Synergies in offshore energy: a roadmap for the Danish sector

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Agenda

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Introduction
Project aim

- Exploit synergies between the oil & gas sector and the offshore renewable energy to reduce:
  - CO2 emissions during the oil & gas platforms’ lifetime.
  - the economic and environmental impact of decommissioning oil & gas platforms by providing new uses for the infrastructures.

- Develop a roadmap for the Danish offshore O&G sector, which highlights the locations and timing of the strongest synergies and provides concrete recommendations in terms of how to exploit these.
Scenarios

- **Electrification and Repurposing**: The model can electrify the platforms and further repurpose the existing decommissioned infrastructure.
Area of interest
Methodology
Modelling Assumptions

- 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

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%                                     |
| CO₂-low         | CO₂ Tax  | €/tCO      | Linear increase from 8 to 60 €/tCO in 2050.    |
| CO₂-mod         | CO₂ Tax  | €/tCO      | Linear increase from 8 to 90 €/tCO in 2050.    |
| H₂-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. |
Results & Discussion
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 ($129 \text{ M€}_{2012}$) and CO$_2$ emissions (1 MtCO$_2$) 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 \( [\text{M\euro}_{2012}]/\text{year} \).

- The costs related to repurposing and operate the platforms account for 14%, in average 90 \( [\text{M\euro}_{2012}]/\text{year} \).
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 plant per scenario

• 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

• Platform operational costs (e.g. fuel consumption, CO2 taxes)
• Platform electrification (e.g. requirements, limitations)
• Platform repurposing (e.g. costs, technical issues)
• Costs allocation of investments (e.g. subsidies, ...)

References

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