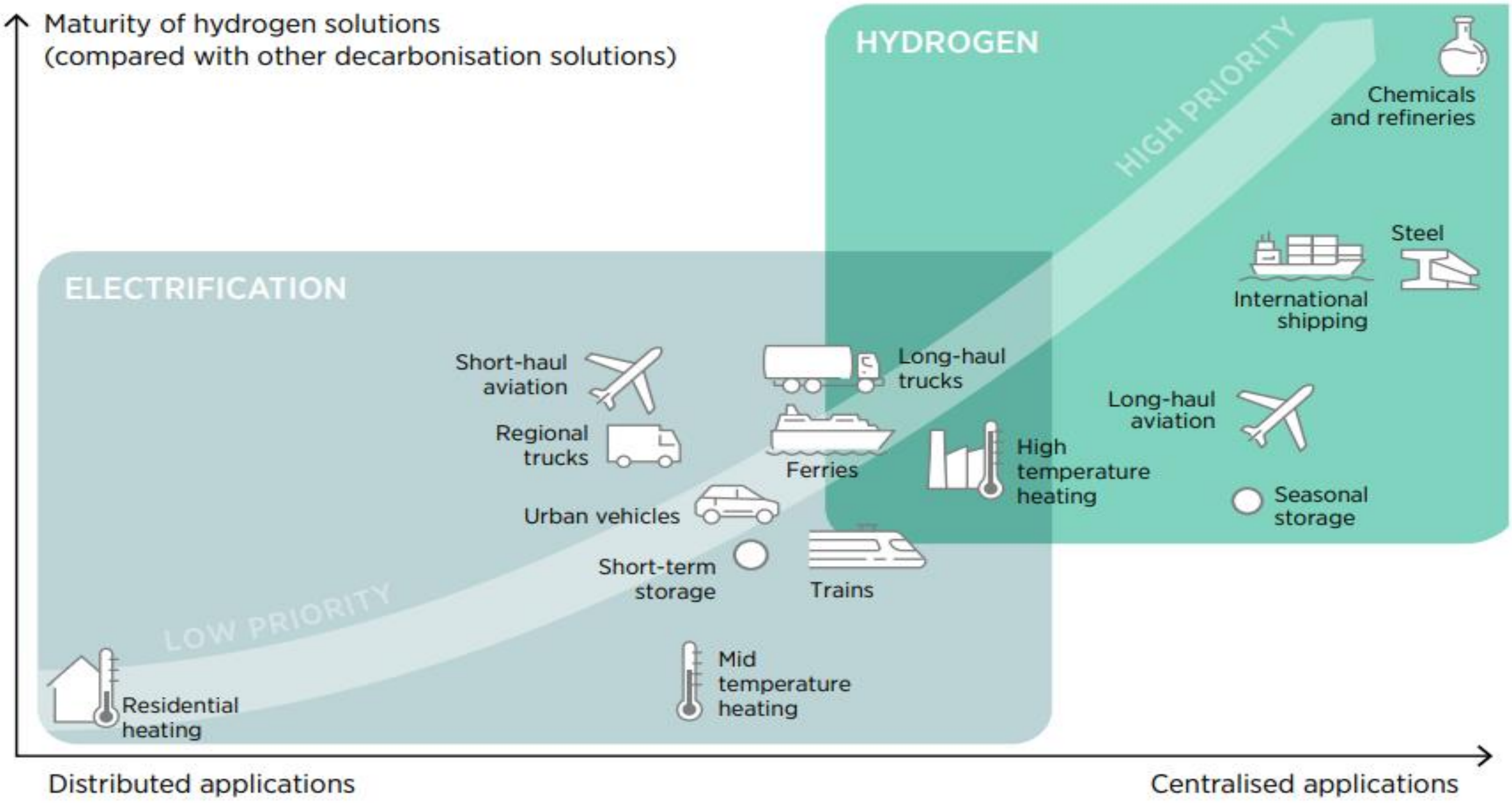
Potential uses of clean hydrogen

- **To decarbonize the economy**
- **To contribute to integrate renewables in the power system**

(intermittency of renewables)

Priority uses of clean hydrogen : »Hard to abate » sectors



Source: IRENA (2022e).

Value chain of clean hydrogen

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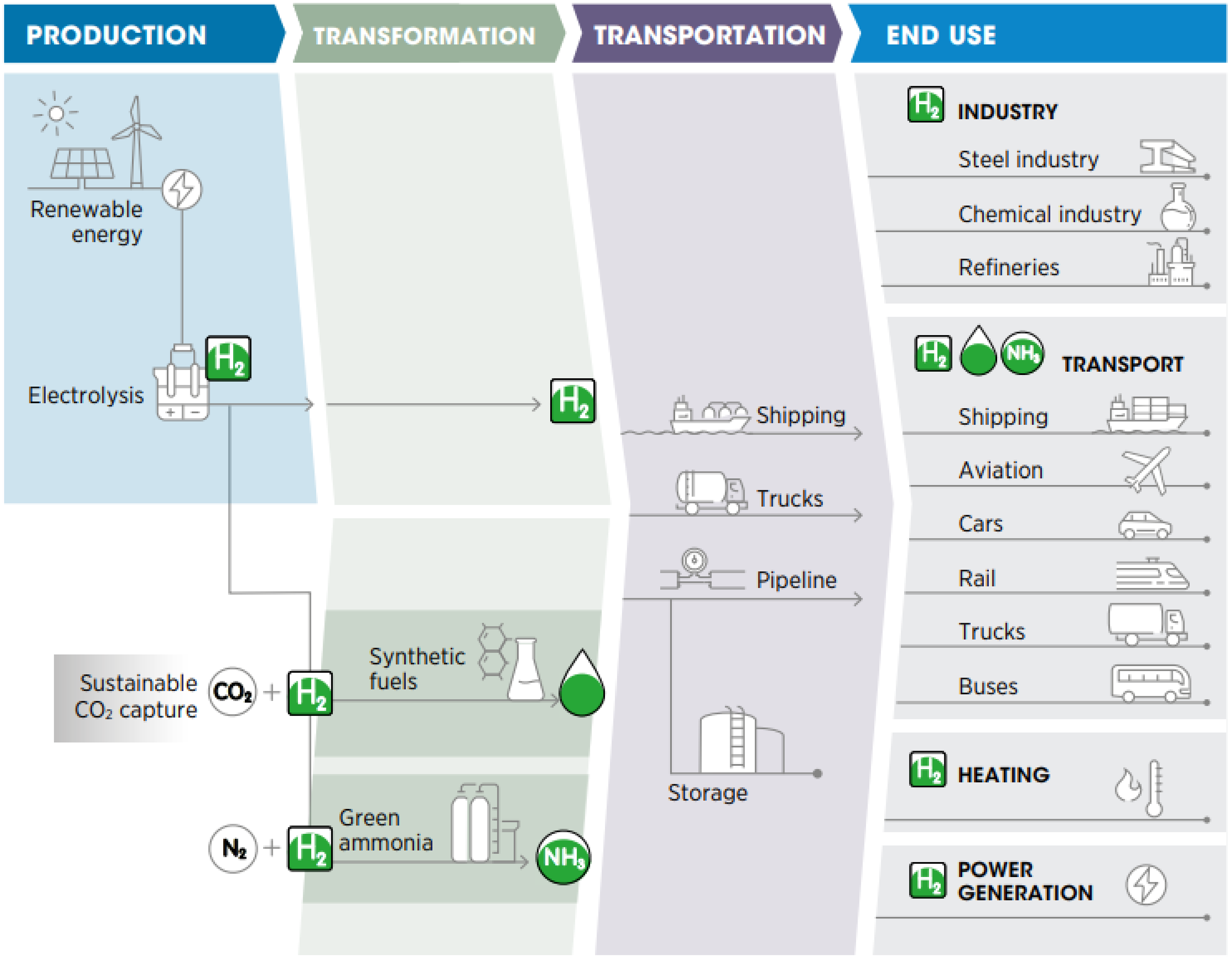
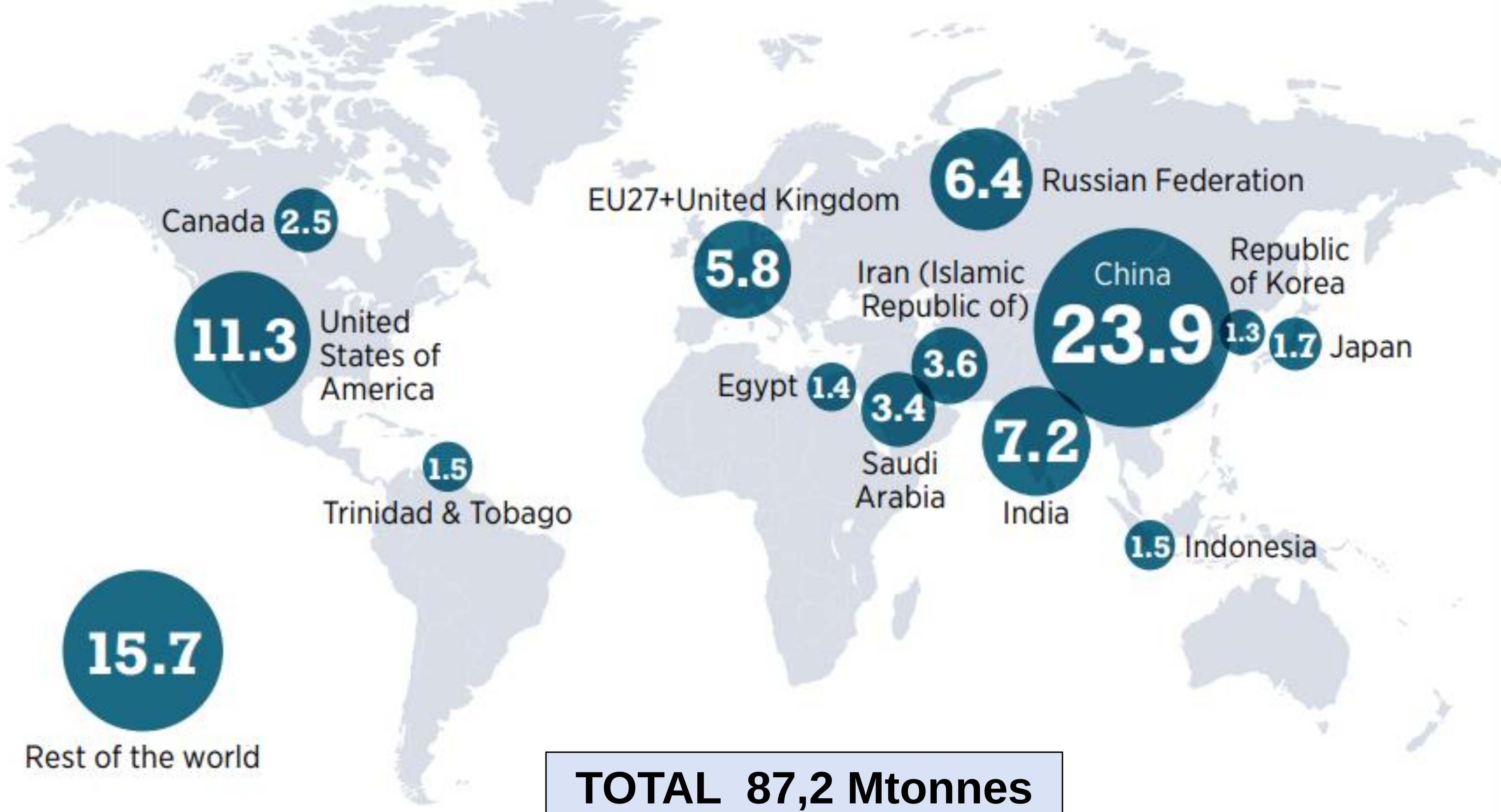


Hydrogen consumption in 2020 (million tonnes per year)



TOTAL 87,2 Mtonnes

Source : IRENA

Many production pathways of hydrogen

- Electrolysis (alkaline, PEM, SOEC, AEM)
- Steam Methan Reforming of natural gas (SMR) with Capture and Sequestration/Utilisation of CO2 (CCS / CCU)
- Pyrogasification / Thermolysis of biomass
- Methan Plasmalysis (Plasma torch, microwave)
- Hydrogen as a by-product
- Native hydrogen

A low volumic energetic density

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In order to transport **10 kWh** of energy, you need :

- 1,1 liter of gazoline
- 1,7 liter of LNG (- 160 °C)
- 3,1 liter of ammonia (- 30 °C, 1 bar)
- 4,2 liter of liquid hydrogen (- 253 °C)
- 5,3 liter of DBT or 6,4 liter of MCH (LOHC-Liquid Organic Hydrogen Carrier)
- 7,7 liter of hydrogen at 700 bar
- 13,3 liter of hydrogen at 350 bar

MANY WAYS OF TRANSPORTING / STORING HYDROGEN

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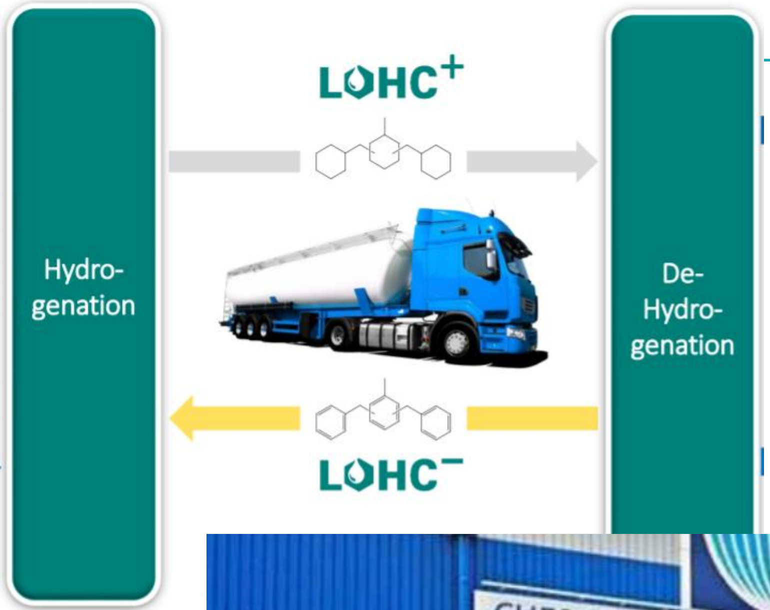
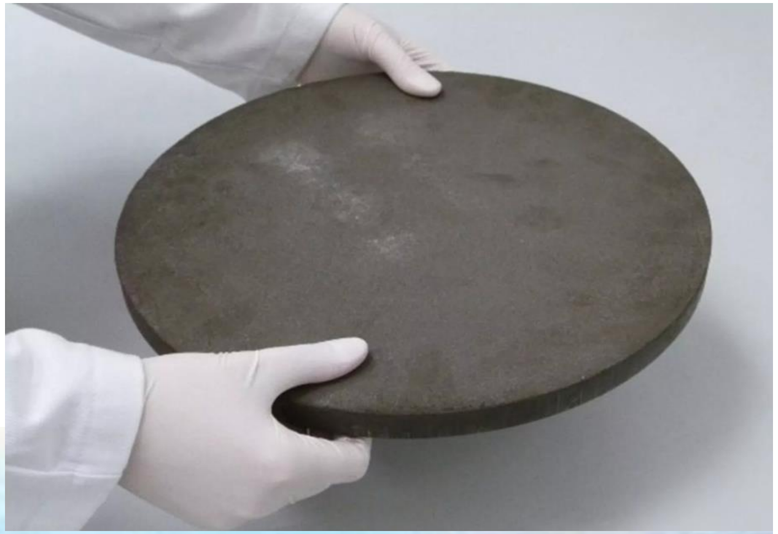
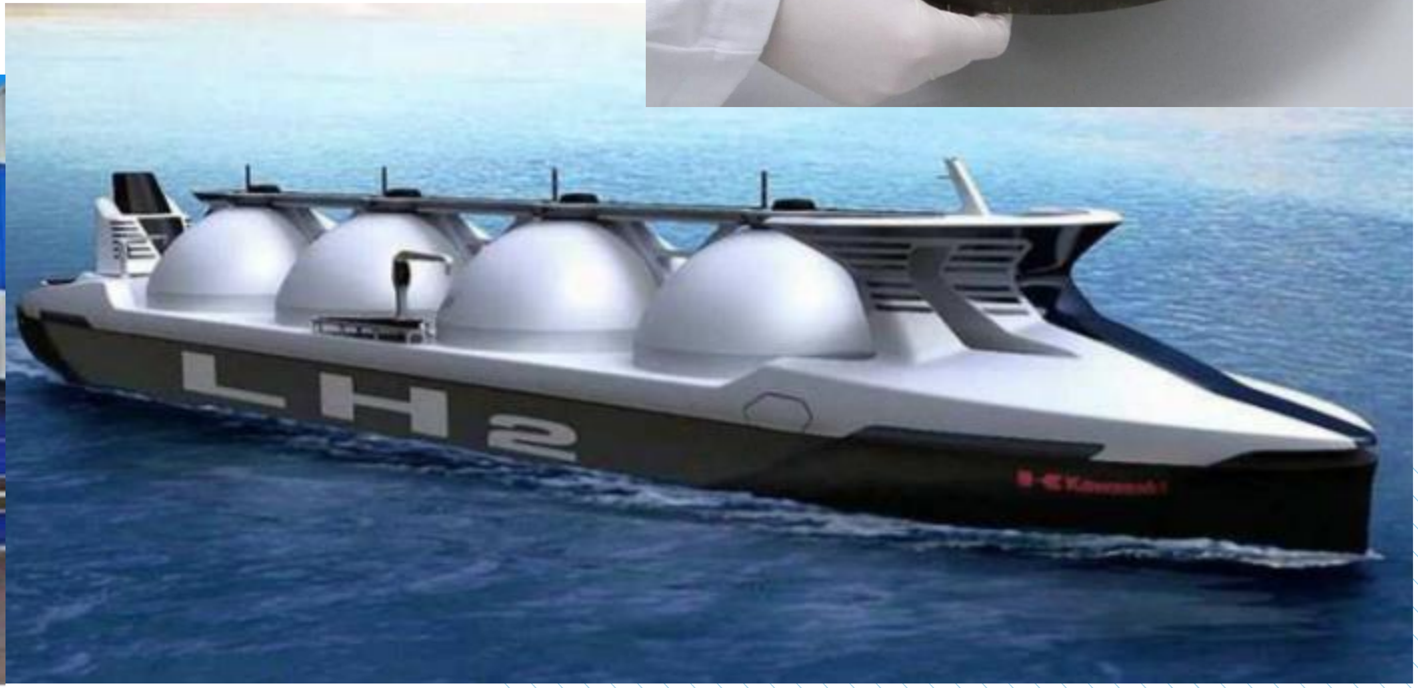


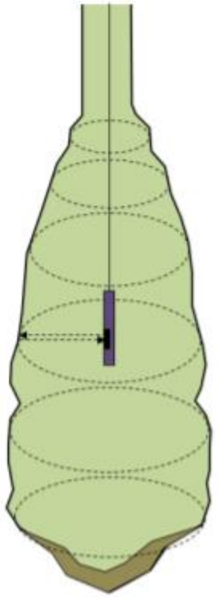


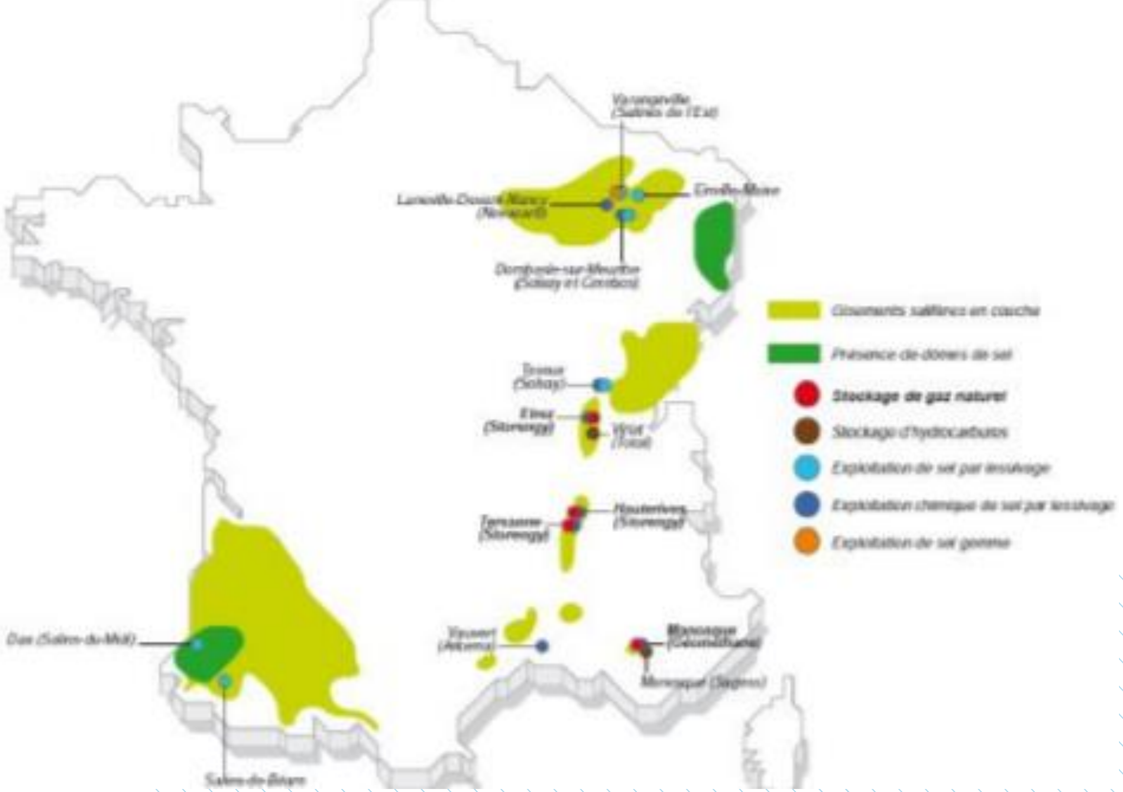


Transport and massive storages

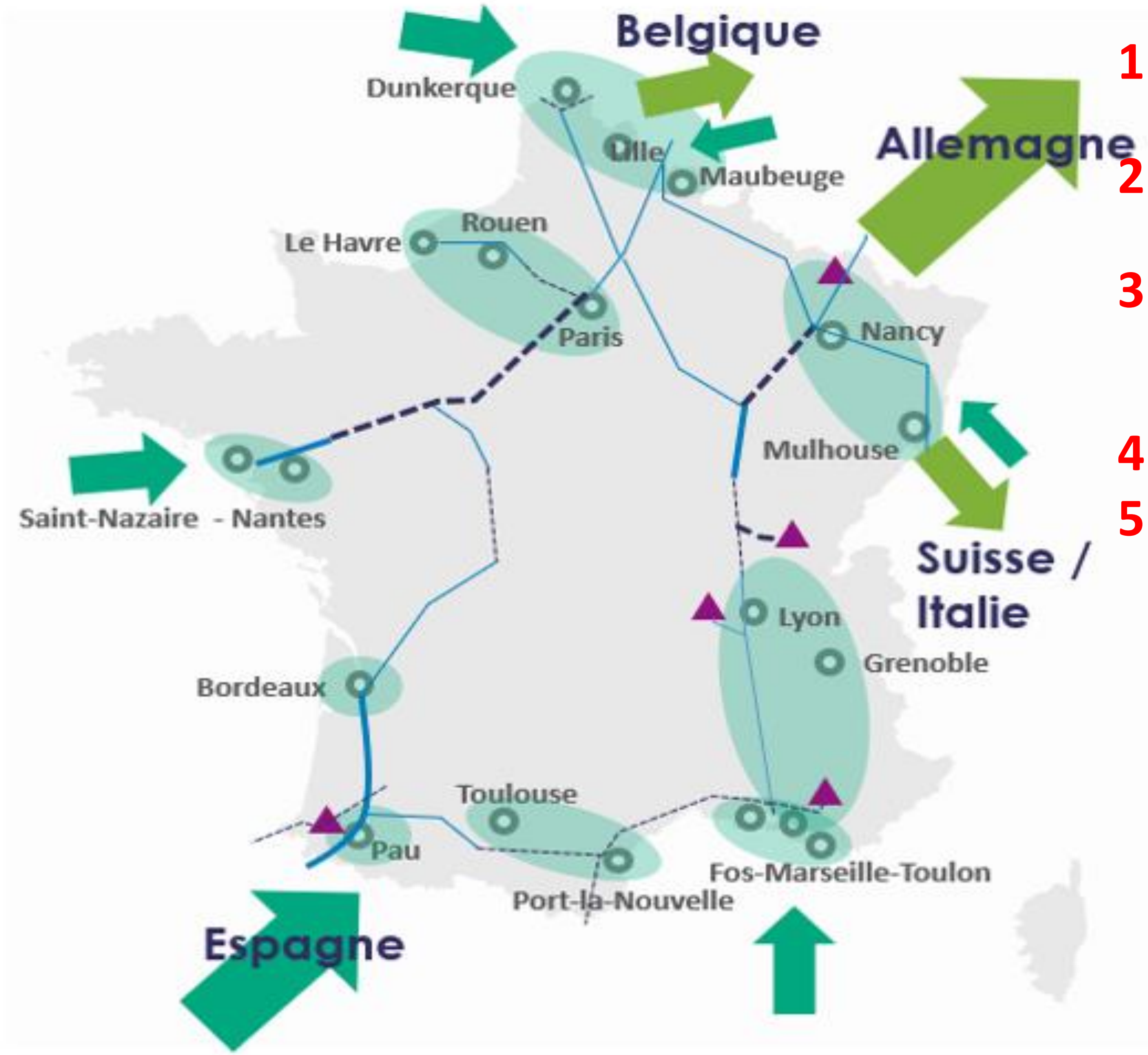
Conversion of existing gas infrastructures :

- ➢ Pipes networks,
- ➢ Salt caverns





Toward an European hydrogen market



1. **MosaHYc (avec Creos)** : 100 km entre la France et l'Allemagne (2026)-Pipe converti
2. **RHYn** : 100 km (60 km convertis) entre Chalampé et Mulhouse (2028), extension possible à Basel (2029)
3. **WHHYn (avec Fluxys)** : Etude d'une canalisation entre la France et la Belgique (Open season - région de Valenciennes)
4. **DHUNE** : Dunkerque
5. **HYnframed**

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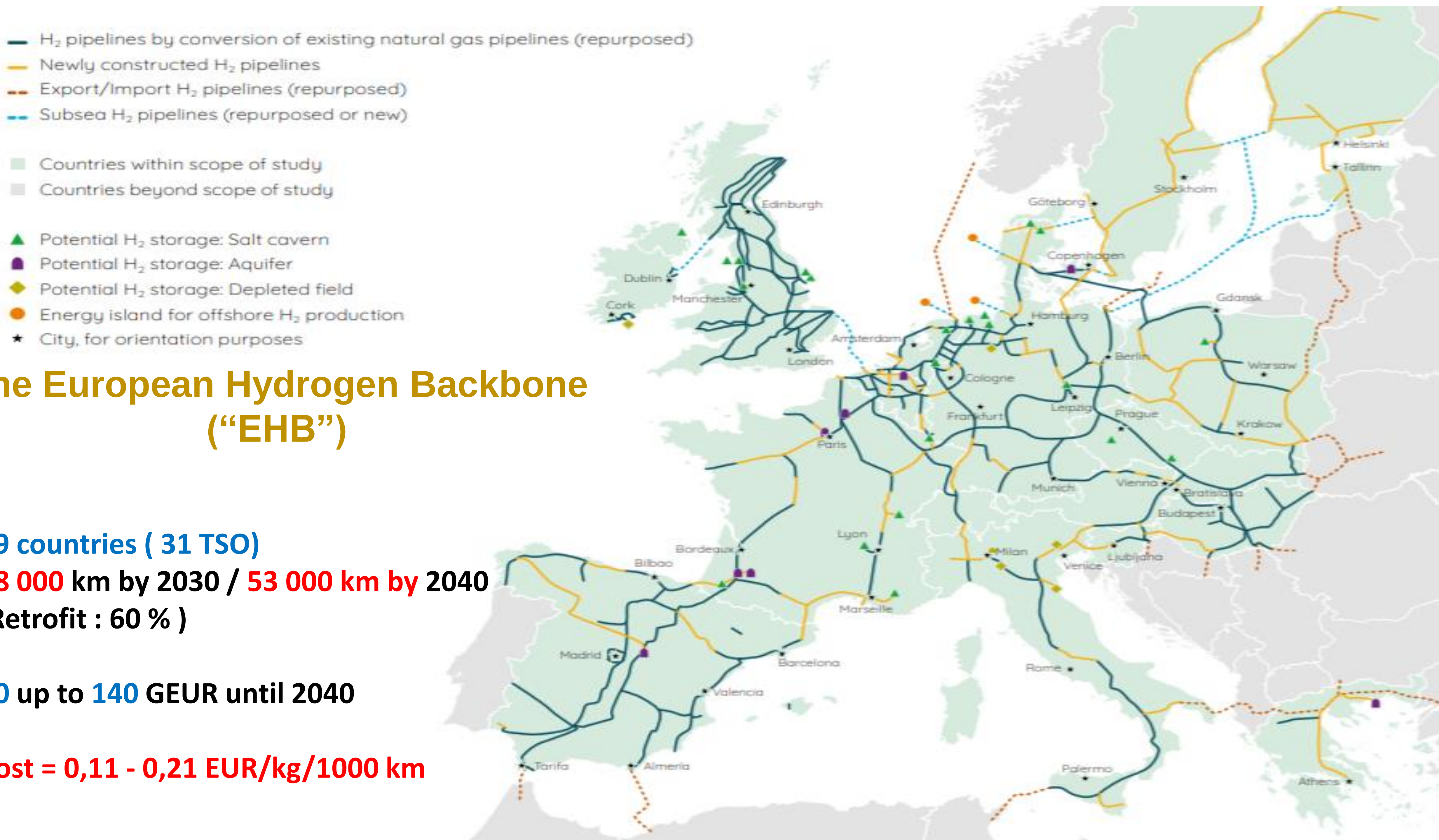
REPower EU (18. May 2022)

10 Mt produced in Europe

10 Mt imported (4 Mt NH3)

3 major corridors

- **Mediterranean Sea**
- **North Sea**
- **Ukraine** (« as soon as conditions will allow »)



The European Hydrogen Backbone ("EHB")

29 countries (31 TSO)

28 000 km by 2030 / 53 000 km by 2040

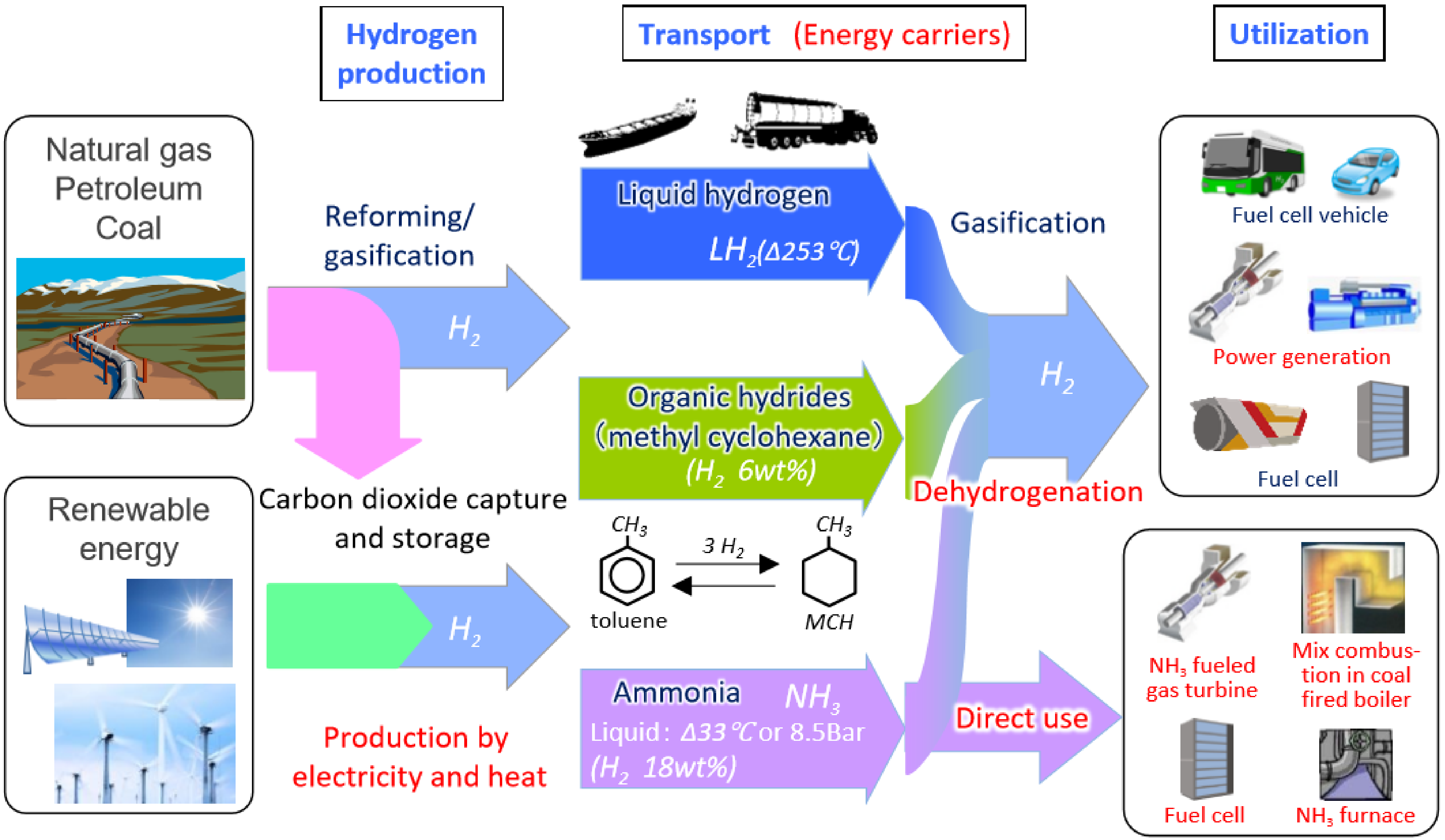
(Retrofit : 60 %)

80 up to 140 GEUR until 2040

Cost = 0,11 - 0,21 EUR/kg/1000 km

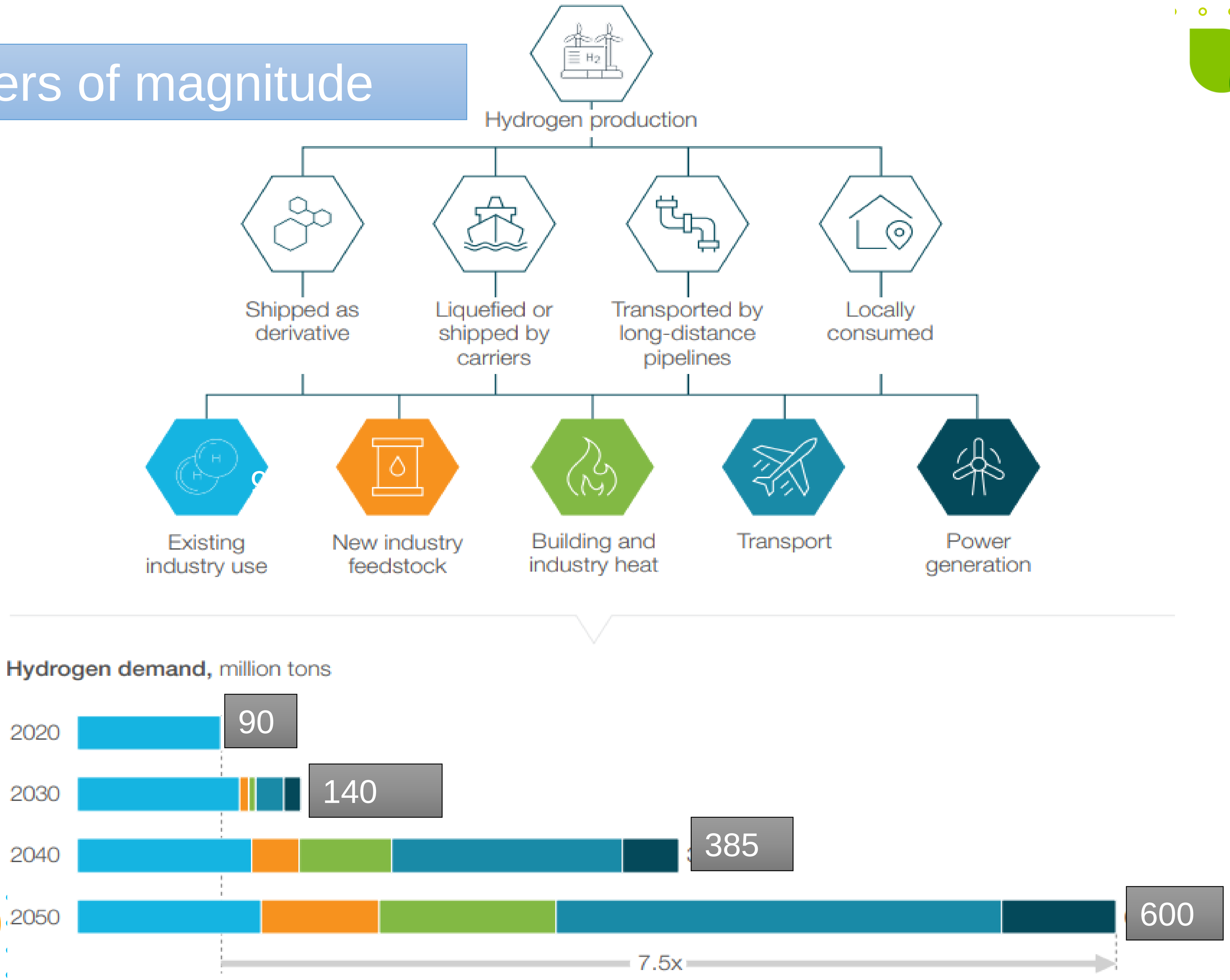
A worldwide dynamics : more than 50 countries published an hydrogen strategy

Value chain of clean hydrogen



≪Ammonia direct use≫ 【Power generation sector】 Gas turbine, Coal fired boiler, Fuel Cell 【Industrial sector】 Industrial furnace 【Transportation sector】 Marine Engine

Orders of magnitude



Toward a new geopolitics of energy

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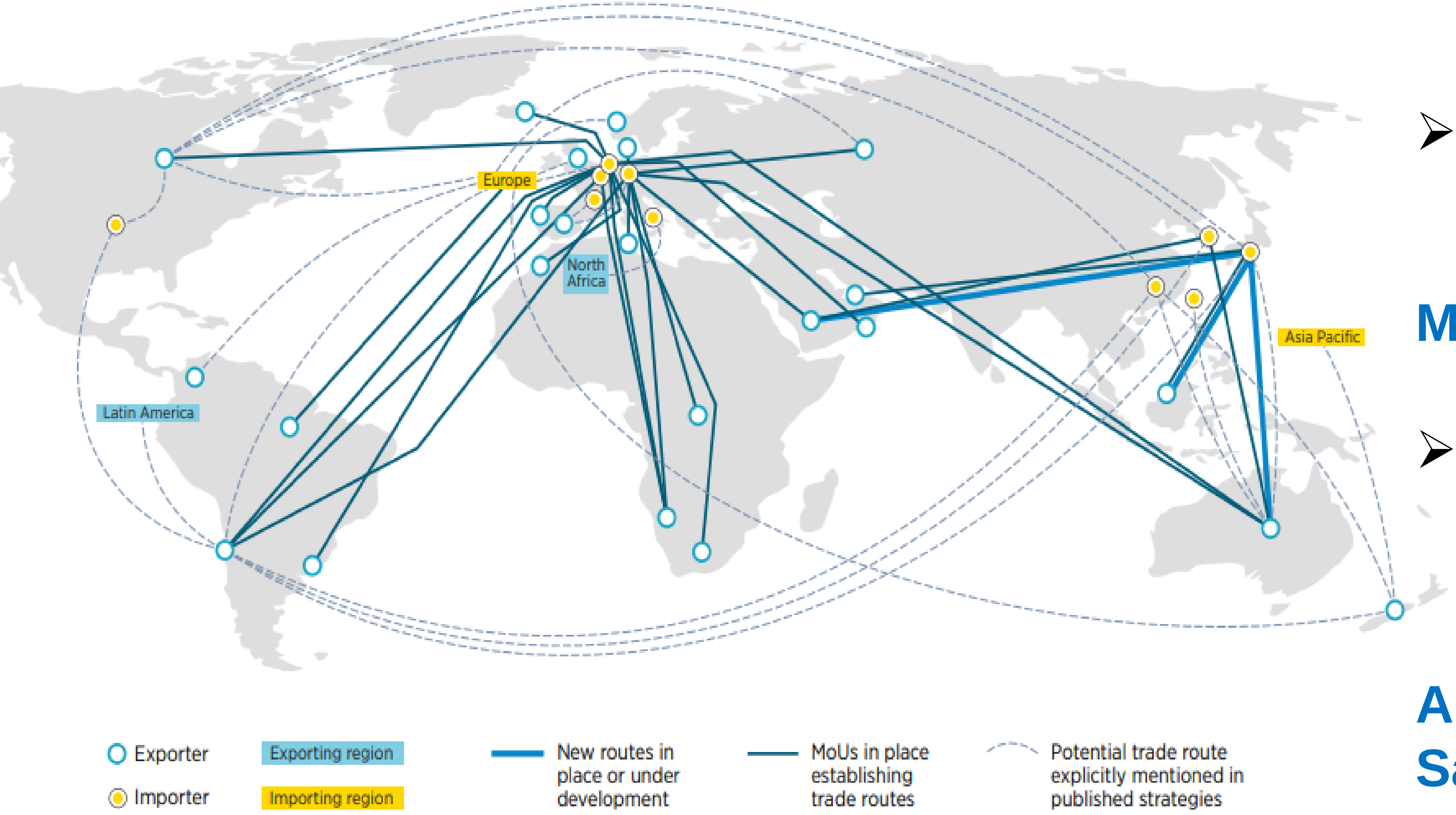


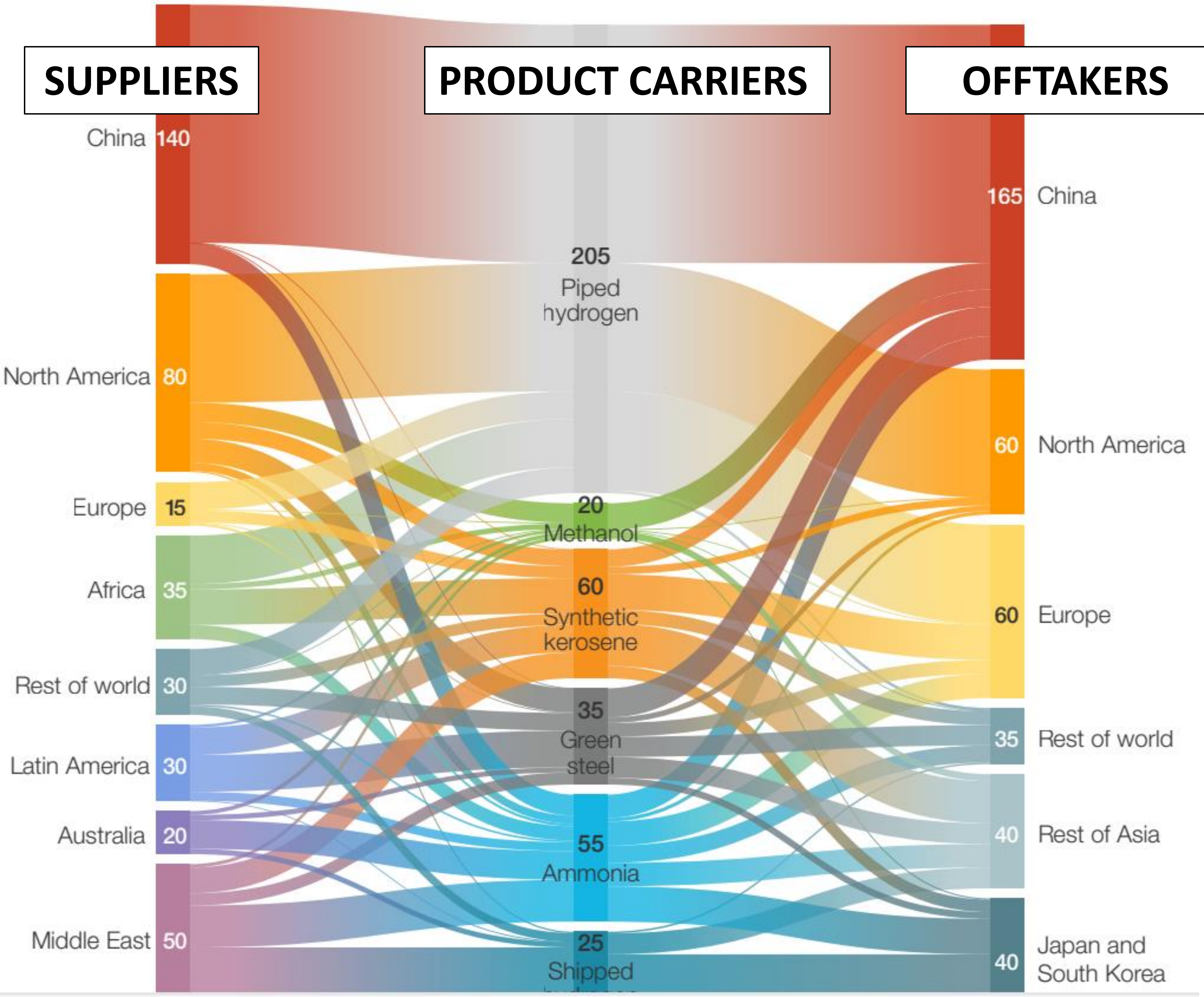
Source : IRENA

- Importer countries of hydrocarbons will become exporters :

Marocco, Namibia , Chile

- Exporter countries of hydrocarbons will export H2 and/or derivatives (ammoniac, methanol):

Australia, Canada, Egypt , Saudi Arabia, UAE, USA



2050

Global hydrogen and derivative interregional long-distance supply (Mtons per annum)

Excludes local production and distribution

Source :

McKinsey for Hydrogen Council

Challenges for the (French) Hydrogen Sector

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- To **reduce costs : scaling up**

- To promote **technological neutrality**
  (3,38 kg CO_2 / kg H_2)
  Certification- Level playing field

- To have **clean, abundant and affordable** electricity available (To develop renewable and nuclear energy)

- To contribute to **re-industrialisation**

Imports versus domestic production

- France Hydrogène Meta-analysis (Imports from outside European Union)
  - Price competitivity of H_2 or derivatives compared to European production is not guaranted
  - Availability of hydrogen or derivatives is not established
  - Necessary infrastructures in order to bring hydrogen or derivatives to Europe are to be developed

- LH2 (liquid hydrogen) : high liquefaction cost and ships do not exist ! Timeframe ?
- NH_3 (Ammonia) : supply chains exist. Suitable for direct use. Impact on employment and activity of present ammonia plant.

  Large scale cracking of ammonia : Cost? Timeframe ? Necessity of a hydrogen network if cracking is done within harbours.
- Methanol : same remarks as ammonia
- LOHC (Liquid Organic Hydrogen Carrier) : easy transportation but presently still at demonstrator level ! Timeframe ?
- Piped hydrogen from the Iberic peninsula or from North Africa (H2MED, SouthH2 Corridor) or from Scandinavia

Some simple calculations !

« Blue Hydrogen »

Energy for Steam Methan Reforming (Natural Gas & Electricity) = **50 kWh/kg**

- Natural Gas price = 20 €/MWh the share of energy within the cost of hydrogen is 1,0 €/kg. To add 0,5 €/kg for capex & maintenance of installations. As a result , Grey hydrogen cost = 1,5 €/kg !

Carbone tax = 80 €/tonne and 10 tCO_2/t H_2 , to add 0,8 €/kg resulting in 2,3 €/kg but without any decarbonization !!

- Natural Gas price = 40 €/MWh, the share of energy within the cost of hydrogen is 2,0 €/kg. To add 0,5 €/kg for capex & maintenance of installations. Result = 2,5 €/kg for grey hydrogen! And 3,3 €/kg including the Carbone tax.

Cost of decarbonization = 100 up to 150 €/tonne of CO_2 : decarbonization impact : 1,0 à 1,5 €/kg H_2

With Natural Gas price at 40 €/MWh, cost of blue hydrogen is 3,5 up to 4,0 €/kg H_2

« Green Hydrogen » : Energy needed for electrolysis = 55 kWh/kg

With the French power mix, load factor of electrolysers can reach 7000 hours a year.

If electrolyser cost is 1400 €/kW, cost of electrolysis (Capex & Opex) is 1,1 €/kg

- With electricity price of 50 €/MWh (on electrolyser site), the share of electricity within the cost of hydrogen is 2,75 €/kg H_2. The resulting cost of green hydrogen is 3,85 €/kg (similar to blue hydrogen if NG price is 40 €/MWh)
- But if electricity price is 90 €/MWh, 4,95 + 1,1= 6,05€/kg H_2

As a CONCLUSION

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- **Without Hydrogen, we will NOT achieve the energy transition**
(decarbonization of economy and integration of renewables within energy systems)

- **Versatile energy carrier : holistic/systemic approach is needed –**
Big challenges , No unique solution

- **To maintain R&D efforts and foster innovation**

- **Pooling usages in order to reduce costs : to build local ecosystems, to scale up, import of H2 or H2 derivatives ?**

- **A very strong dynamics at world level thanks to Regulation and public financial support - Strong competition (China, USA)**

- **A new geopolitics of energy will appear**

- **Europe has strong assets and must ACCELERATE : industry is at stake and time is now !**

THANK YOU FOR YOUR ATTENTION

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