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Energy Modelling Platform for Europe

EMP-E 2021: Re-Energising Sustainable Transitions in Europe

Energy System Modelling, Methods & Results to support the European Green Deal

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Synergies in offshore energy: a roadmap for the Danish sector

Russell McKenna[1], Matteo D'Andrea[1] Mario Garzón González[2]

1. University of Aberdeen, 2. Technical University of Denmark

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Parallel session 7: Offshore energy system integration

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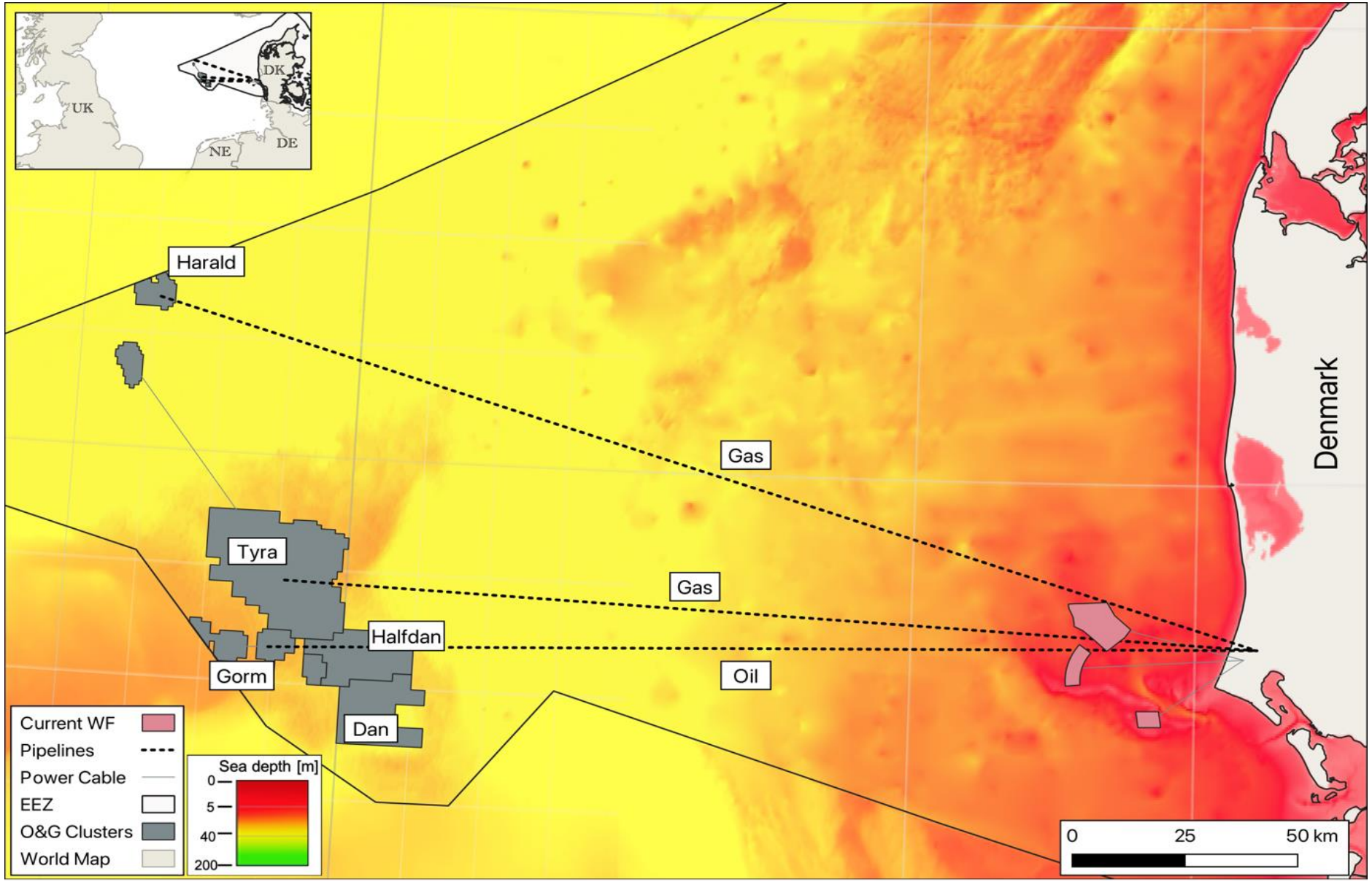
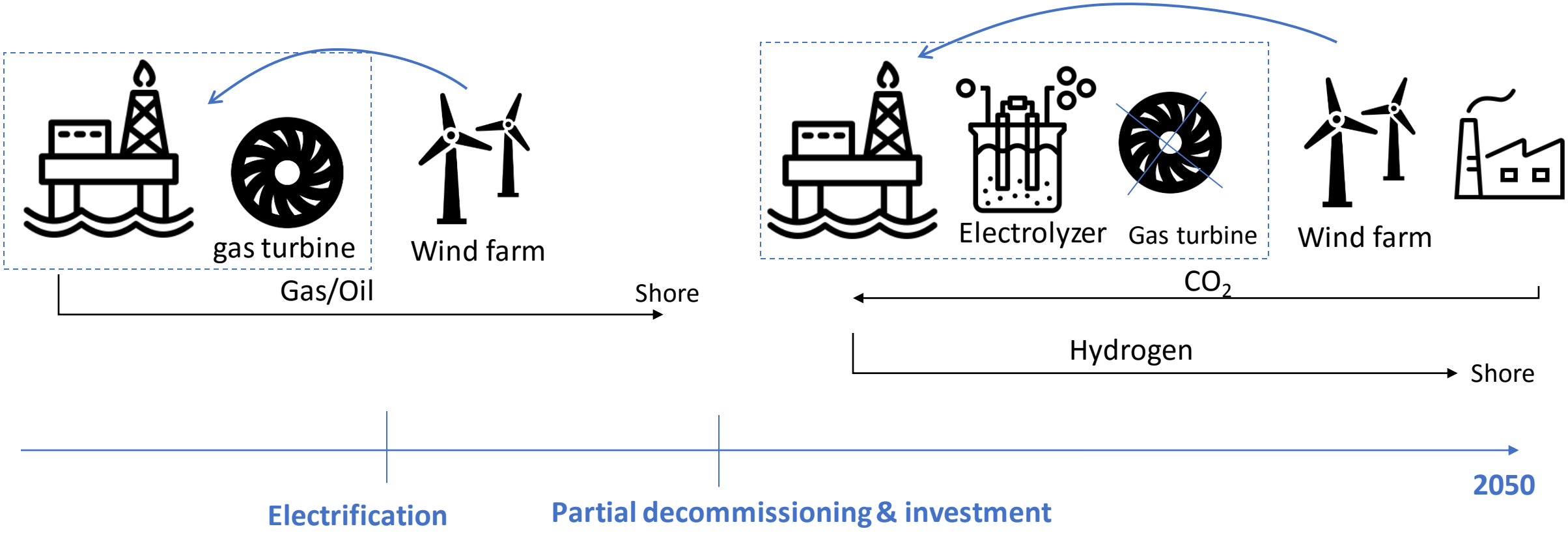
Background and objective



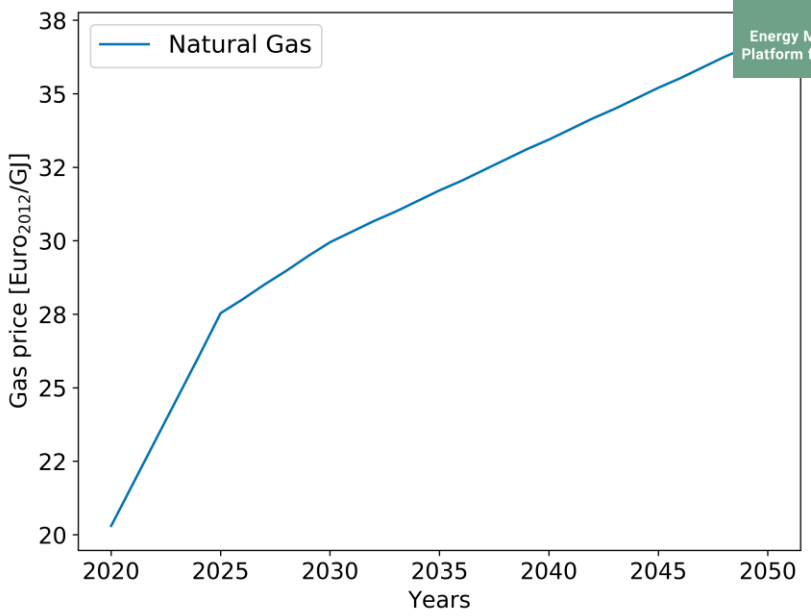
Energy system integration technologies

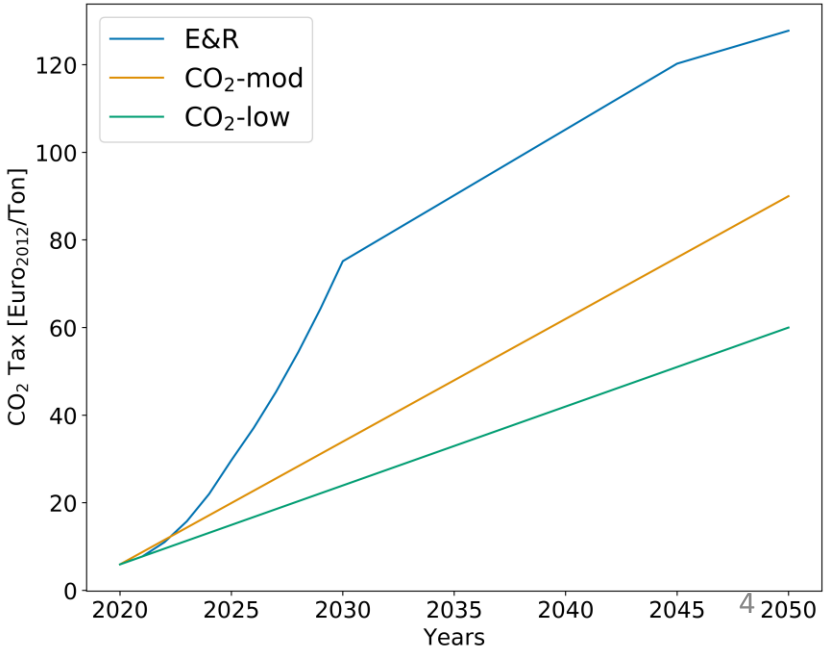
- **Electrification and Repurposing** : The model can electrificy the platforms and further repurpose the existing decommisioned infrastructure.



Modelling assumptions: Balmorel

- Whole system **cost minimisation**, including:
  - Investment/decommissioning in new/existing plants
  - Operation and costs of plants
- Planned developments in offshore wind are considered.
- Long term modelling horizon to 2050 with 6 modelling years from 2025.
- **Perspective of the system planner**, not the individual operators
- The Natural Gas prices reflect the market price cost; the development towards 2050 is based on a study from DEA.
- The CO2 tax development is based on the Balmorel model.



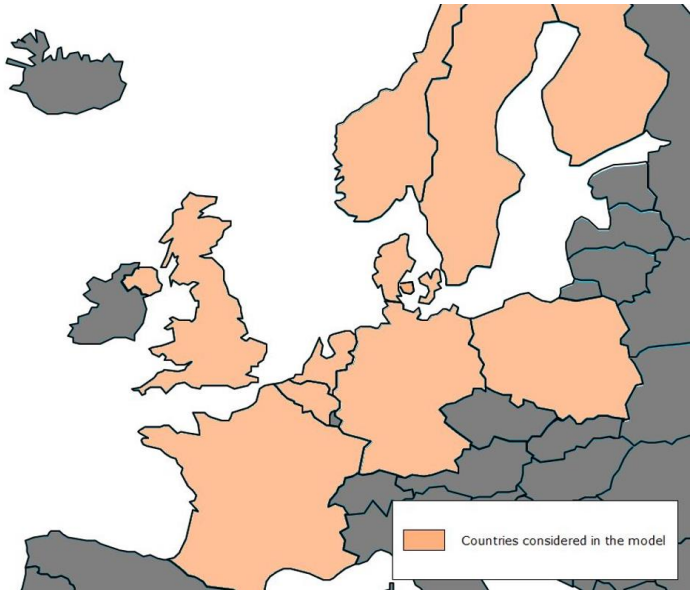


Hydrogen production

- **Hydrogen** as a **commodity** is **not implemented** in the model.
- We included an **electricity demand** for the **decarbonization** of the **transport sector**.
- The model can **allocate** this **demand** between **all countries** included in the model (see figure).
  - It chooses the **cheapest regions** based on the electricity price.
  - The maximum demand allocation in each region is limited.

- When the **demand** is **allocated** on the **platform**, it is considered as the **input electricity** of the **electrolyser**.
- **Demand** for **hydrogen** across all these countries **increases** towards **2050**.

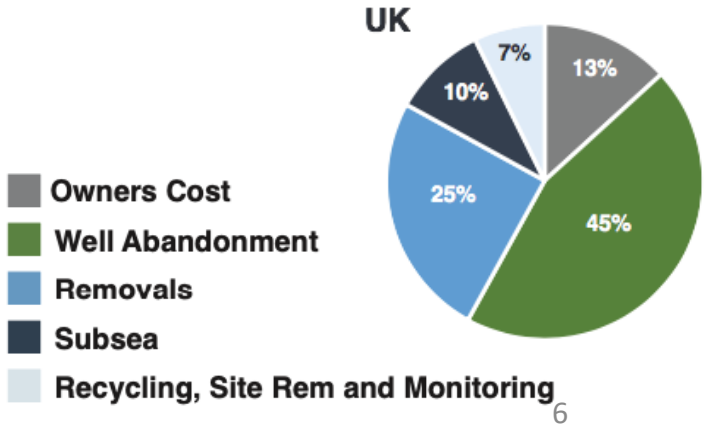
➢ The **allocation** of the **hydrogen production** is only **optimum** in this **larger context** (i.e. not just Danish O&G).



Repurposing costs

For each cluster the repurposing costs are assumed as the following:

- The **wells**, the **jackets,** the **pipelines** and the **subsea structure** can be used as they are. The **decommissioning costs** of these structures are **saved**.
- **50 %[a] of the platforms can be** renovated with a **new topside** to host the hydrogen plant. For these platforms, the **old topside** is **decommissioned** with a cost about 30%[b] of the full decommissioning cost.
- The new topside has the same weight of the old one and costs 40 €/Kg [c].



[a] Own assumption based on future uses of the platform.
[b] UKCS Decommissioning - Cost Estimate 2020, Oil & Gas Authority
[c] On the economics of offshore energy conversion: smart combinations, 2017, Energy Delta Institute

Scenarios

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Main scenarios

- **Decommissioning (BAU)** : Platforms are decommissioned according to the timeline.
- **Electrification and repurpose (E&R):** Platforms are electrified and the existing infrastructure is repurposed for alternative uses.

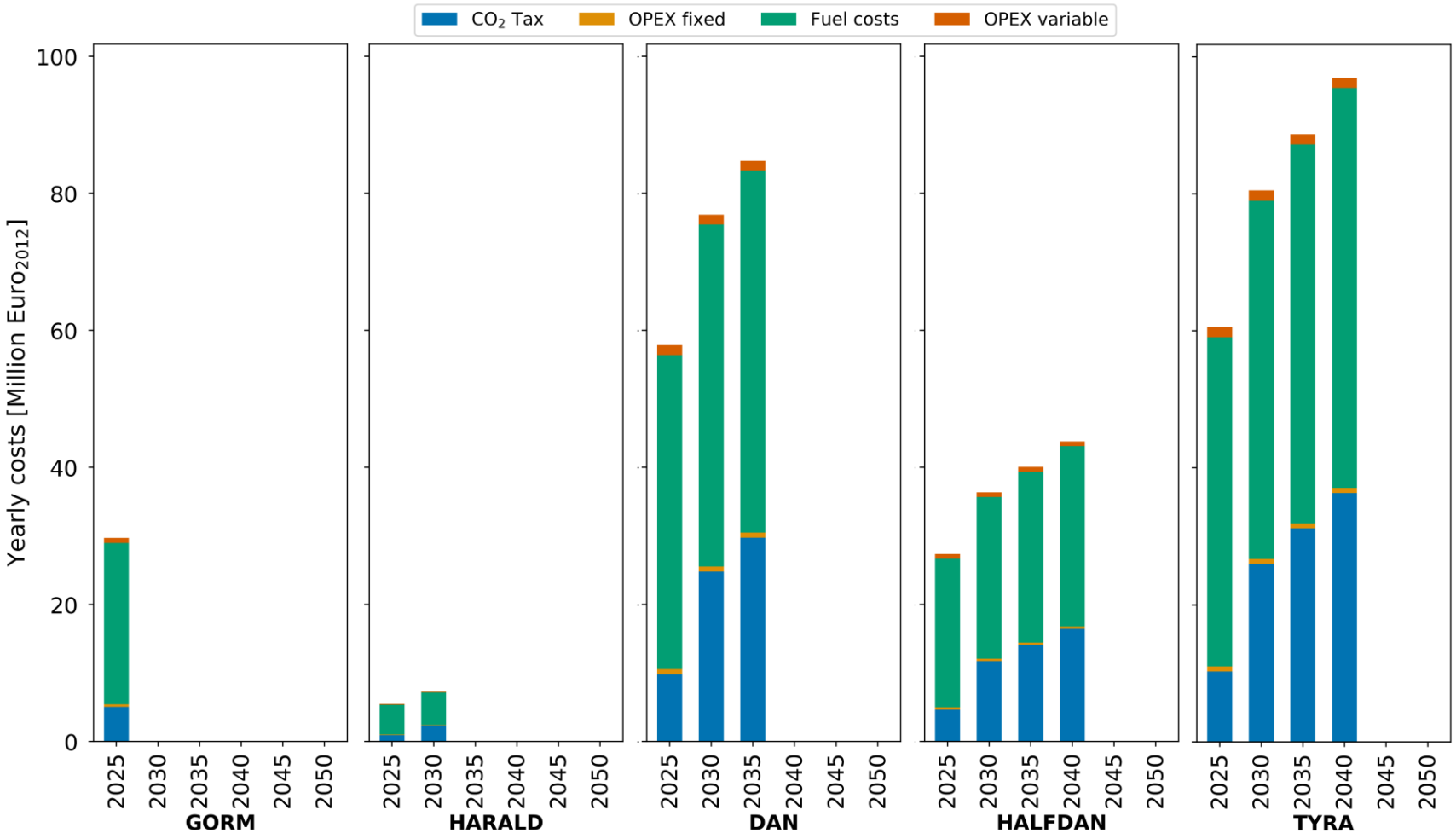
Sensitivity analysis scenarios

The sensitivity analysis scenarios are based on the E&R scenario.

Scenario's name	Variable	Unit	Variation
FW-high	Floating Wind turbines LCOE	€/MWh	+25%
FW-low	Floating Wind turbines LCOE	€/MWh	-25%
TL-25, TL-50	Electricity transmission line	€/MWh	+25%, +50%
CO_2-low	CO_2 Tax	€/tCO	Linear increase from 8 to 60 €/tCO in 2050.
CO_2-mod	CO_2 Tax	€/tCO	Linear increase from 8 to 90 €/tCO in 2050.
H_2-low	Reuse of existing gas pipeline to transport hydrogen	€/MW/Km	Existing gas pipelines can be used for hydrogen at 10% of the costs of a new Hydrogen pipeline.

Decommissioning (BAU) scenario

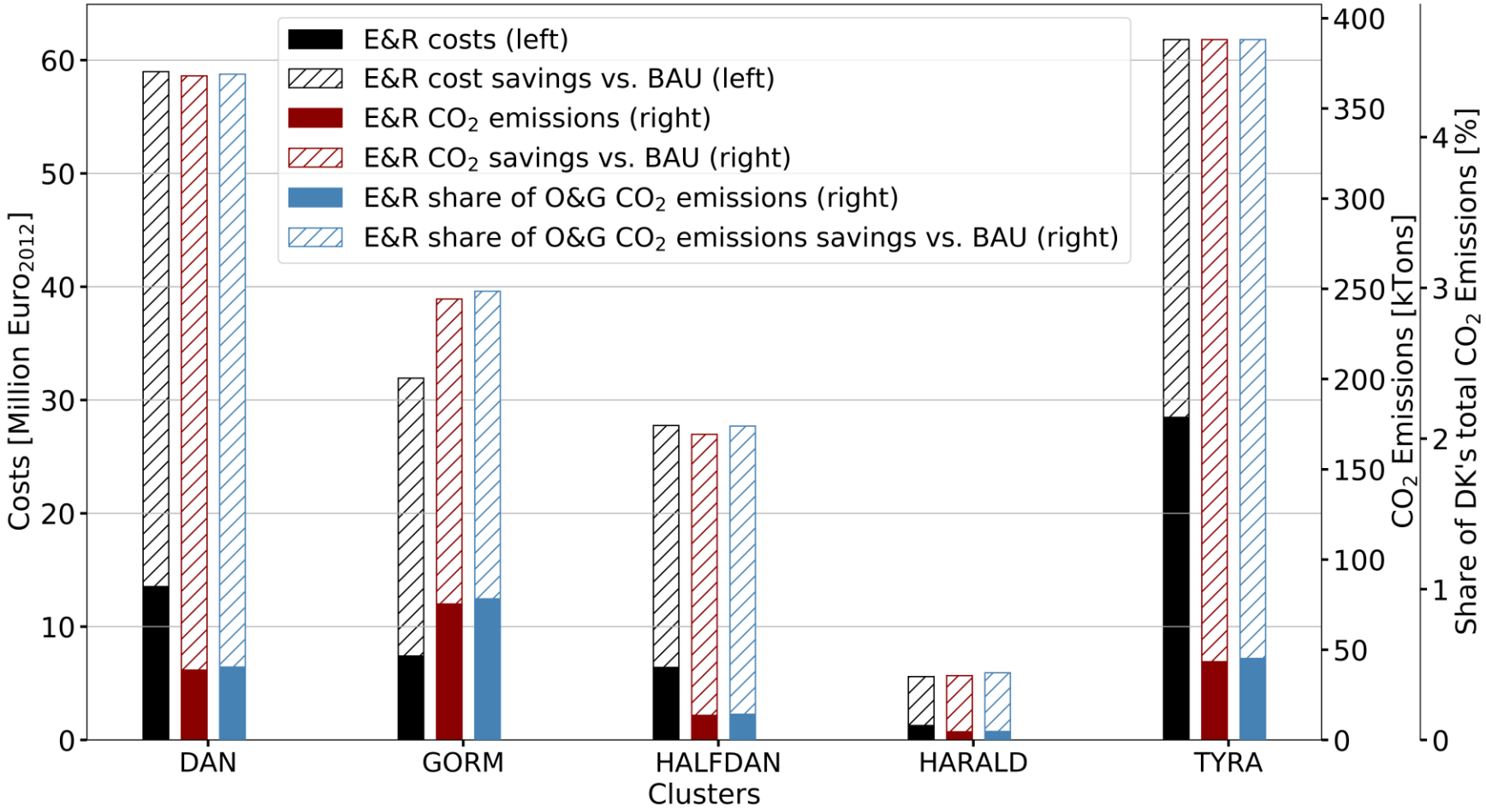
- All platforms increase in costs towards 2050 until decommissioning.
- CO_2 and Fuel related expenses represent the highest share of costs among all clusters.
- CO_2 has the highest impact on the costs.
- The clusters' OPEX ranges from 0.74% to 1.44% of the cumulative energy related yearly costs.



The costs shown are energy related. Decommissioning costs and the platform OPEX are not considered.

Electrification

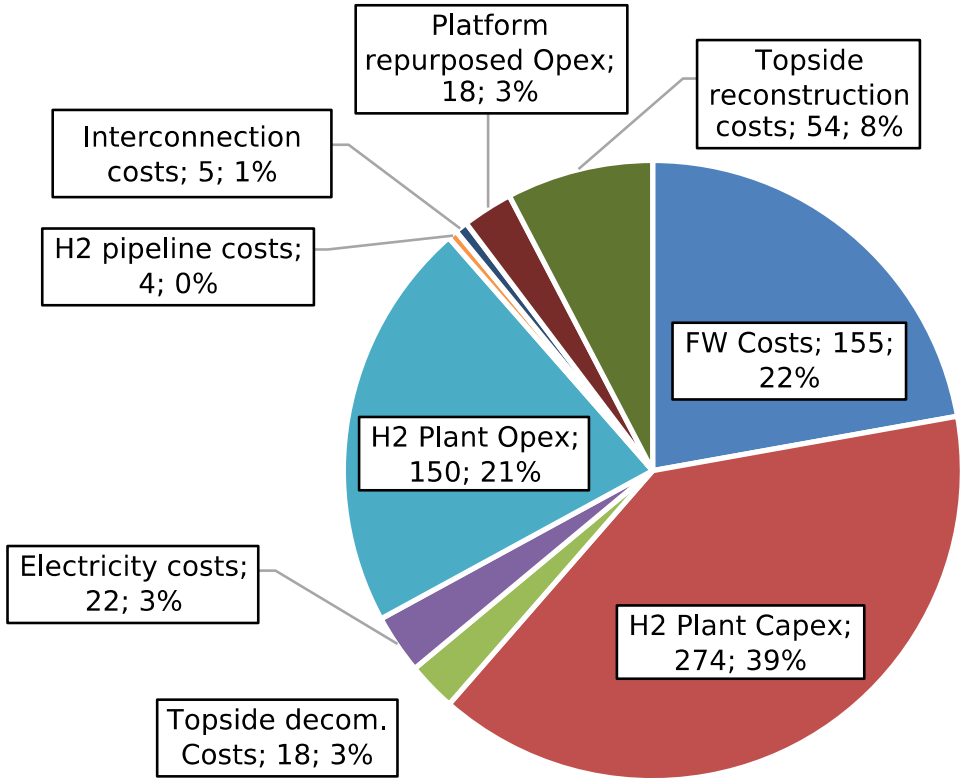
- The platform Electrification results in large savings in Costs (129 M€$_{2012}$) and CO_2 emissions (1 MtCO2) in 2025



Repurposing

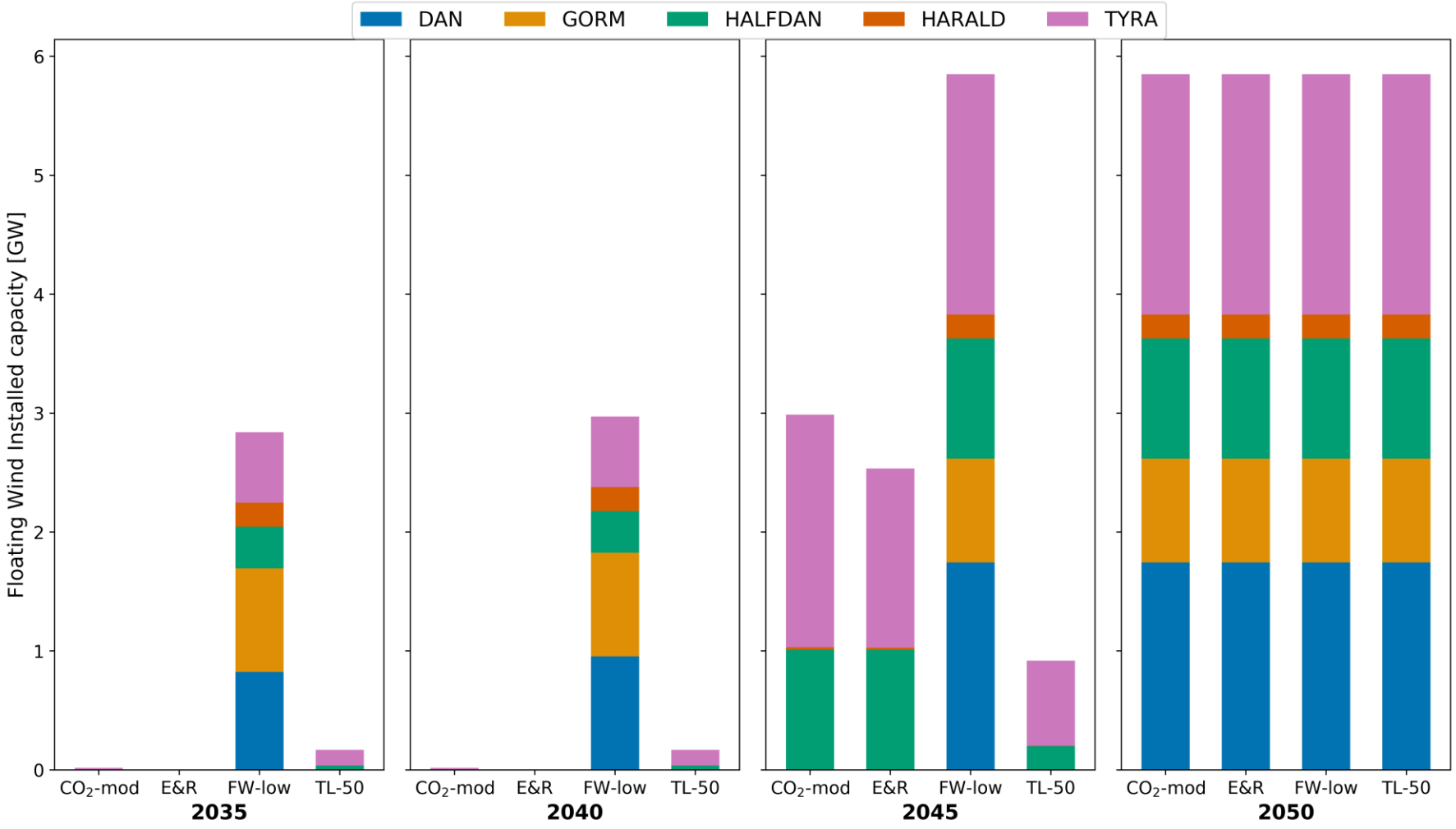
- All platforms are repurposed in alternative to a Full Decommissioning.
- The hydrogen plant accounts for 60% of the costs, on average 428 [M€$_{2012}$/year].
- The costs related to repurposing and operate the platforms account for 14%, in average 90 [M€$_{2012}$/year]

Clusters Average Yearly Costs [M€$_{2012}$/year]



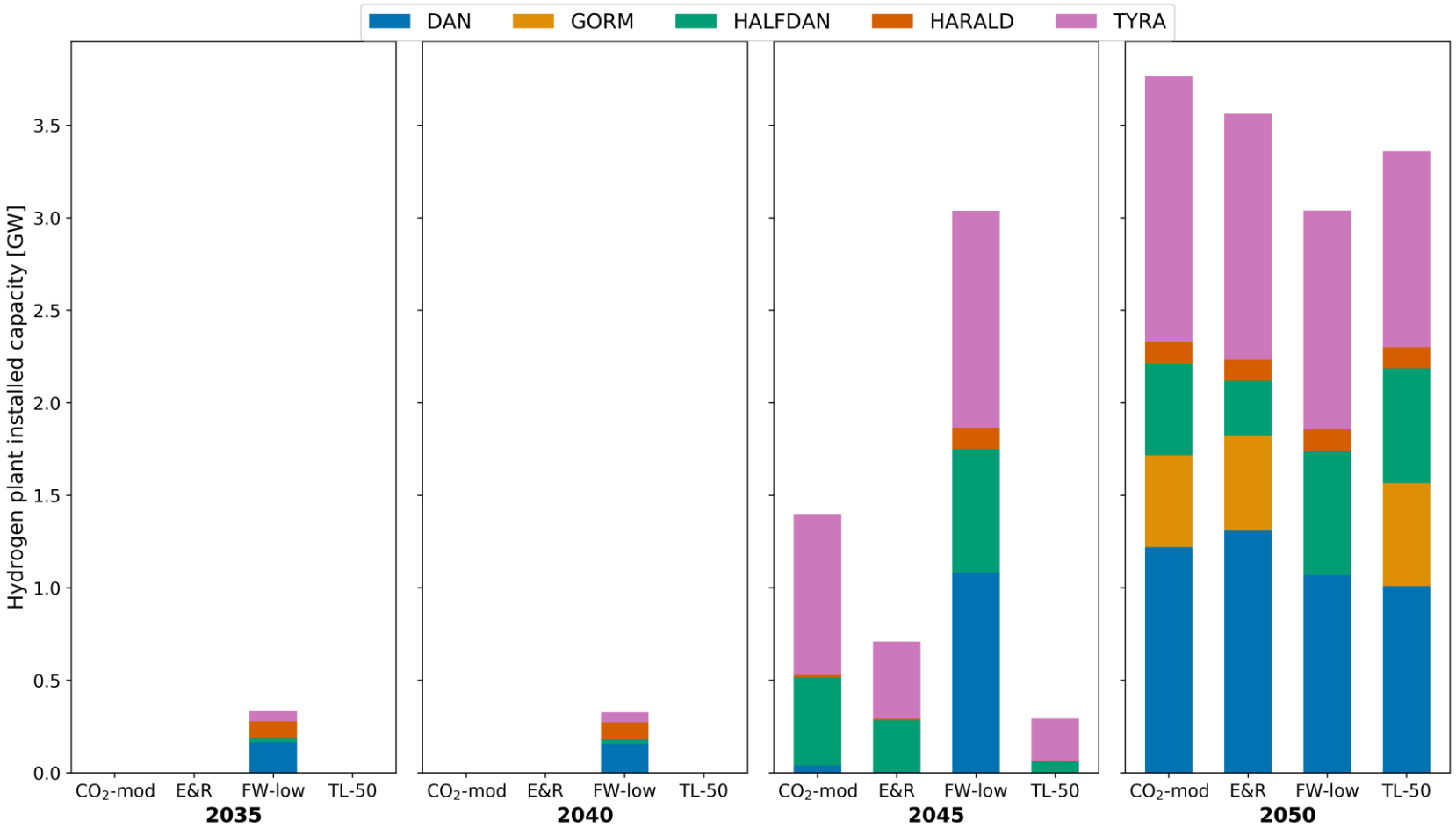
Floating wind installed capacity

- In E&R (reference) scenario FW is installed from 2045.
- Halfdan and Tyra have the largest share of FW capacity in 2045.
- FW reaches the aggregated capacity limit in 2050 (5.8 GW).
- FW is installed at the earliest in 2035.



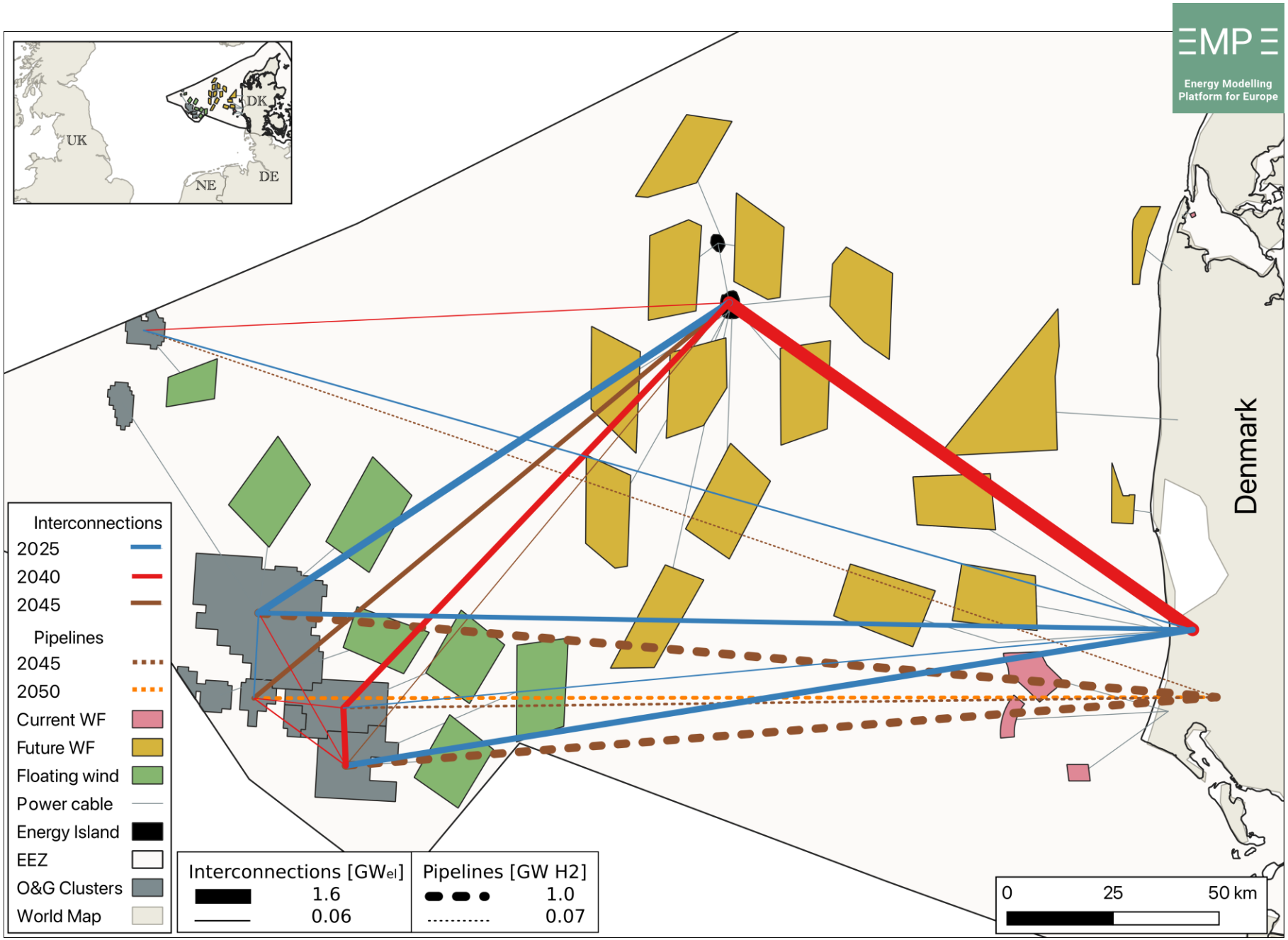
Hydrogen production capacity

- In E&R (reference) scenario, Hydrogen is produced from 2045.
- Halfdan, Tyra and Harald are the first platform to produce hydrogen.
- On average about 3 GW of electrolyser capacity is installed across all fields.
- In a low FW scenario, production starts in 2035 with 0.4 GW plus.



Layout in 2050

- Pipelines are used only from 2045
- All platforms are interconnected to mainland in 2025
- Each cluster has invested in Floating Wind
- The Energy Island works as a bridge between the shore and the platforms



Discussion

- Hydrogen modelling
- Spatial resolution
- Technical feasibility: heat demand, infrastructure constraints for repurposing and electrifying
- Platform operational costs (e.g. fuel consumption, CO_2 taxes)
- Timeline and temporal resolution
- Perspective and costs allocation of investments (e.g. subsidies, …)

Summary and conclusions

- Energy system analysis of synergies between O&G and renewables in the Danish North Sea with Balmorel to 2050
- Cost and CO_2 savings through electrification of 72% and 85% respectively
- Energy system integration involves connecting platforms to offshore island and shore
- Platform repurposing to 3.6 GW hydrogen producers with 5.8 GW floating wind, transport in new/existing pipelines, avoids decommissioning costs
- LCOE of hydrogen is about 4$€_{2012}$/kg in 2050, high but not considering policies
- Several limitations: technical feasibility, perspective/business model, spatial and temporal resolution