



Oil and gas decommissioning: opportunities for reuse and repurposing

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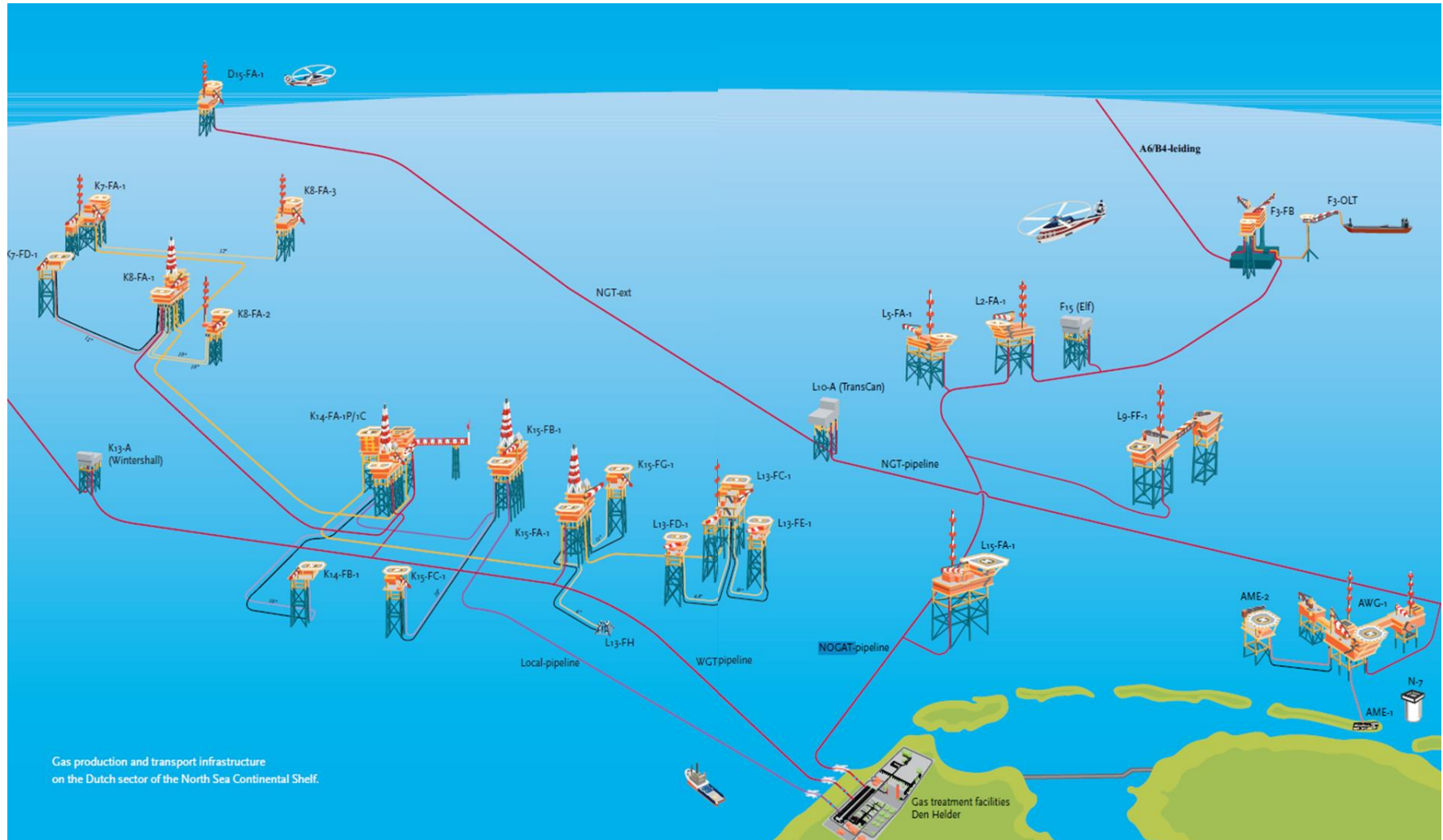
Final Conference for the MUSES project
Brussels, 10 October 2018

Founding partners





Offshore potential of energy conversion





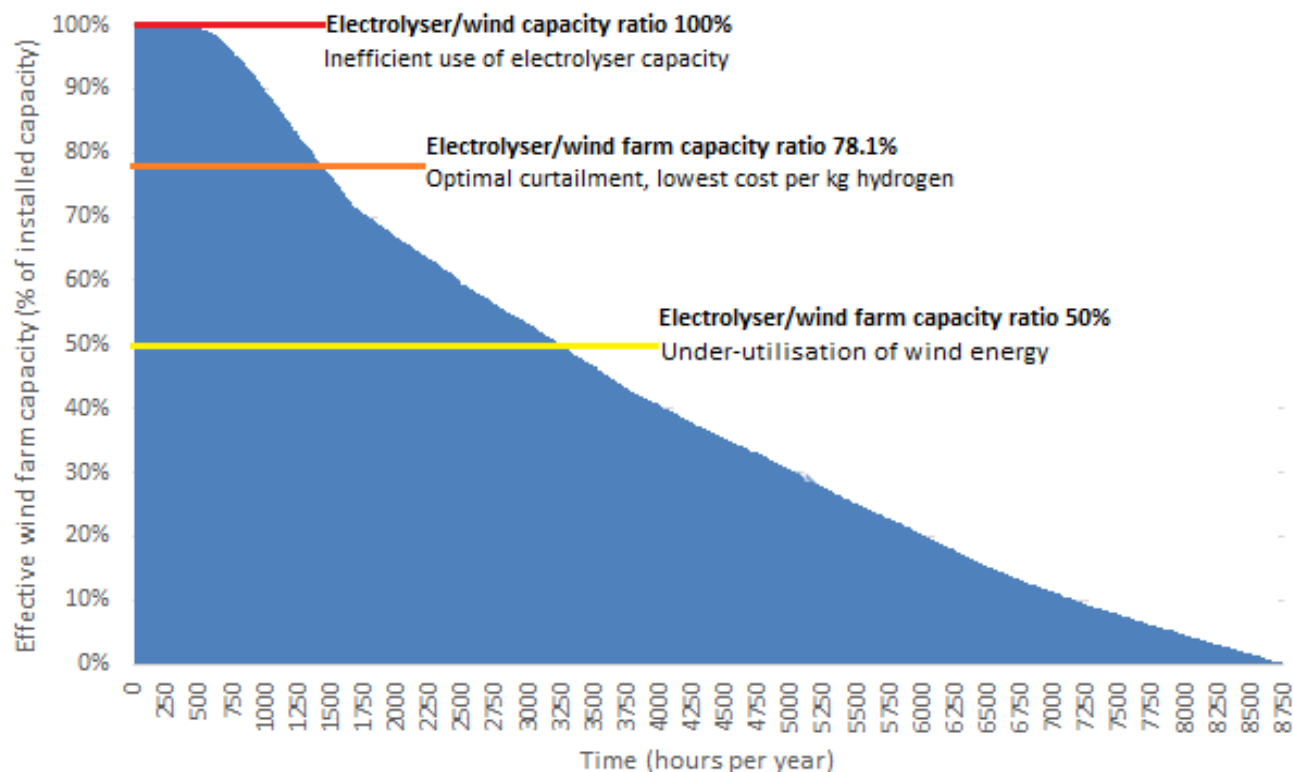
Two key options (except from platform electrification and gas-to-wire)

1. Use platform for conversion of nearby wind energy
2. Use platform for offshore CCS



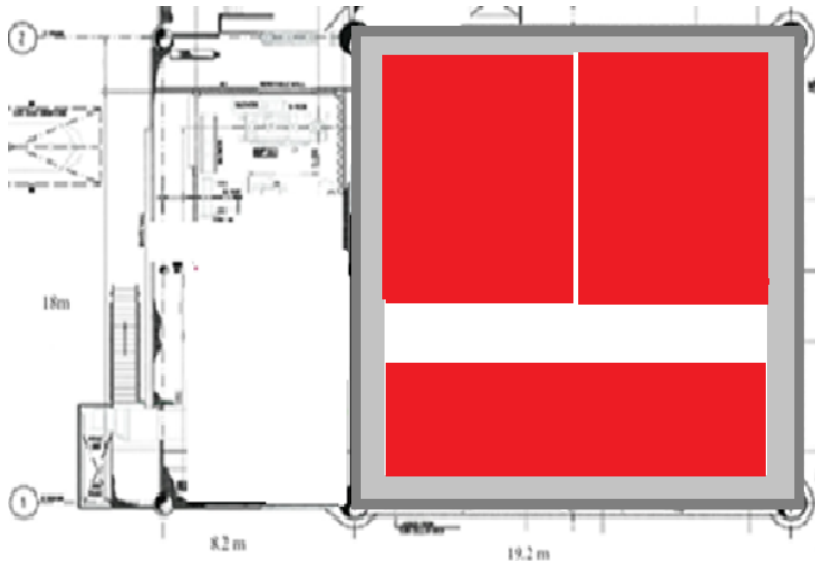
Platform for conversion offshore wind energy

- Some curtailment economically optimal at current electrolyser prices



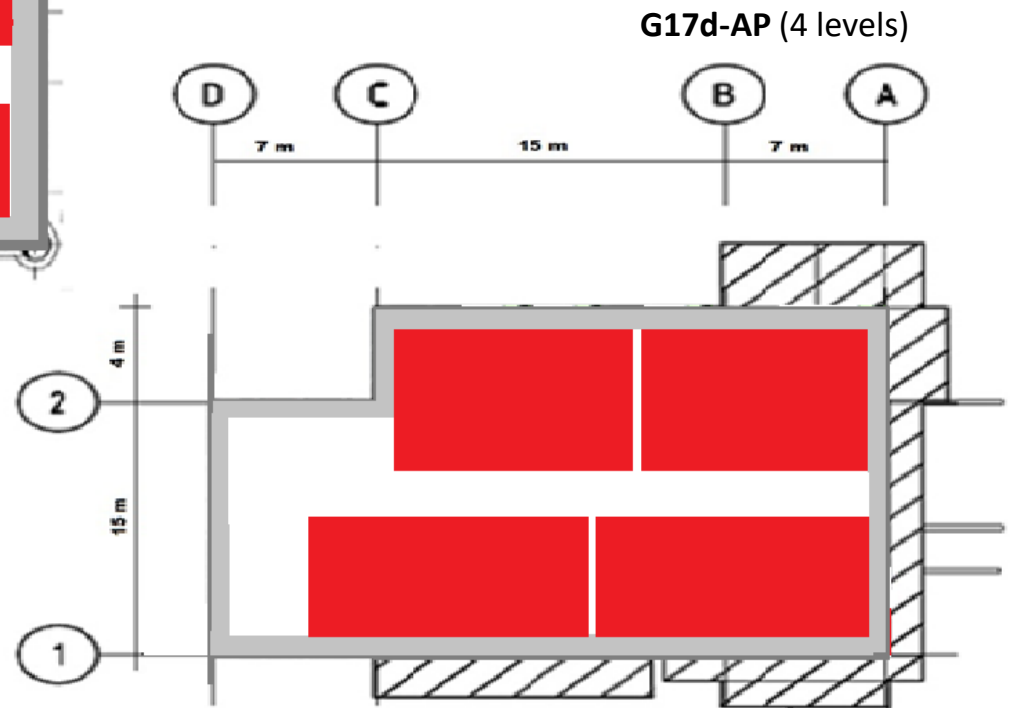


Platform use: Siemens Sylizer 300 electrolyser (10 MW)



G17d-A (3 levels)

- A 'mother platform' can host over 200 MW electrolyser capacity (satellite some 70 MW)



G17d-AP (4 levels)



Power-to-gas: current cost price data

(NSE1 study)

- Cost price of **'grey'** hydrogen: some **€1 – 1.50/kg** (but some 13 kg CO₂ footprint)
- Cost price of **'blue'** hydrogen: ca **€2.50/kg** (informal information from Norwegian project)
- Cost price of **'green'** hydrogen:
 - Onshore electrolysis: ca **€3 – 4/kg**
 - (by 2025 possibly **€2 – 3/kg**)
 - Offshore electrolysis (including savings on e-grid): **€2 – 3/kg**
 - (by 2025 possibly **€1.50 – 2/kg**)
- Note that an EU ETS allowance price increase by €1, implies an increase in the price of a kg of 'grey' hydrogen of about €0.01 only.
- So, a more effective allowance price development is probably not sufficient to in itself cover the price gap between 'grey' and 'blue'/'green' hydrogen; additional PAMs may be needed to speed up



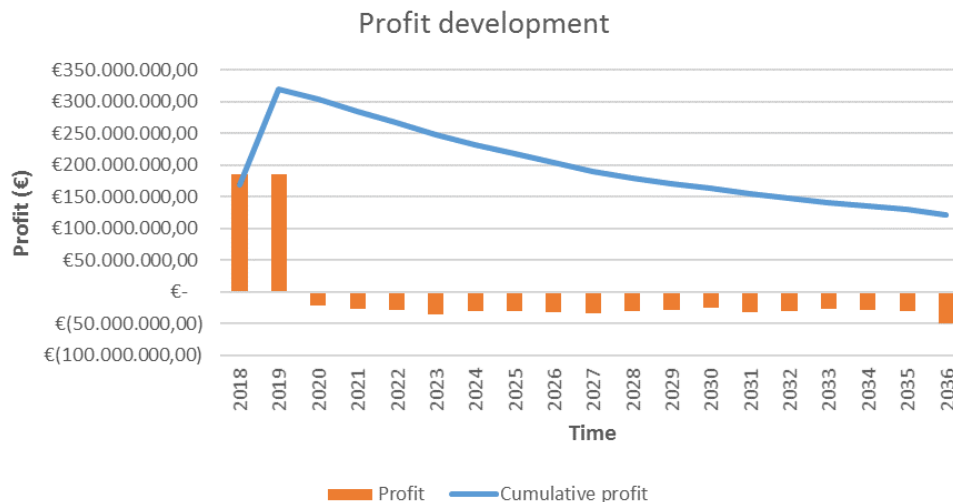
Power-to-gas: a case study

- Caveats:
 - Beginning learning curve
 - Externalities difficult to quantify
 - Rules, regulations and public acceptance issues unclear
- Positive aspects:
 - Potential game-changer / enabler
 - Various output options
 - Technologies well-known
 - Demand for 'green gas' growing

All power to platform for conversion

Look from a platform perspective while keeping all current external ROIs the same.

i.e. windfarm will always get market value for their wind



- Saving on electric cable monetized
- Savings on e-grid onshore also included
- €1- €1.75 hydrogen price kg
- Assumed green hydrogen price: €2 / kg

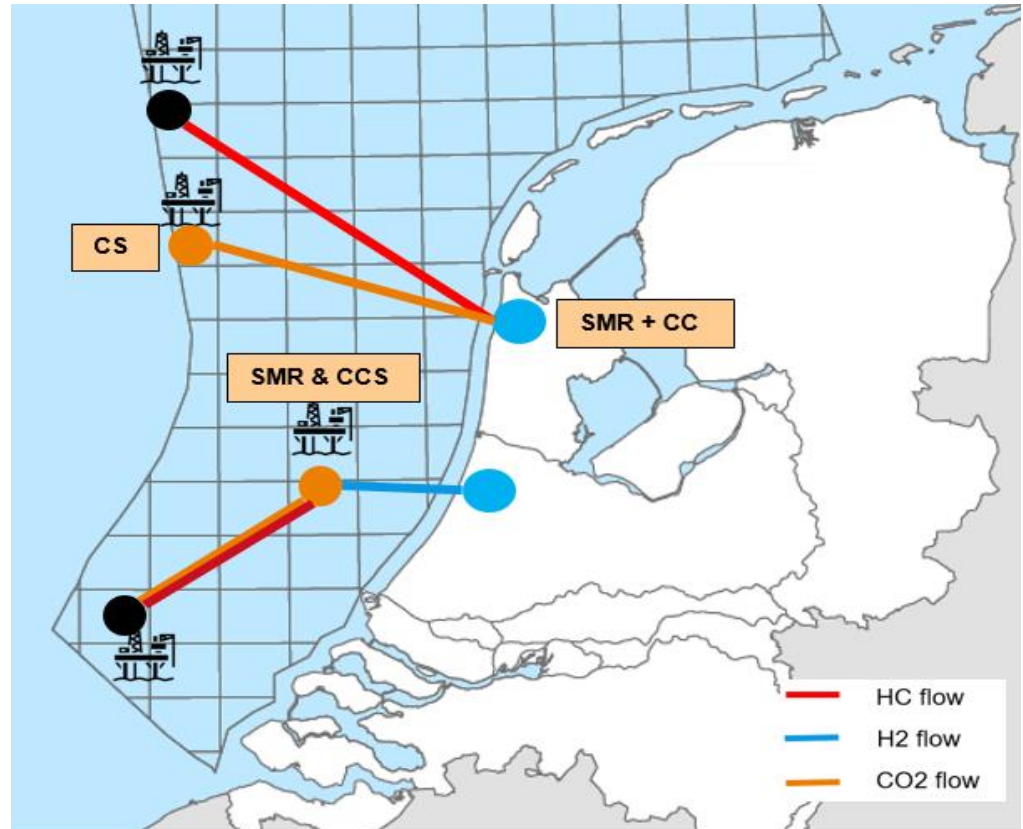
Sensitivity for: **Size, price stochastics, externalities, old/new pipeline, efficiency electrolyser, learning curve, distance to shore, refurbishment costs**

Steam Methane Reforming & CCS

- Location comparison of CCS + SMR:

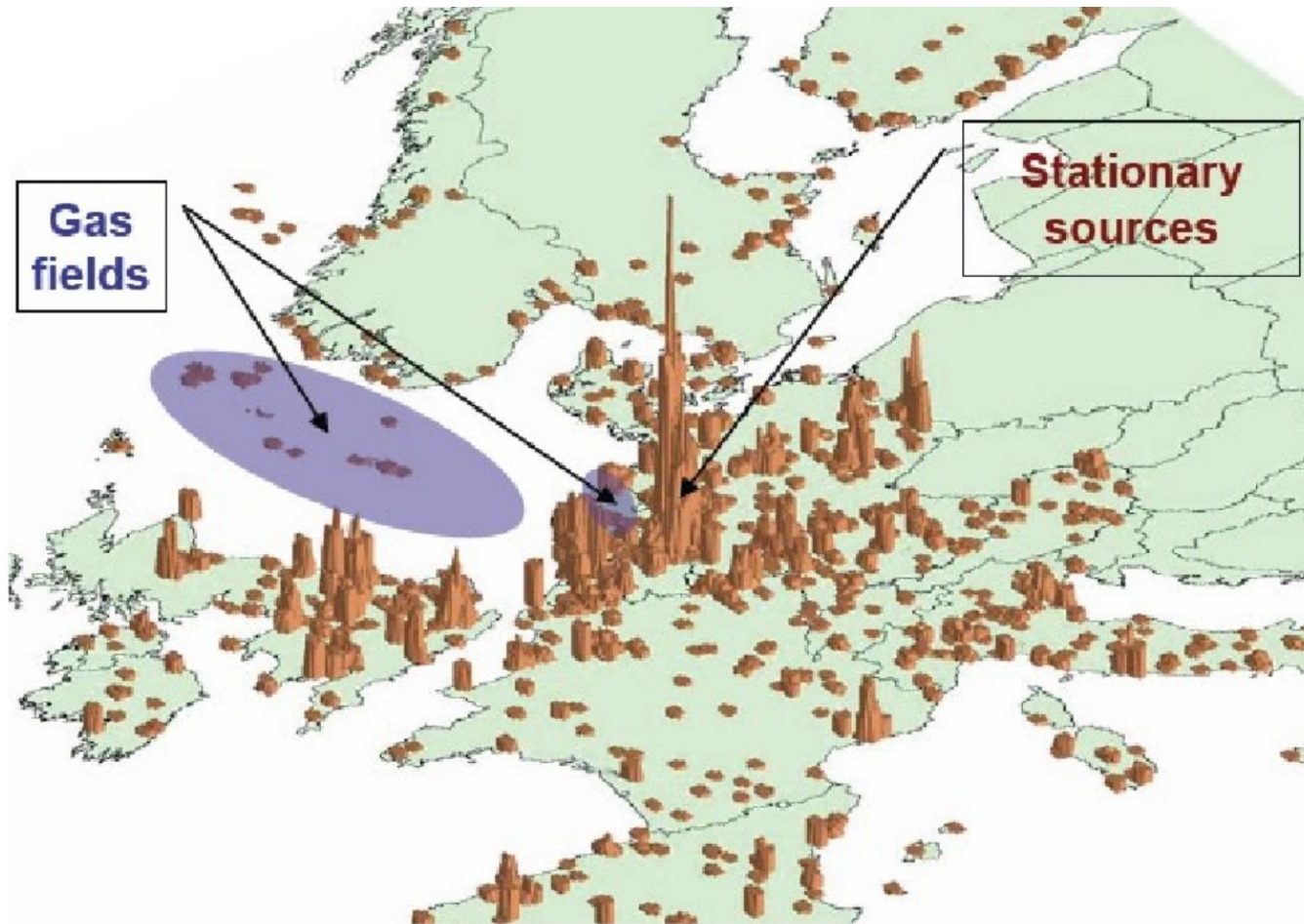
1. SMR + CC onshore → CS offshore
2. SMR + CCS offshore → sell H₂ onshore

- Pre-combustion capture of CO₂
- Focus on CO₂-value chain excl. H₂





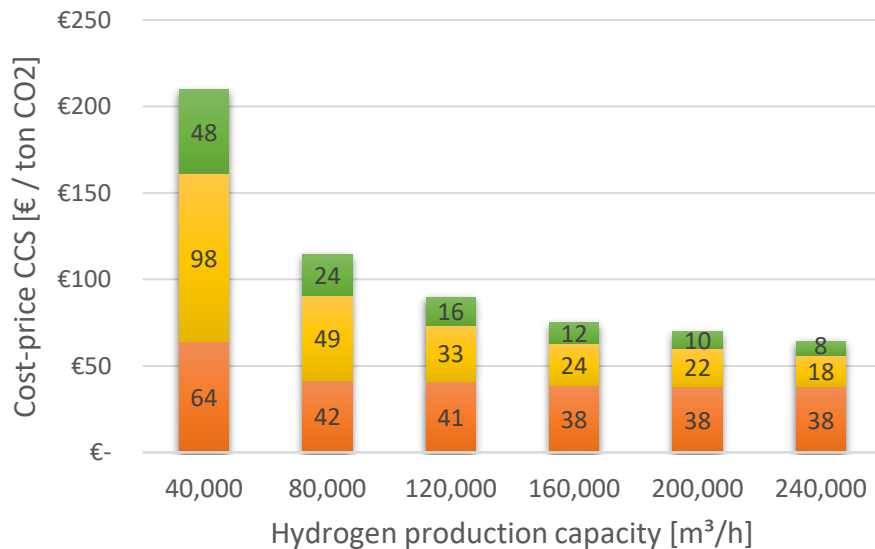
North Sea located well for CCS





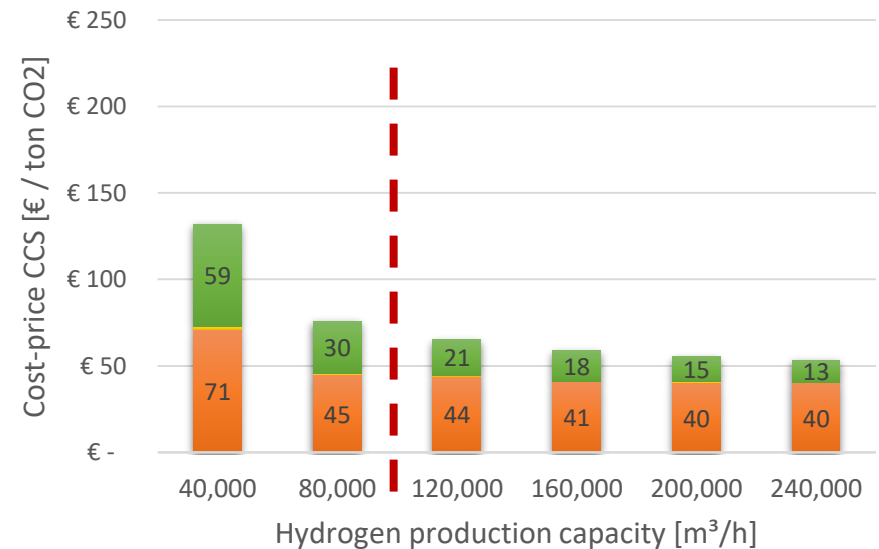
Results – Cost-Price of Storing CO₂

Cost-price composition onshore SMR



Opt. 1 Capture Opt. 1 Transport Opt. 1 Storage

Cost-price composition offshore SMR



Opt. 2 Capture Opt. 2 Transport Opt. 2 Storage

- Capture and storage costs are higher in the offshore SMR case, still the savings on CO₂ pipelines from onshore to the platform could lead to a lower offshore cost-price
- Highest SMR capacity leads to ~1 Mt CO₂ captured and stored per year



Thank you for your attention

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www.storeandgo.info

Jepma & Van Schot (2017): On the economics of offshore energy conversion: smart combinations (www.gasmeetswind.eu/wp-content/uploads/2017/05/EDI-North-Sea-smart-combinations-final-report-2017.pdf)

Jepma, et al. (2018): Towards sustainable energy production on the North Sea – Green hydrogen production and CO2 storage: onshore or offshore? (available on request)



Key assumptions

Assumptions regarding financing

- inflation rate: 0%
- tax rate: 20%
- minimum required return on equity: 10%
- interest long-term private debt: 4.0%
- debt/equity ratio: 60/40
- opportunity cost of capital: 7,6% (WACC)
- year of starting investments: 2025
- year of starting operation: 2026
- operating period 10 years
- oxygen is not valued

Assumptions regarding prices

- the average production costs of offshore wind energy: €100/MWh
- SDE+ subsidy: €70/MWh (only for non-curtailed wind-power)
- average APX price: € 30/MWh
- effective power price: €34,60/MWh
- green hydrogen price (chemical industry): €1.56/kg or €25.20/MWh
- green hydrogen price (mobility): €4.67/kg or €75.55/MWh
- Current ETS-allowance price impact: €6cts/kg

Assumptions regarding energy transport

- CAPEX E-grid 320 MW shore - wind farm (near G17): €147 million
- CAPEX E-grid 77 MW shore - wind farm (near D18): €38.5 million
- Capex new compressor: €2.802/kWh
- Annual maintenance fee compressor: 3% CAPEX
- CAPEX PSA extraction station: €1,000 per 1 Nm³/h
- OPEX PSA extraction station: 5% CAPEX
- CAPEX dedicated hydrogen pipeline: €450,000-625,000/km, depending on diameter
- OPEX dedicated hydrogen pipeline: 2% CAPEX
- Transport costs hydrogen in existing network: €16.50/1000m³



Assumptions regarding G17 & D18

- CAPEX platform preplacement: €10/kg
- CAPEX new deck for the electrolyser: €40/kg
- weight of gas-specific installations: 25% of total

Assumptions regarding platform G17

- OPEX of manned platform G17: €8,800,000/y
- weight G17: 3200 ton
- max. electrolysis capacity: 250 MW
- CAPEX rebuilding decks G17: €176,000,000
- decommissioning costs G17: €20,000,000

Assumptions regarding platform D18

- OPEX of satellite platform D18: €4,000,000/y
- weight D18: 1000 ton
- max. electrolysis capacity: 60MW
- CAPEX rebuilding decks D18: € 40,000,000
- decommissioning costs D18: €7,000,000

Assumptions related to CAPEX and OPEX investments

- CAPEX Sylizer 300 (projection): €600/kWh
- CAPEX desalination unit: €61.200 for a 2000L/h capacity unit
- OPEX Sylizer 300 and desalination unit: 2,5% CAPEX
- energy efficiency: 75%
- depreciation period electrolyser: 10 years
- residual value: €0