

Offshore hydrogen production

Industrial context and market perspectives

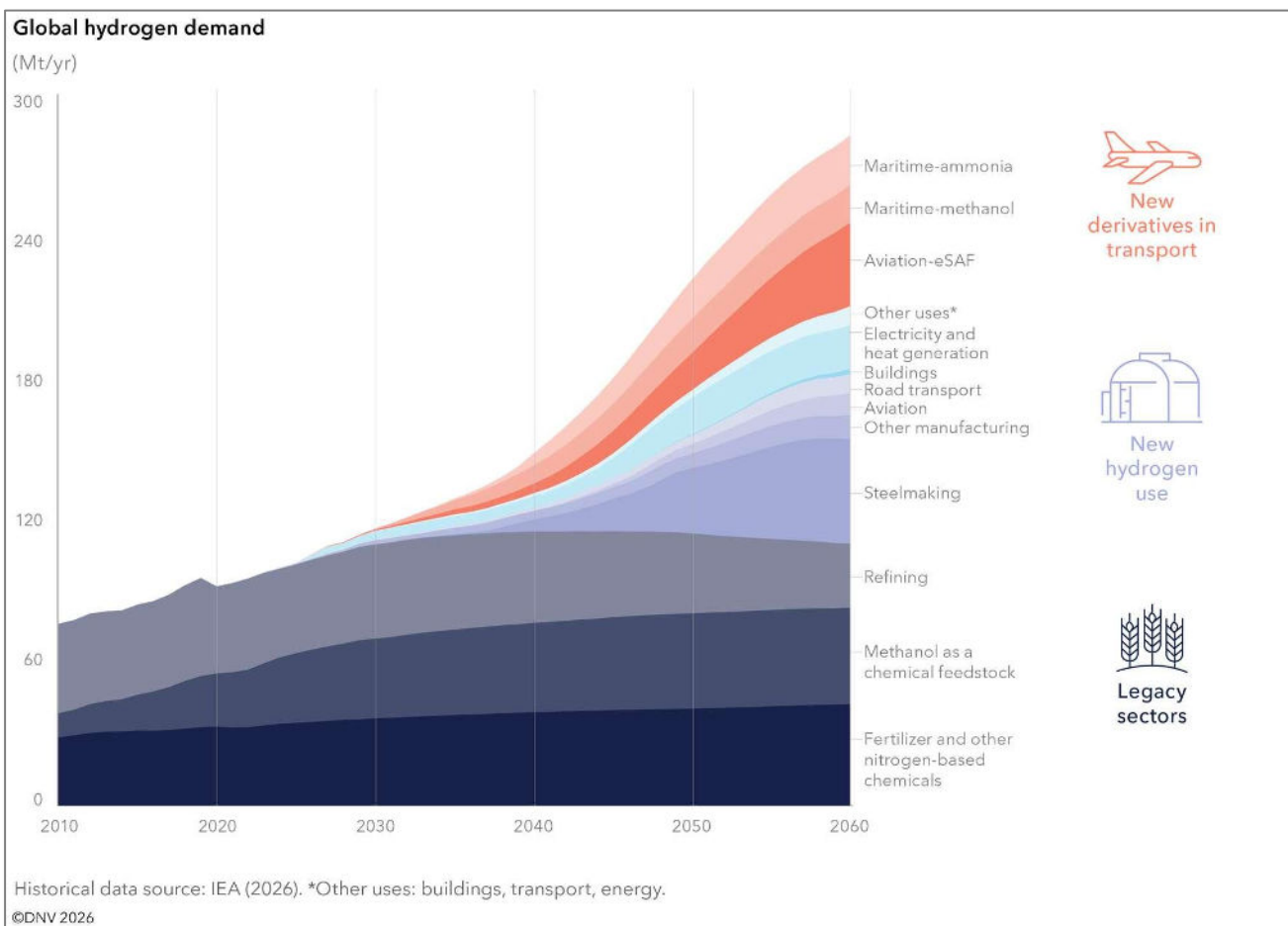
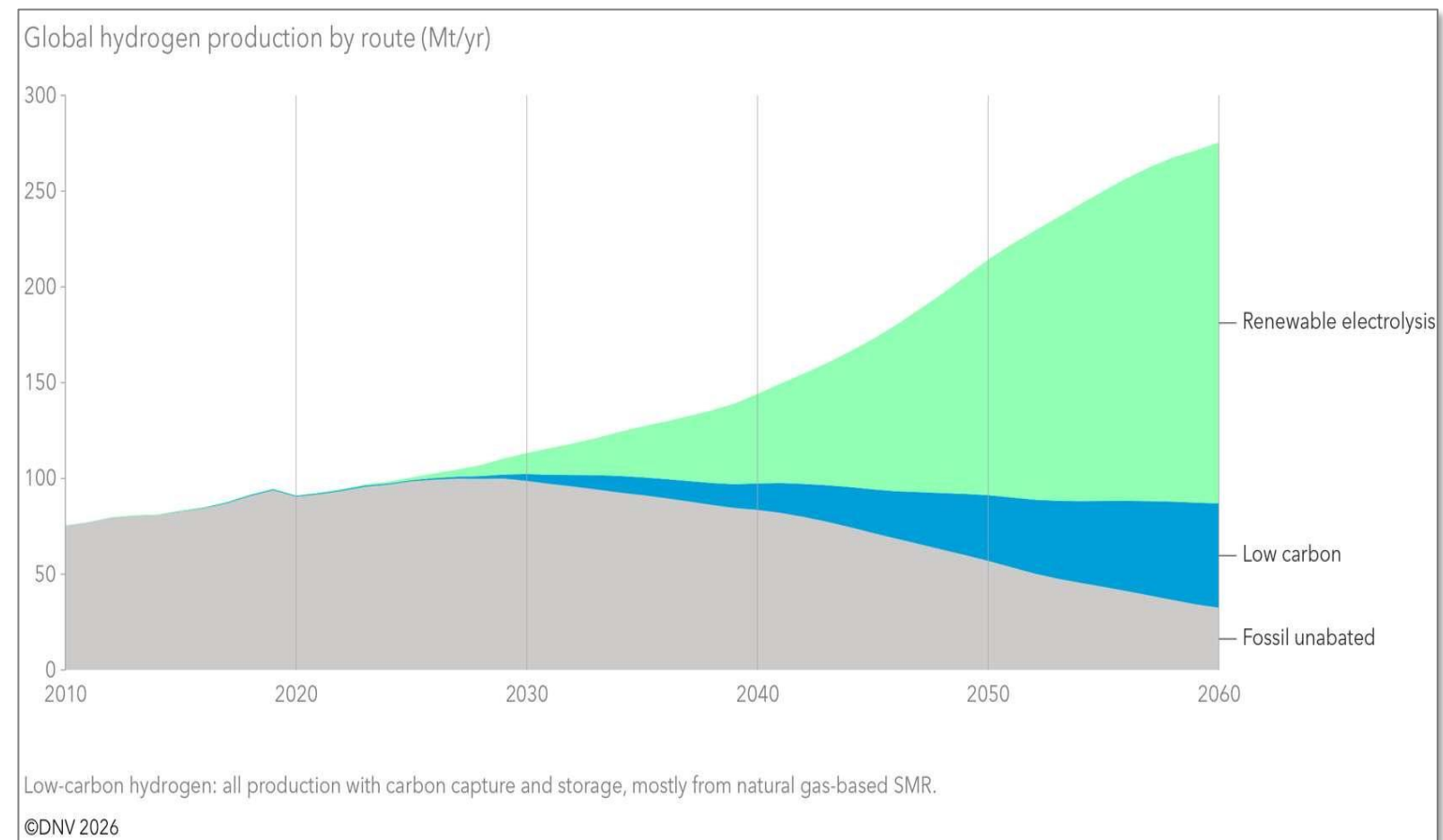
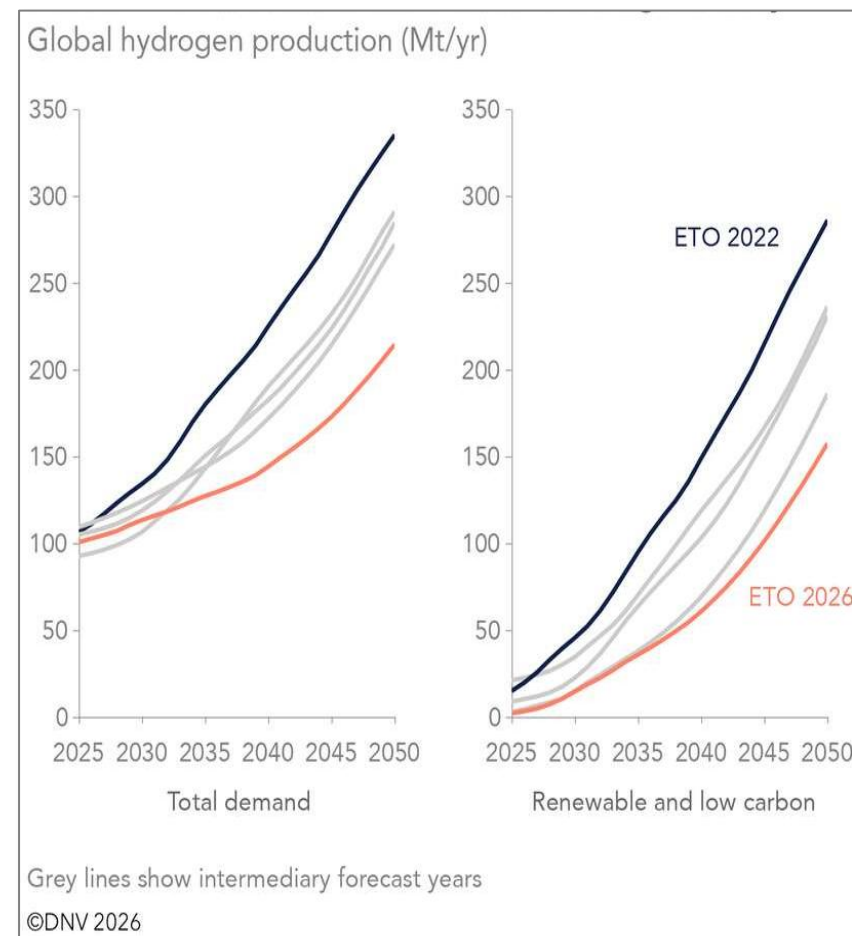
Christophe BRICE – Subsea7 – Hydrogen Strategy & Technology Manager

Global Hydrogen Market Forecast

DNV Energy Transition Outlook 2026 – Hydrogen to 2060

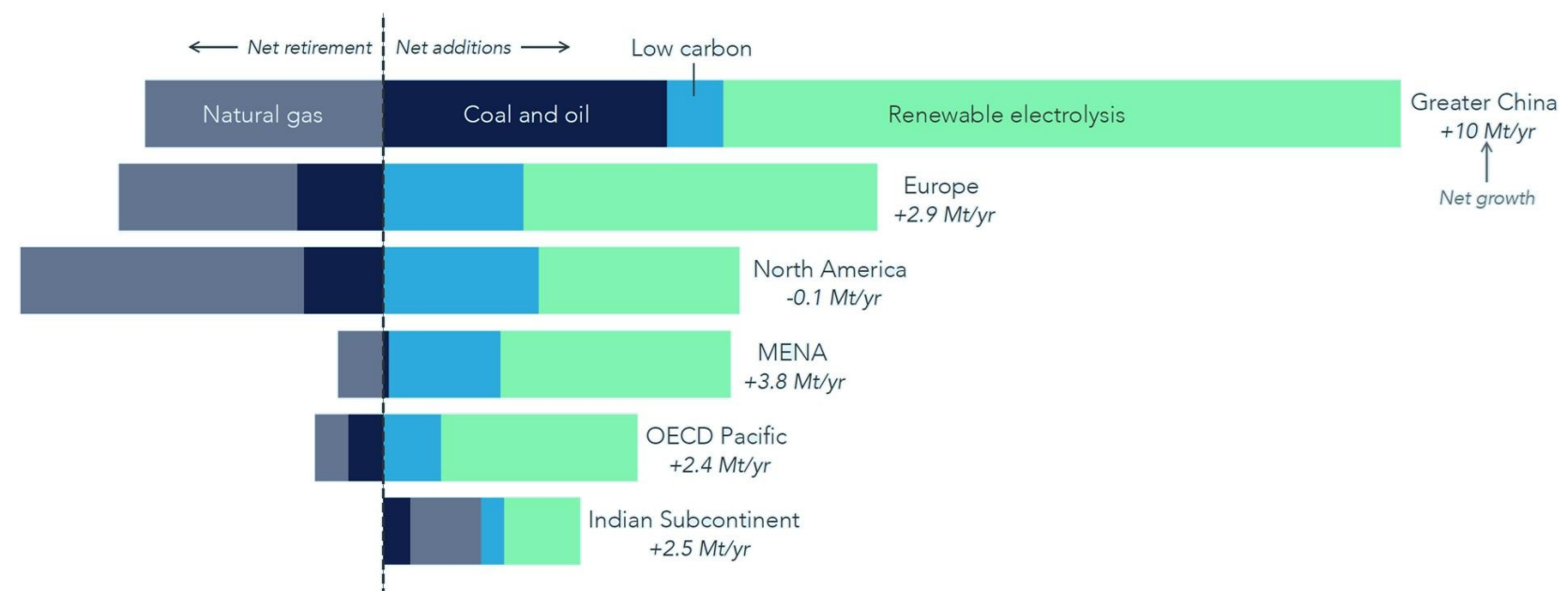
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- 2050 forecast has been revised down significantly for hydrogen production & consumption
- Still a x2 or x3 expected at world scale with a strong growth of renewable electrolysis
- “The global hydrogen industry is currently a USD 240bn market by value, producing 100Mt of fossil-based hydrogen per year, accounting for 1.3Gt of CO2 emissions”
- “Clean hydrogen will grow 100-fold from today and mitigate over 2Gt of emissions from hard-to-electrify sectors annually by 2060”
- Very different situations depending on the region of the world: Significant growth is expected in Europe, given its economic weight in absolute terms compared with China

Growth of hydrogen production, 2025-2035



HIGHLIGHT 2 | Evolution of all hydrogen supply in selected regions, including derivatives. 'Oil' refers to process hydrogen in refineries.

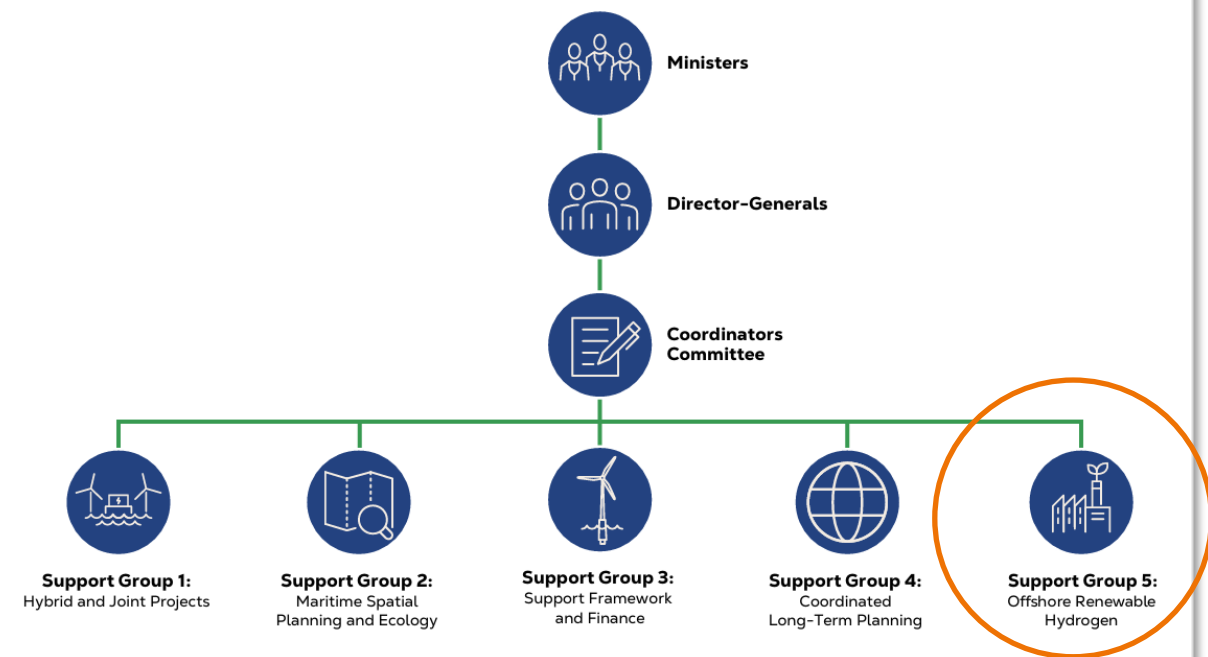
Offshore Hydrogen Production

North Seas Energy Cooperation & North Sea Summit Jan 2026

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Redefined NSEC Support Group Structure



- Support Group 5 – Offshore Renewable Hydrogen integrated in the Work Programme 2025 - 2027
- « *Offshore renewable hydrogen has the potential to play an important role in the European energy system post-2030, including in decarbonising hard-to-abate sectors and providing flexibility to our energy systems* »



JOINT OFFSHORE WIND INVESTMENT PACT FOR THE NORTH SEAS

With this Pact, solemnly declared at the North Sea Summit 2026, all signing sides commit to working together towards our shared ambition: to scale offshore wind energy to the levels required for Europe's decarbonisation, to enable hydrogen as complementary energy carrier to offshore renewable electricity (where cost-efficient), to ensure affordable and secure energy for citizens and businesses, and to strengthen Europe's industrial base and technological leadership.

Governments are committed to:

- Explore offshore wind tender designs that, where relevant, take into account the potential integration of electrolyzers.
- Mandate electricity and hydrogen transmission system operators and system planners to jointly assess how to coordinate offshore planning for electricity and hydrogen networks, where relevant.

Industry is committed to:

- Support research and development for scaling up electrolyser technologies in connection with offshore wind energy.



NORTH SEA SUMMIT 2026 HAMBURG DECLARATION OF ENERGY MINISTERS

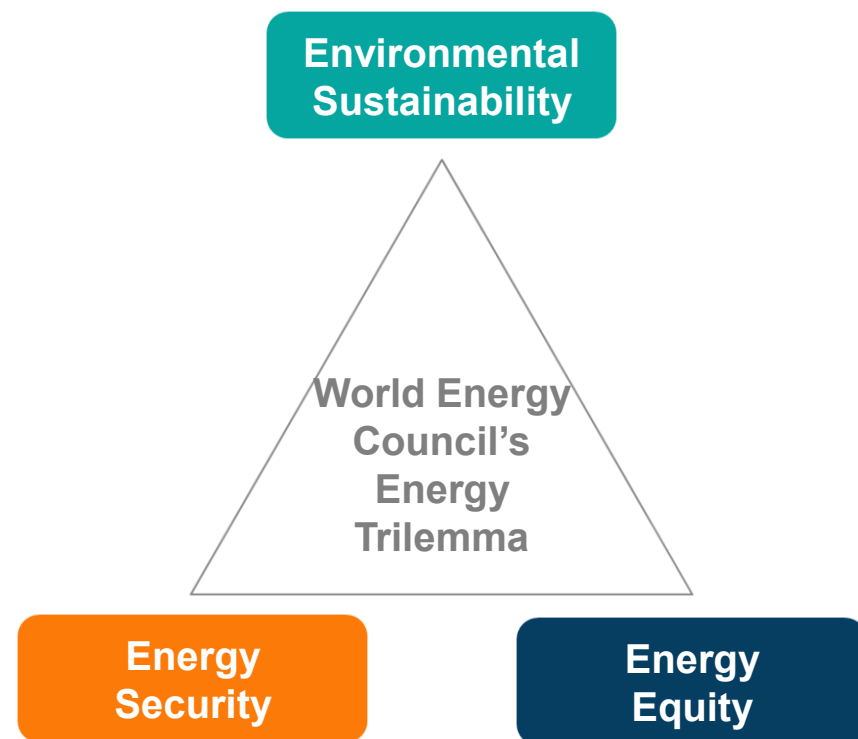
From national to regional: delivering on our joint vision of the North Seas as Europe's Clean Power Hub

(36) Offshore hydrogen infrastructure, in areas where it has demonstrated cost-effectiveness and provides value to the energy system, could become a key building block for achieving European decarbonisation targets and enhancing energy security and independence. Under some conditions, offshore hydrogen systems could offer significant synergies with the direct use of offshore electricity, while dedicated offshore hydrogen transport infrastructure enables cross-border hydrogen trade between North Seas States.

(39) The participating EU Member States and the UK express the need for assessing the opportunity of a long-term strategy for combining offshore wind and offshore hydrogen projects in the North Seas where it is cost-effective and provides value to the energy system, and call on HyNOS and the OTC to deliver a roadmap for the joint coordinated planning of offshore energy networks until the next North Sea summit.

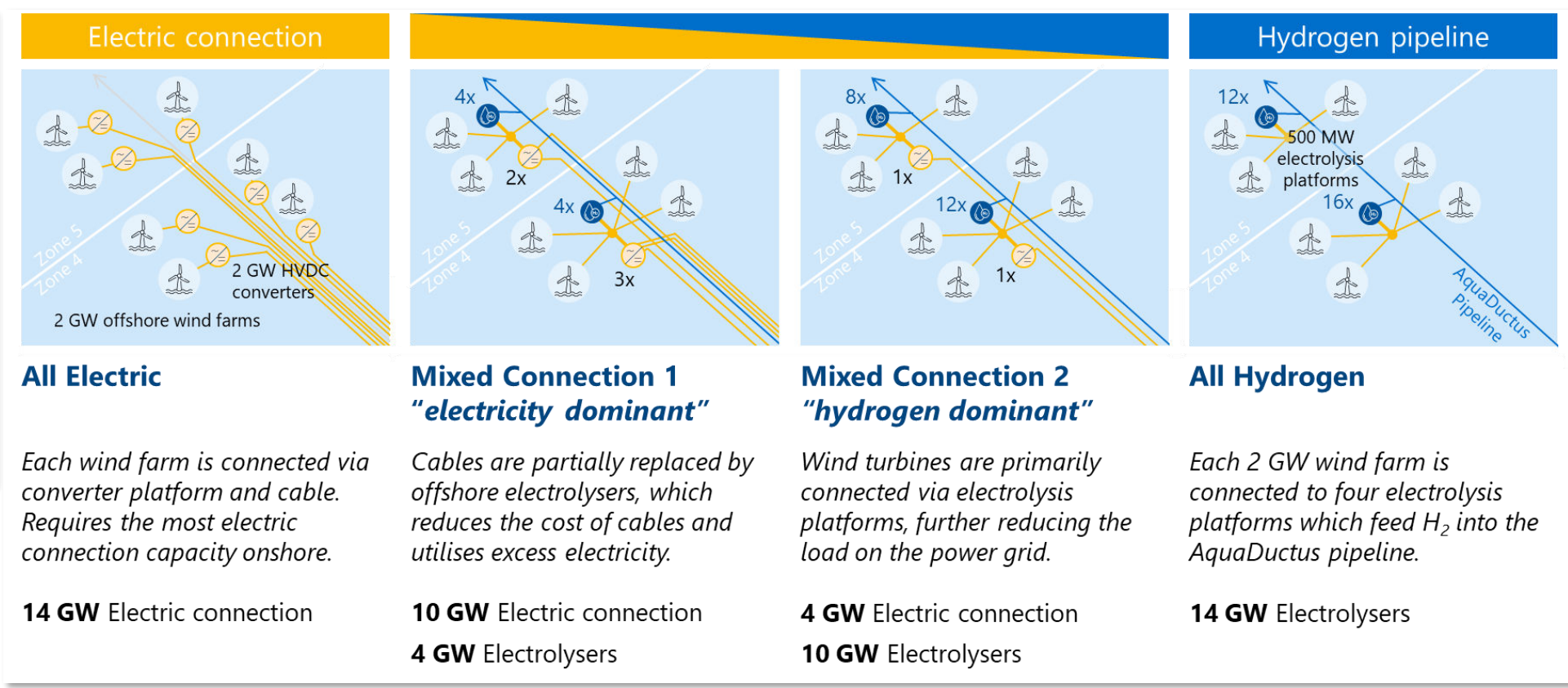
Why will Hydrogen be produced offshore?

- **Wind power is a mature, large-scale renewable energy source**
 - Electrolysis has access to an unlimited water supply via seawater desalination
 - Offshore locations face fewer land-use constraints and generate less visual impact than onshore sites
 - Offshore environments are inherently safer for industrial production facilities compared to onshore settings
- **Enables local gas production from domestic renewable resources, reducing dependence on imports**
 - Helps bypass onshore grid constraints that limit large-scale power transmission
 - Unlocks wind development farther offshore, as near-shore sites will likely be prioritized for grid connection
- **Major cost savings on offshore electrical infrastructure, including substations and export cables**
 - H₂ transport & storage offer lower costs and higher efficiency than transmitting electricity over long distances
 - GW-scale networking improves infrastructure utilization and strengthens projects economics
 - Offshore wind sites deliver high capacity factors, resulting in more efficient hydrogen production
 - Local energy production drives local content, enabling high-quality, long-term employment opportunities
 - Creates export opportunities for countries with strong offshore wind resources (e.g., Scotland).



Extract from *Assessment of connection concepts for Germany's far out North Sea offshore wind areas for an efficient energy transition* (August 2024)

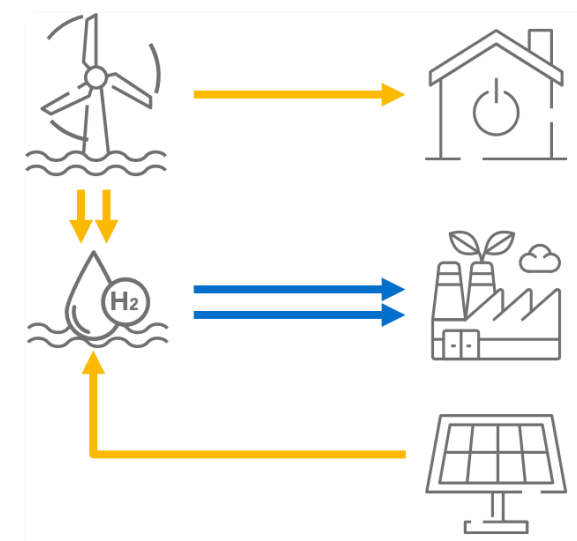
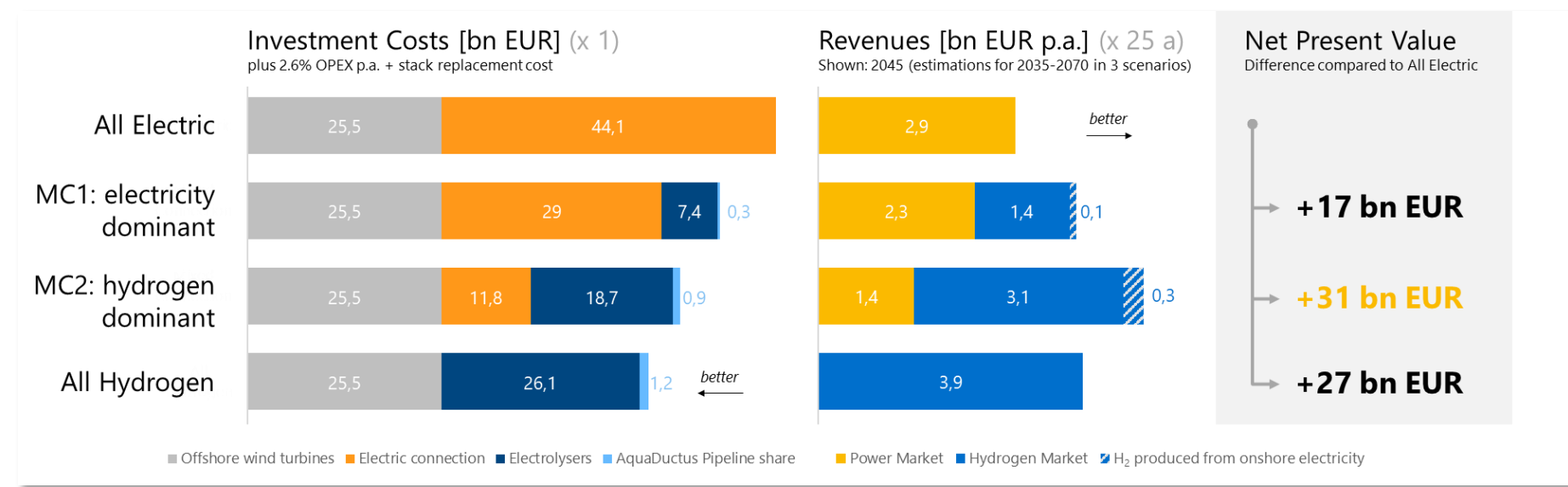
Courtesy of AquaVentus Förderverein e.V., E-Bridge Consulting GmbH, Planungsgemeinschaft Umweltplanung Offshore Windpark GbR



The study investigates four options to integrate 14 GW of far out offshore wind farms into the energy system - two using electricity and hydrogen simultaneously

The hydrogen dominant mixed connection concept maximises the socio-economic benefits and requires the least socially shared costs

Hydrogen dominant mixed connection concepts are especially valuable for their flexibility and their main energy carrier H₂



- **Electricity supply**, when demand is high
- **High revenue potential**, when renewable energy is scarce
- **Green offshore hydrogen production**, when wind is abundant
- **More stable hydrogen prices**: lower price risks
- **More electrolysis** with onshore renewables
- **Bidirectional cable use increases utilisation** of offshore infrastructure

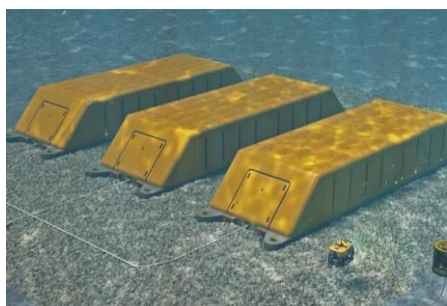
Offshore Hydrogen – Market Evolution

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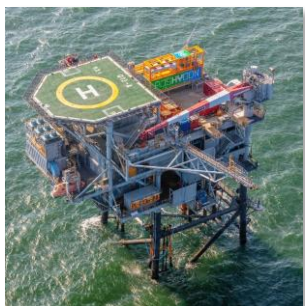
Welding for H2Pipe JIP
Image courtesy of Subsea7



Subsea H2 storage **PowBox-H™**
Image courtesy of Subsea7



Sealhyfe by Lhyfe
(lhyfe.com)



PosHYdon offshore NL
(poshydon.com)



Phynix in NL
(phynix.now)



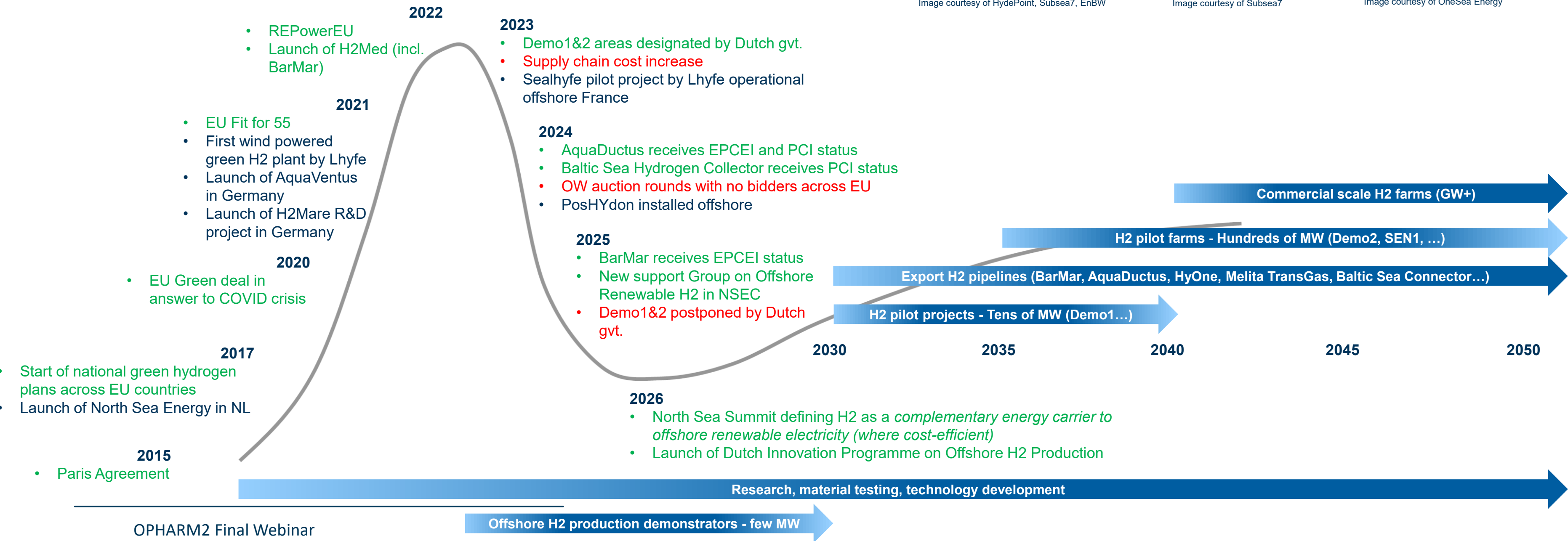
Image courtesy of HydePoint, Subsea7, EnBW



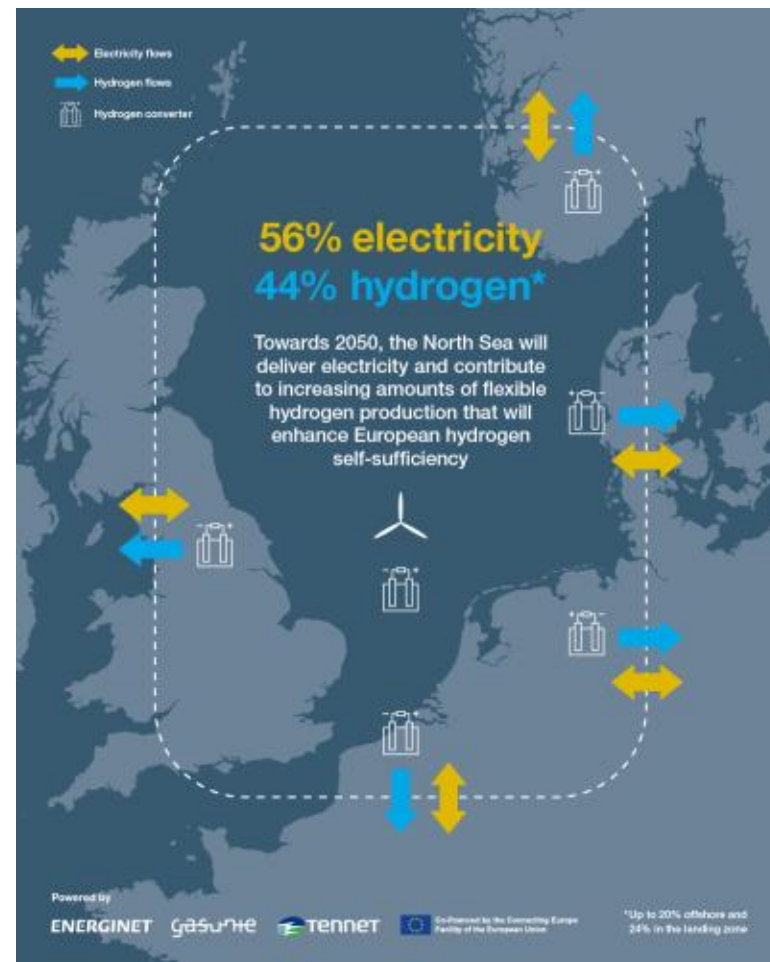
Image courtesy of Subsea7



Image courtesy of OneSea Energy



Offshore Hydrogen – Current Status in the North Sea



North Sea Wind Power Hub Pathway 2.0 study
(Pathway 2.0 Study | North Sea Wind Power Hub)

- Current 2050 targets considered:

- 5-10 GW offshore the Netherlands (collected by HyOne – AquaDuctus)
- 10-15 GW offshore Germany (collected by AquaDuctus)
- Other North Sea countries (UK / Scotland, Denmark...) have GWs potential but no clear targets for offshore H2 production

And elsewhere?

- BarMar pipeline (Barcelona to Marseille, part of the H2Med corridor) just entered FEED. COD expected in 2032.
- Other regions except China are unlikely to develop faster than the North Sea.

- North Sea Wind Power Hub Pathway 2.0 study issued in June 2024: by 2050, about 250GW of OW in the North Sea, and up to 20% of this (i.e. 70GW) should be used for offshore hydrogen production
- The pace of offshore hydrogen production development (pilot projects...) in the North Sea has slowed, driven primarily by:
 - A slowdown in Offshore Wind deployment and reduced 2050 OW ambitions
 - Lower-than-expected growth in green hydrogen demand
 - Slower scaling of onshore hydrogen production capacity
- The current context makes offshore green hydrogen development challenging...
- ...however, offshore hydrogen production remains the most economic way to develop OW farms far from shore and mitigate grid connection issues, and therefore GW-scale production is still envisaged in the 2040s
- Pilot offshore hydrogen farms (100s of MW) could have development time of 8-10 years → needs to be kicked off soon to enable first hydrogen production by 2040
- Technology development must progress steadily to enable cost-efficient offshore hydrogen production

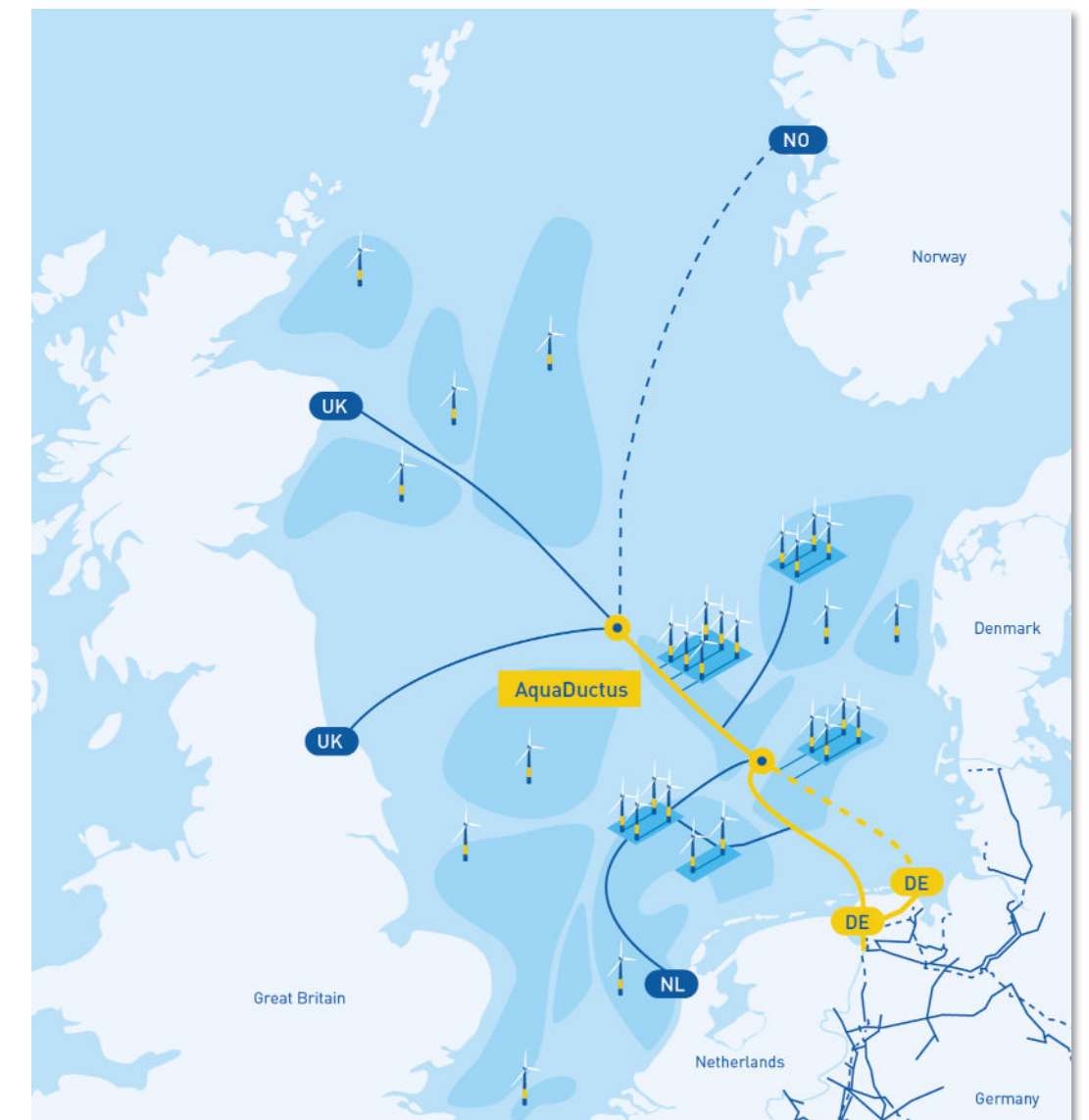


Image courtesy of GASCADE

Offshore H2 Production: French Industrial Context & Market Perspectives

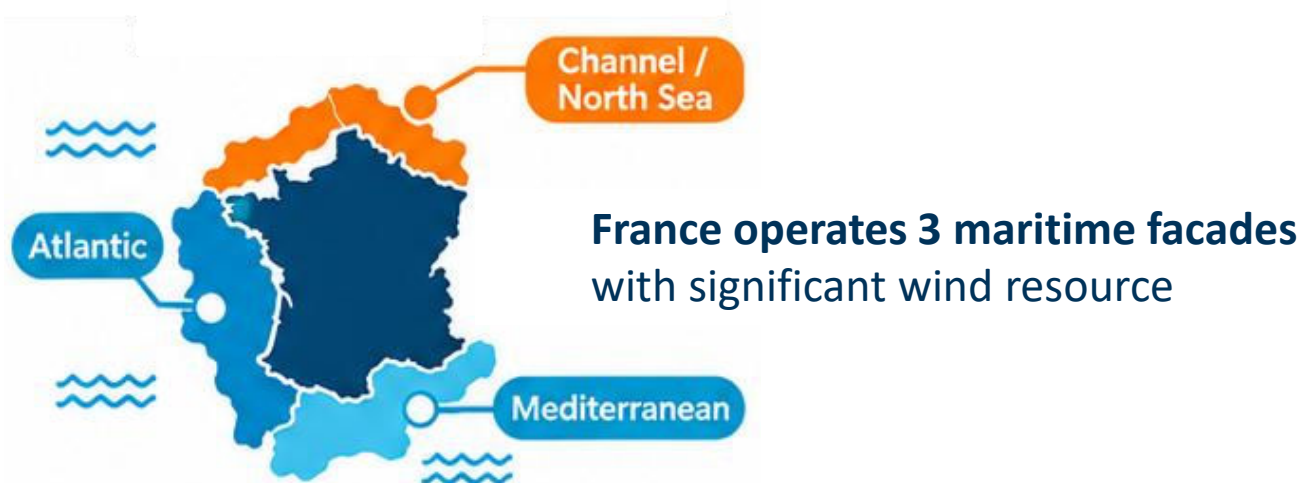


Gwenaëlle Benoit, Innovation Leader at Ekium

French Context: Why Offshore Green Hydrogen?



- French offshore wind: a maturing pipeline



≈ **2 GW**

installed as of early 2026



Iles d'Yeu-Noirmoutier, Saint-Brieuc, Fécamp, Saint-Nazaire



Floating offshore wind entering decisive industrial phase
New deep-water zones open for commercial projects

- PPE3 (2026–2035): A Clear Policy Signal

Three strategic priorities

France's 3rd Multi-Annual Energy Programme (PPE3) published by decree on **February 2026**



Energy
sovereignty



Carbon
neutrality



Price
competitiveness

Offshore wind target

3,6 GW
by 2030 → **15 GW**
By 2035
1,3GW/year (attribution rate required)

Hydrogen electrolysis target

4.5 GW
by 2030 → **Up to 8 GW**
by 2035

- France's Strategic Case for Offshore renewable hydrogen



Industrial coastal demand: major hydrogen-consuming industries (refining, chemicals, fertilisers) concentrated near French Atlantic and Channel ports

Export potential: proximity to North Sea H₂ backbone infrastructure and European demand centres



- R&D Actors in the French Offshore H₂ Ecosystem (non exhaustive)

Materials & Components	Electrolysis & Hydrogen Production	Fuel Cells & Energy Conversion	Hydrogen Storage & Transport	Safety, Risk & Metrology	Test Facilities & Experimental Platforms
CETIM CNRS CEA LITEN IFPEN IMN LEPMI Institut de la Corrosion	CEA LITEN / LETI CNRS ICPEES IFPEN Université Grenoble Alpes / G2Elab ENGIE Lab CRIGEN Laboratoire Laplace	CEA LITEN FEMTO-ST FCLAB LEPMI LaTEP Laboratoire Laplace	CNRS – ICMCB CEA – LITEN IFPEN BRGM IMN LGC (INP Toulouse)	INERIS LNHY / LNE CNRS ICARE	CEA LITEN FCLAB (Belfort) CETH2 SYMBIO / GENVIA pilot lines SEM-REV

- PEPR-H2: France's National Research Programme

PEPR Hydrogène Décarboné co-piloted by CEA and CNRS, funded under France 2030 plan



83 million €
Over 8 years



20
R&D projects



>200
permanent
researchers

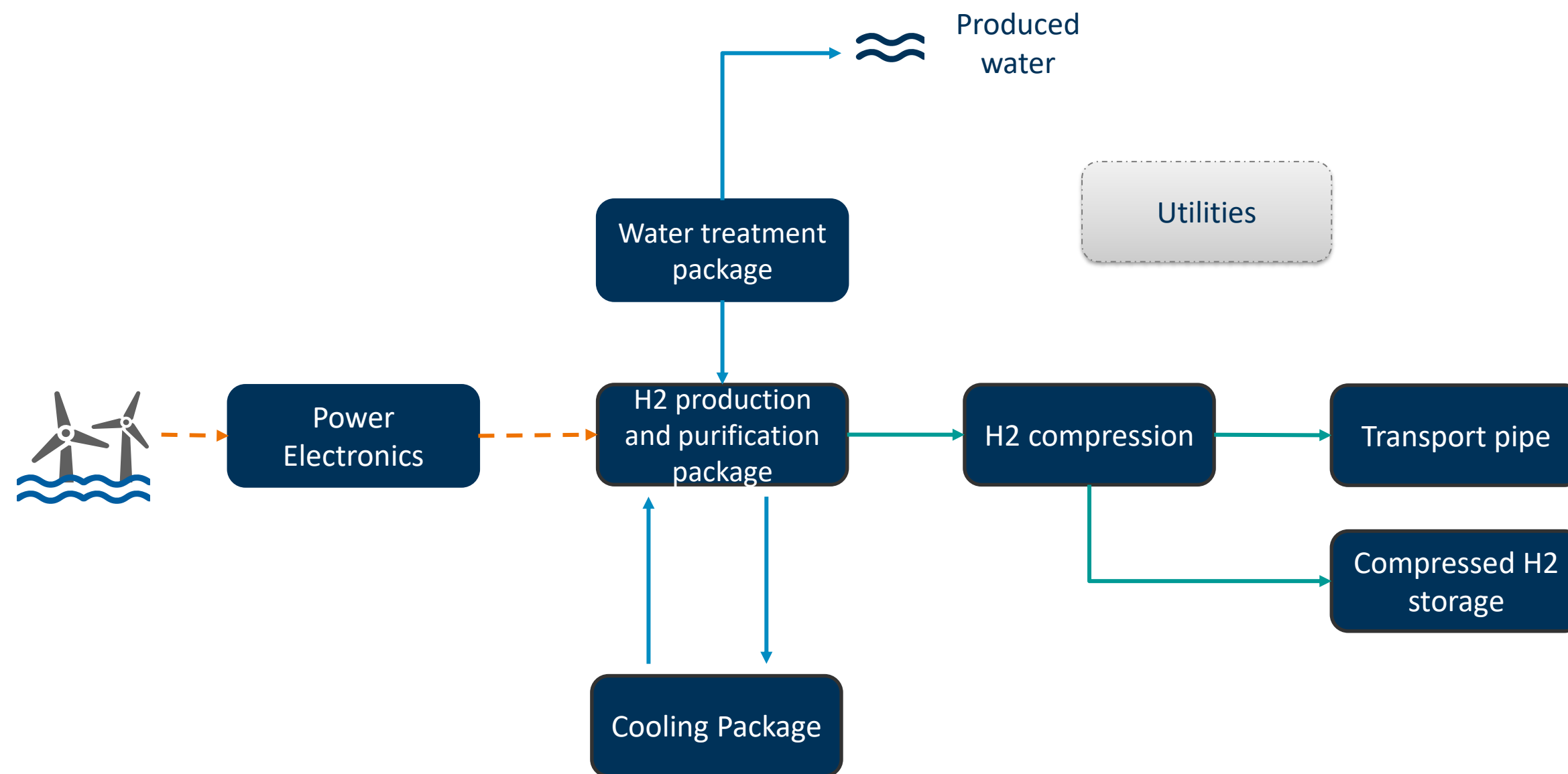


>100
PhD students and
80 post-docs
trained



To date **7**
patents filled and
44 open-access
publications

French Ecosystem: A Complete Value Chain



- **Electrolyser** PEM, alkaline and SOEC
 - *Elogen, GENVIA*
- **Seawater desalination** critical upstream step for offshore electrolysis
 - Thermal processes: *Entropie (Veolia)*
 - Membrane processes (RO): *Entropie, SLCE Watermakers*
- **Compression** H₂ produced at 5–30 bar, storage 350–900 bar, export by pipe ≈80 bar
 - *Eifhytec, Boostheat, Enertime*
 - Liquefaction expertise: *Air Liquide* (space & aeronautics heritage)
- **Storage** Type III and Type IV tanks, compact for offshore
 - *Mahytec, Plastic Omnium, Faurecia, Europe Technologies, H2X, Raigi, Stelia*
 - Underground/subsea storage: *Vallourec (Delphy™), Subsea7 (PowBox-HTM), TechnipFMC*
- **Export** subsea pipelines, risers, H₂ carriers
 - *Vallourec* tubular solutions for high-pressure H₂ transport
 - *GTT + TotalEnergies* cryogenic membrane system for LH₂ carriers

EPCI & Service Companies operating in France: decades of offshore O&G expertise repurposed for the H₂ value chain (installation, subsea infrastructure, systems integration)

Saipem



Material qualification for subsea H₂ pipelines (RINA certified); SUIISO concept (floating wind + solar + marine energy)

Subsea7



JIP H2Pipe (DNV), H2Shore (Scotland), NeFHyPro (Netherlands); **OPHARM2** participant; PowBox-HTM subsea storage

TechnipFMC



Deep Purple™ pilot (Kongsberg); BEHYOND study; Hardanger Hub subsea storage

Technip Energies



GO.H₂ by T.EN™: full modular offshore H₂ solution (fixed/floating, pipeline or carrier export, LOHC/ammonia conversion)

Bourbon Offshore, Louis Dreyfus Armateurs



Marine services, O&M support, H₂ propulsion innovation

Bureau Veritas



Risk and safety studies for offshore H₂ units; involved in PEPR-H2 ecosystem

French Pilot Projects & Industrial Concepts



Sealhyfe

(Lhyfe, 2023)

World's first offshore H₂ production pilot 1 MW PEM, 400 kg H₂/day, <200 m² footprint

SEM-REV test site, GEPS Techno (WAVEGEM floating platform), Chantiers de l'Atlantique, Plug Power PEM

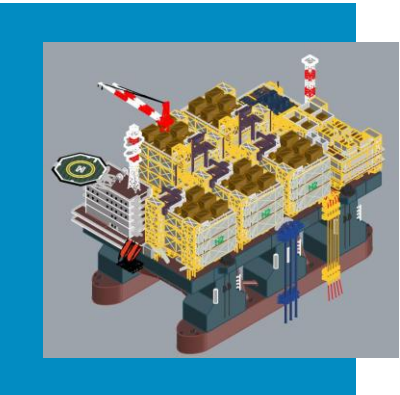


Hyskua

(EMEC + Sofresid Engineering / Ekium 2022-2024)

Funded by EETF (Scotland)

Semi-submersible platform (~30,000 t), located **~200 km offshore** near Scottish Targeted Oil & Gas (TOG) wind zone



Normand'Hy

(Lhyfe, Normandy, 2026)

Large-scale onshore green H₂ project feeding coastal industrial demand; operational ramp-up expected end 2026

First step toward offshore-coupled production



Fills a **critical gap** in the French and European R&D landscape

Addresses the key open questions for industrial deployment

Multi-objective optimisation of offshore H₂ supply chains

Technology screening and equipment selection for decentralised units

Floating wind turbine design integrating electrolysis capacity

PEM electrolyser behaviour under motion first experimental qualification

Environmental integration regulatory and ecological challenges at sea

Outputs directly usable for **future project development, permitting, and funding applications**

(ADEME, BPI, Horizon Europe, Innovation Fund...)

Offshore green H₂ is a **nascent but fast-growing market** with first commercial projects expected in the 2030s

France's competitive advantages:

- Complete industrial ecosystem across the full value chain
- Strong EPCI companies with offshore track record
- Leading research institutes and growing academic offer
- Active participation in European collaborative projects

Remaining barriers to commercial scale:

- **Cost reduction** offshore H₂ still significantly more expensive than onshore
- **Regulatory frameworks** offshore H₂ not yet covered by existing maritime codes
- **Standards & certification** DNV, Bureau Veritas frameworks still maturing
- **Financing** large CAPEX, long lead times, uncertain demand signals

OPHARM2 contributes directly to reducing technical risk and building the evidence base needed to unlock investment and policy support