



THE OXFORD  
INSTITUTE  
FOR ENERGY  
STUDIES

# HYDROGEN AND CCUS MARKETS – NUMBERS, PROJECTS, POLICIES

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# Green hydrogen production: Some key challenges

## 1. Electricity cost is critical

- ~73-75% of hydrogen production cost comes from electricity
- So, cheap power is essential to make green hydrogen competitive

## 2. Renewables are cheap, but intermittent

Wind/solar are now the **cheapest power sources**, but **intermittent**

- **Balance of Plant (BoP)** (valves, pumps, etc.) is the **2nd largest cost contributor**  
BoP is cheaper when built at scale
- Therefore, **small modular systems** may be flexible but are **economically inefficient**. Larger plants are better from a **cost-reduction perspective**.

## 3. In Europe, the 'additionality' principle - the principle that renewable electricity used to make hydrogen must come from *new* renewable sources, not from ones already on the grid - is hampering the ramp-up of green hydrogen production

- **Massive gap in renewables for hydrogen:**  
EU's 40 GW electrolyser target by 2030 requires ~80–100 GW of *dedicated* new renewables, but only ~20 GW is currently announced/committed for hydrogen
- **Actual build-out not earmarked for H2:**  
EU added ~69 GW of solar + wind in 2023, yet most new capacity serves general electrification and decarbonisation, not green hydrogen projects

## Main cost drivers for green hydrogen

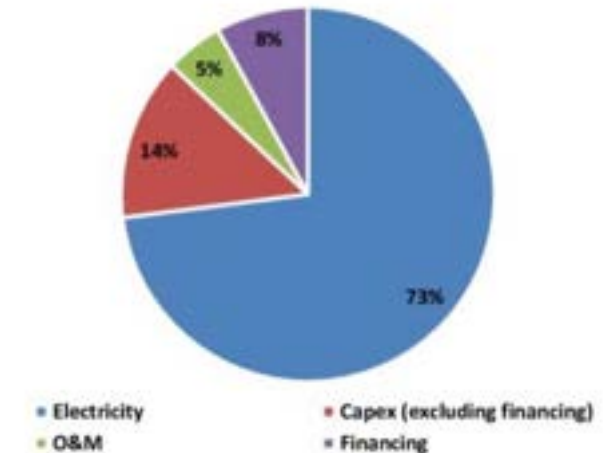
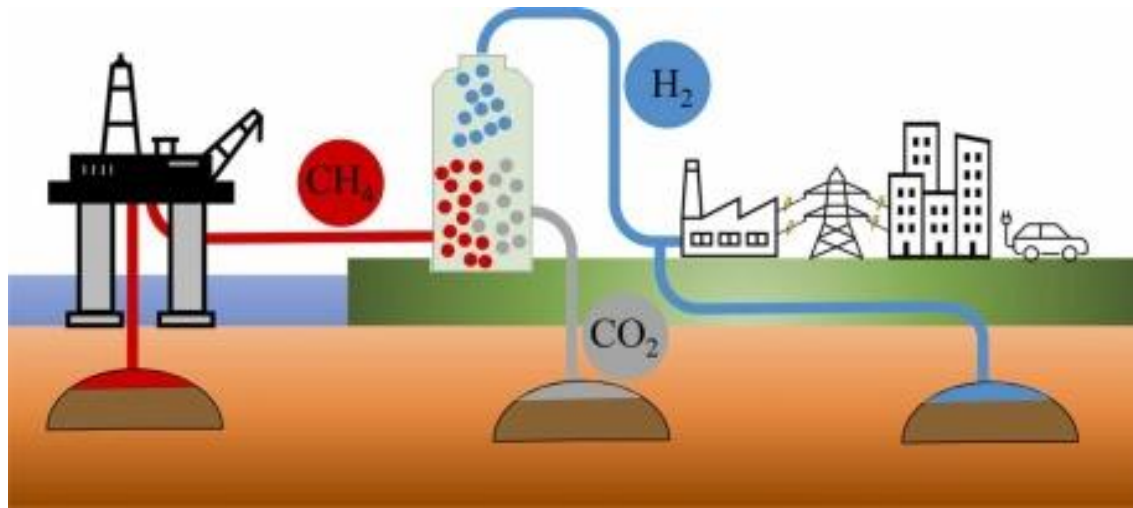


Image: Patonia and Poudineh (2021)



# Steam methane reforming + carbon capture and storage



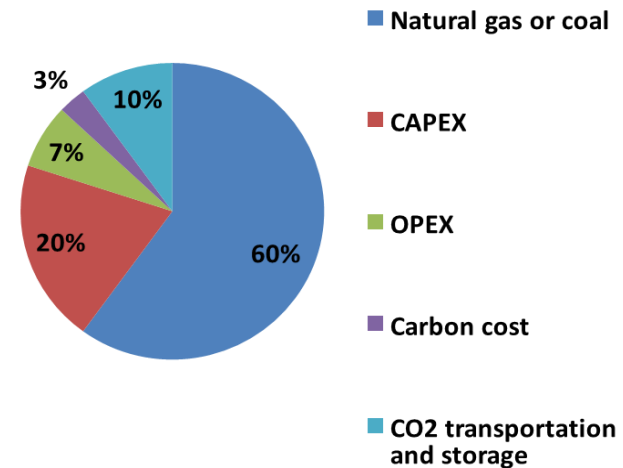
Hydrogeninsight

## ExxonMobil threatens to scrap world's largest blue hydrogen project over US emissions criteria for tax credits

Requirements to use zero-carbon electricity in H2 production processes could push the project into the tax break's lowest bracket



## Key components of 'blue' hydrogen production



Source: GEP (2023)

- Expected output of **largest green H2** production plant (NEOM, KSA): **220,000 t/a**

vs.

- Output of **largest grey H2** production plant (Baytown, USA): **900,000 t/a**



# Is CCS a less problematic option for hydrogen production?

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Implementing CCS is still challenging because of:

- Economics (**CCS technologies are still expensive**)
- **Long permitting process** and associated uncertainties (at least 5-6 years to get permitting for underground sequestration)
- The **chicken-and-egg problem of infrastructure**
- **No direct financial incentives** (low cost of carbon, no feasible subsidies, etc.)

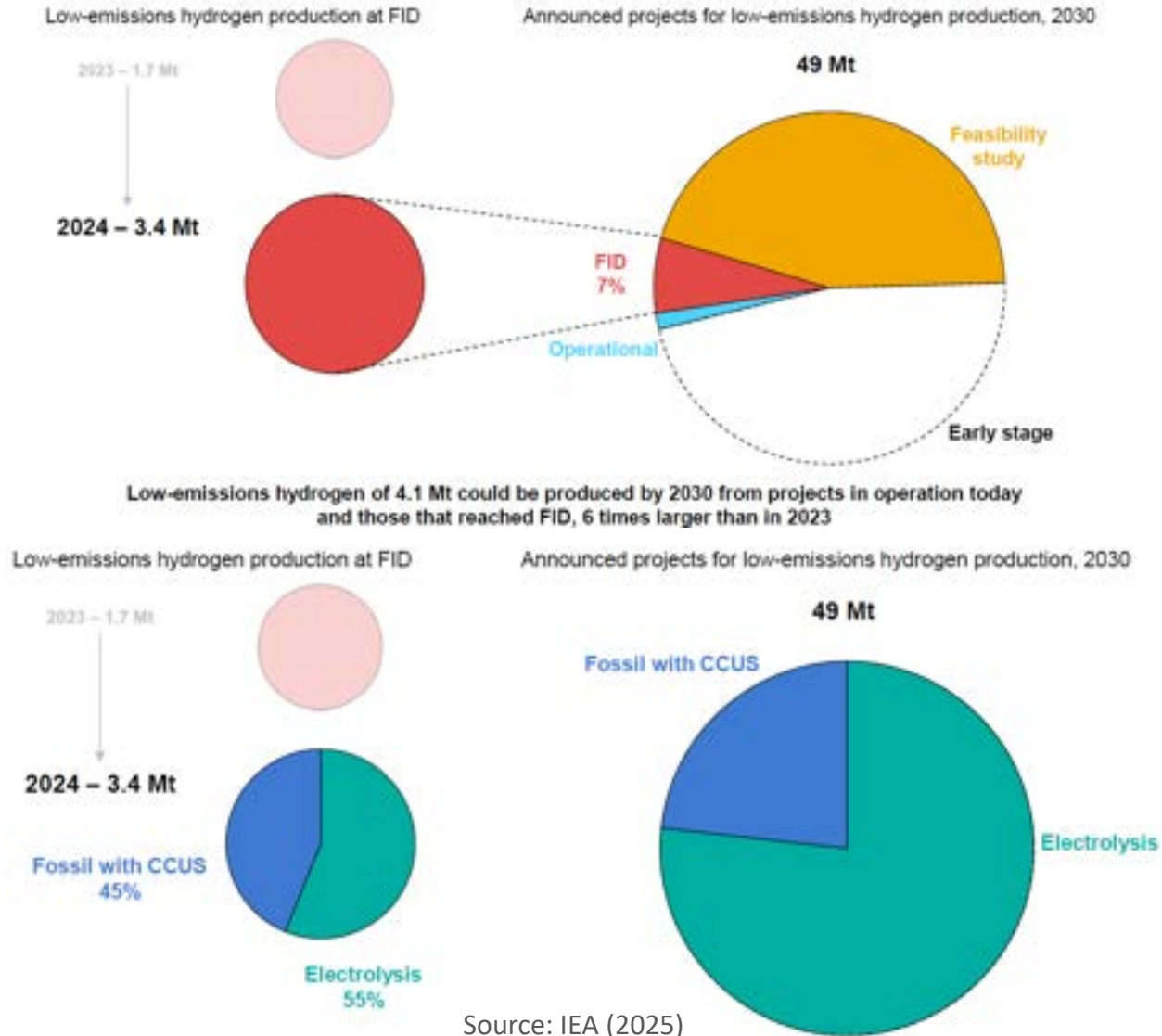
As of 2025, out of ~395 CCS initiatives only **~45 projects currently in operation** and not all of them are for **'blue' hydrogen production** (compared to 522 announced and **57 operational green H<sub>2</sub> projects**)

By comparison, there are only **14 CCU projects in operation**

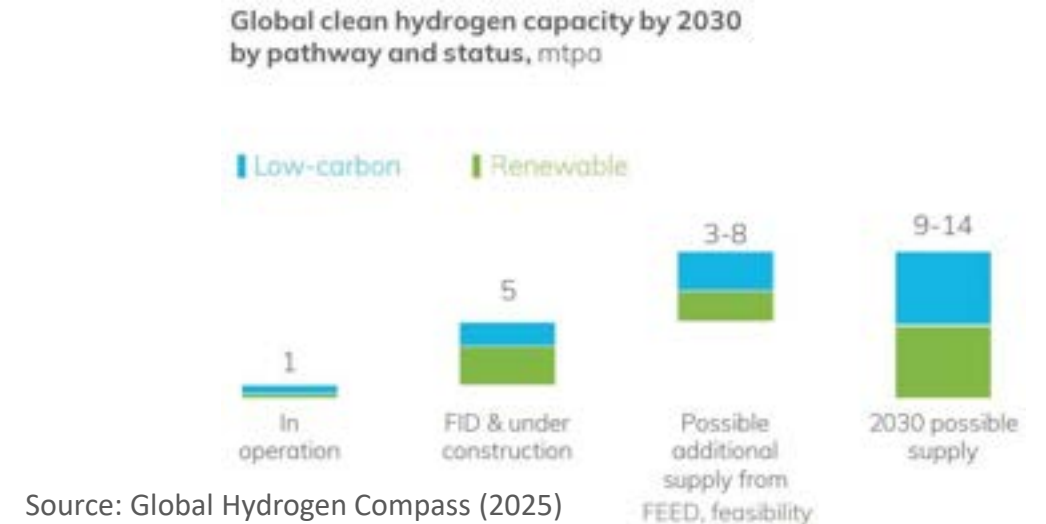
**Capture efficiency** between 30 and 90 percent (**normally 30-60%**)



# Clean hydrogen development: MOUs vs. FIDs, green vs. blue



- **95 million tonnes per year** current global hydrogen production:
  - **ONLY < 1million tonnes** is low carbon/ renewable
- However, **investment decisions doubled in the last year** (from 1.7 Mt at FID in 2023 to 3.4 Mt in 2024)
- At the moment, the majority of **FIDs are favouring electrolysis over SMR+CCS**
- However, **cost and scale** still remain **critical impediments** for green (and blue) hydrogen's ramp-up





# Hydrogen market

## Regional production close to demand

**Model:** Production is co-located with demand in industrial ‘hubs’ or ‘valleys’

**Rationale:** Minimises costs and complexities of long-distance hydrogen transport

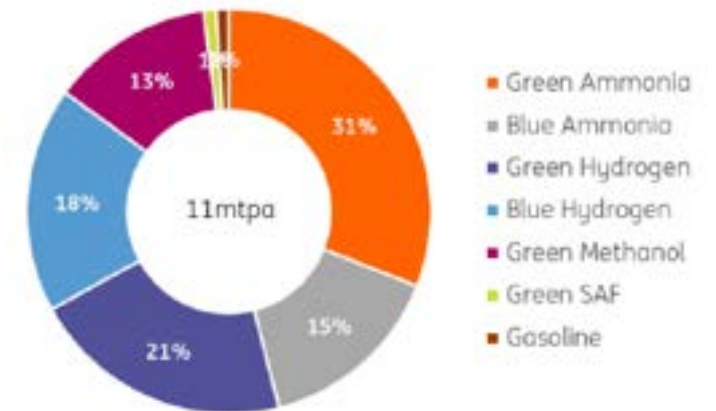
**Trade:** Primarily through hydrogen derivatives like **ammonia** and **methanol**, which are easier to ship globally

**Example:** US Regional Clean Hydrogen Hubs (H2Hubs) program - to meet near-term demand at low cost



Source: Agora Energiewende (2023).

## Low-carbon hydrogen off-take by product



Source: ING (2025).



# CCS market

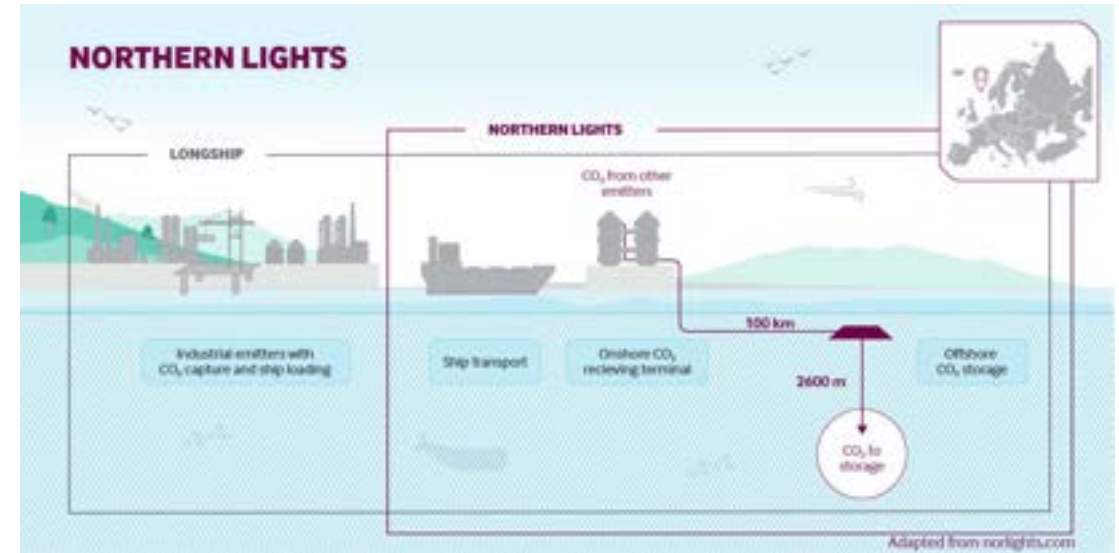
## The 'CO<sub>2</sub> Transport and Storage as a Service' model

**Model:** Emulators a waste management or midstream pipeline business

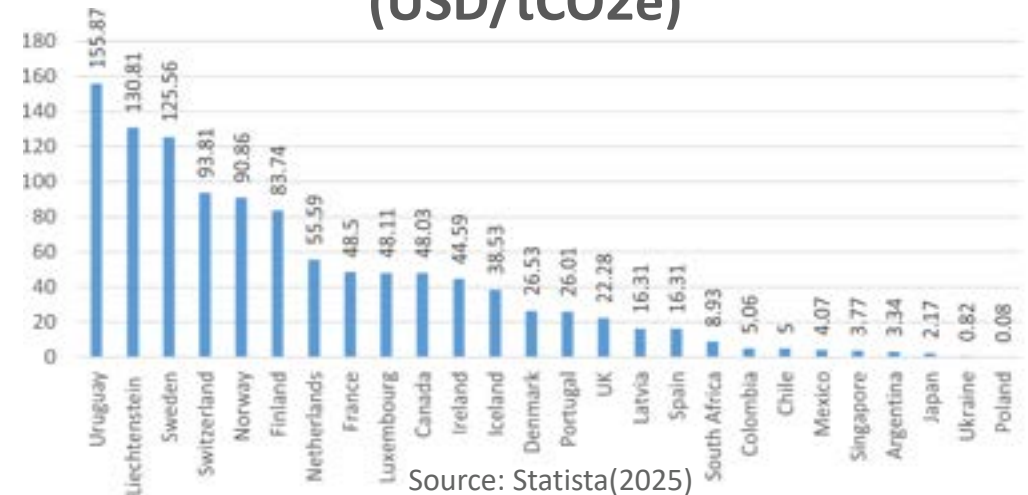
**Revenue:** Fees for collecting, transporting, and permanently storing industrial CO<sub>2</sub>

**Driven by:** Policy incentives (tax credits, carbon pricing) that make CO<sub>2</sub> avoidance valuable + voluntary commitments

**Example:** The **Northern Lights** project in Norway



## Carbon tax rates by country as of March 2023 (USD/tCO<sub>2</sub>e)





# Hydrogen vs. CCUS: Typical policy models

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## Hydrogen policy drivers: Subsidies & mandates

### **Driver:**

Direct production subsidies (e.g., US **45V Hydrogen Production Tax Credit**, EU's Hydrogen Bank auctions)

### **Demand pull:**

Low-carbon fuel standards and quotas (e.g., in transport, industry)

### **Supporting policies:**

R&D funding, grants for infrastructure, and international cooperation on standards

## CCUS policy drivers: Valuing avoidance

### **Primary driver:**

Carbon pricing (ETS) and **tax credits for sequestration** (e.g., US **45Q Tax Credit**) and also voluntary commitments

### **Contract-for-Difference (CfD) Models:**

Governments underwrite the price difference to de-risk storage development

### **Regulatory push:**

Stringent emissions standards for industry, making CCUS a compliance option



# Flagship hydrogen project - US H2Hubs

## Project:

US Regional Clean Hydrogen Hubs (H2Hubs)

## Scope:

Establish 6–10 regional networks for clean hydrogen production, storage, and end-use, following a hub-and-spoke model

## Capacity:

Large-scale deployment across multiple states (exact capacity varies by hub, collectively targeting several million tonnes of H<sub>2</sub> per year)

## Significance:

A landmark policy to catalyse a domestic hydrogen market and demonstrate scalable hydrogen infrastructure

## Funding:

\$7 billion in **Bipartisan Infrastructure Law subsidies**, enabling development, deployment, and scaling



## Key challenges:

- **Demand uncertainty:** The 'chicken-and-egg' problem of securing guaranteed off-takers
- **Infrastructure gap:** High cost of building new pipelines and storage facilities
- **Strict regulations:** Navigating the "three pillars" of the 45V tax credit (additionality, deliverability, hourly matching)



# Decarbonising the Port of Rotterdam: Porthos CCS project

## Project:

Porthos (Port of Rotterdam CO<sub>2</sub> transport and storage infrastructure)

## Scope:

Capture CO<sub>2</sub> from industrial emitters in the Rotterdam port area and store it in depleted gas fields under the North Sea

## Capacity:

~2.5 MtCO<sub>2</sub>/year initially, with potential for expansion

## Significance:

Enables industrial decarbonisation in one of Europe's largest industrial clusters

## Funding:

Supported by Dutch government subsidies and EU funding, enabling project feasibility and early deployment



## Key challenges:

- **Off-taker certainty:** Securing long-term CO<sub>2</sub> supply agreements from industrial emitters
- **Infrastructure development:** High cost and complexity of constructing transport pipelines and offshore storage facilities
- **Regulatory & permitting hurdles:** Navigating Dutch and EU regulations for CO<sub>2</sub> transport, storage, and safety compliance



# US H2Hubs vs. Porthos: Business models

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## US H2Hubs

- **What they do:** Produce, store, transport, and sell clean hydrogen to industry & transport
- **Revenue:** Hydrogen sales to end-users
- **Funding:** **\$7B federal subsidies** to de-risk early deployment
- **Scale:** Multi-state regional networks (hub-and-spoke)
- **Model:** Hybrid – **private revenue + public funding**

## Porthos

- **What they do:** Capture, transport, and permanently store CO<sub>2</sub> for industrial emitters
- **Revenue:** Fees from companies sending CO<sub>2</sub>
- **Funding:** **Dutch & EU grants of €2.2-2.3B** to cover infrastructure and operational costs
- **Scale:** Industrial cluster in Port of Rotterdam
- **Model:** Hybrid – **service fees + public support**



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**Thank You!**

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