Offshore Wind Power for supplying Local Off-Grid Electricity Demand

Til Kristian Vrana, Luca Riboldi, Mari Voldsund, Harald Svendsen, Olve Mo
SINTEF Energi, Trondheim, Norway, vrana@sintef.no

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Abstract:

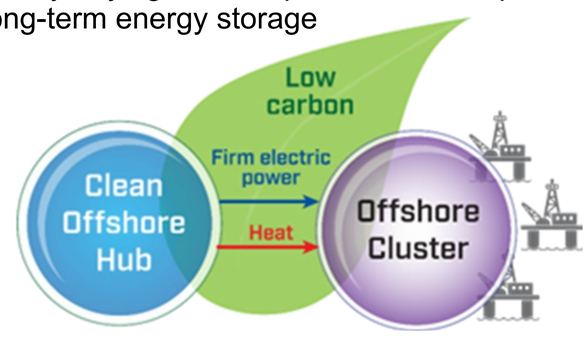
This article introduces to the idea to deploy offshore power hub platforms with connected floating wind turbines, including short-term (battery) energy storage on the platform and long-term (hydrogen) energy storage located subsea. These energy hubs can provide low-carbon heat and electric power to offshore off-grid customers, which as of today are clusters of offshore oil&gas production facilities, but they might in the future as well serve other offshore customers like deep sea mining facilities and offshore charging and/or hydrogen supply stations for electric vessels. Such a hub approach can significantly reduce the emissions offshore, as it can replace today's fossil-fuel-based gas turbines. In the light of the tremendous plans for offshore wind power in Europe, it can also help to avoid electric transmission system investments and transmission losses if a part of the offshore wind power is used locally. In addition, it can provide a great arena for the floating wind power industry to mature, where it does not need to compete with bottom-fixed wind turbines (due to deep waters) and where a local market with higher electricity prices can be accessed.

Clean offshore hub concept

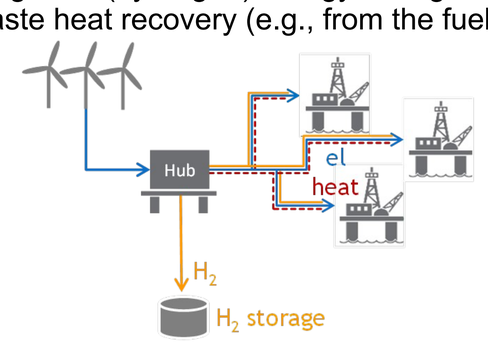
Energy and emissions - Norway
- Electricity is provided by renewable energy
- Heating is provided by electricity and firewood
- Similar emissions as other European countries

Energy and emissions - offshore oil&gas platforms
- 15 TWh/a electrical energy
- 7 TWh/a mechanical energy
- 12 TWh/a covered by gas turbines (2023)
- 28 % of the Norwegian GHG emissions
- 10 TWh/a electric power from shore (2023)
- Shifting emissions to onshore power stations (often continental European coal and gas)

Connecting wind turbines to oil&gas platforms
- Unusual concept compared to the main trends
- Hywind Tampen
- Stochastic power production is challenging
- Emission reduction potential is limited
- Purely relying on wind power would require long-term energy storage



Clean offshore hub concept
- Floating wind turbines
- Short-term (battery) energy storage
- Electrolysers and fuel cells on the platform
- Long-term (hydrogen) energy storage subsea
- Waste heat recovery (e.g., from the fuel cells)

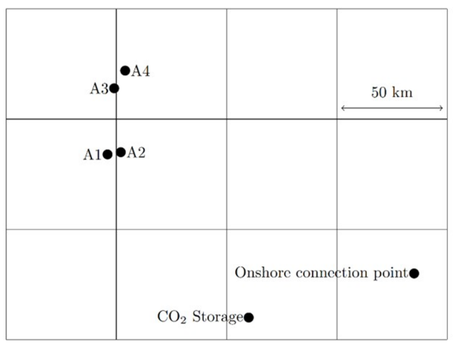


Provide clean heat and electric power to clusters of offshore oil&gas production facilities and other potential future customers

Case studies

The clean offshore hub concept is investigated by studying hypothetical but realistic offshore clusters.

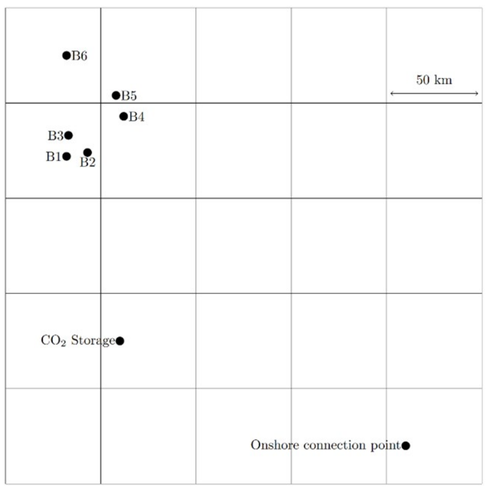
Cluster A: Existing field



Plat form	Power [MW]	Heat [MW]	Depth [m]
A1	110	12	135
A2	80	6	215
A3	50	12	335
A4	30	10	350
Total	270	40	---

Expected lifetime	20	a
Distance from shore	144-160	km
Distance between platforms	6-39	km
Distance to CO_2 storage site	95-125	km
Air temperature	8	°C
Seawater temperature	8	°C

Cluster B: New field development



Plat form	Power [MW]	Heat [MW]	Depth [m]
B1	65	55	360
B2	75	35	360
B3	50	30	360
B4	45	25	360
B5	35	30	360
B6	55	20	360
Total	325	195	---

Expected lifetime	30	a
Distance from shore	227-271	km
Distance between platforms	11-53	km
Distance to CO_2 storage site	100-153	km
Air temperature	8	°C
Seawater temperature	8	°C

Discussion

Clean offshore power hubs have a large potential for the energy transition.

Differences in fossil gas use efficiency
- When wind replaces gas, it gives a **higher emission reduction** when happening offshore
- Gas used at efficient onshore power stations

European energy security and independence
- The oil&gas industry in the North Sea will be crucial for Europe in **many years** to come
- Emission reductions are important also offshore

Avoiding unnecessary transmission
- Both power from shore links to oil&gas platforms and offshore wind parks are in the North Sea
- Offshore electricity sent to shore through one cable, and back offshore through another
- Significant **cost and loss reductions** by offshore system integration

Kick-starting floating wind power
- Most of the **global wind power potential** (and a lot of the European) is in deep waters (the shallow North Sea is a fortunate exemption)
- Development and maturing needs a **learning curve** and economically feasible business cases
- Offshore oil&gas platforms have **high electricity cost** and (often) deep water
- Opportunity to deploy (still) more expensive technology that is outcompeted elsewhere
- Can also benefit wave power or other pre-commercial technologies

Underpinning the hydrogen economy
- Advancement of **compact electrolyser** and fuel cell technology
- Similar development and maturing effects as on floating wind power

Future offshore electric power & hydrogen demand
- **Offshore charging station** for electric ships
- Hydrogen fuel supply for ships
- Deep sea mining
- Other future energy customers?

Conclusion:

The clean offshore hub concept provides a solution for clean and reliable off-grid electric power and heat supply for remote locations at sea. While today's focus is on greenhouse gas emission reductions of the offshore oil&gas industry, several other offshore energy customers are envisaged that could also benefit from such power hubs. In addition, the development of such energy hubs at sea can become the driver for much needed technology development, such as that of floating wind power and hydrogen storage technologies. As the potential deployment of such hubs highly depends on several uncertain future developments (e.g. future improvements of hydrogen storage technology, political offshore greenhouse gas emission regulations, etc.), it remains difficult to sketch a clear roadmap. The concept remains still important to focus on, especially due to the lack of good alternatives for the long-term perspective of a sustainable future.

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