



Electrification of the Norwegian shelf with local wind energy

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Why should we care?

- 28% of Norway's Co₂ emissions come from the Norwegian shelf.
- 80% from inefficient gas turbines providing electricity for the platforms ($\eta = \sim 30\%$).
 - Reduce Norway's carbon footprint!
- Export of the gas → no global reduction of Co₂?
- More efficient gas turbines at the continent: make use of the waste heat (CCGT: $\eta = \sim 60\%$).
 - same kWh but release less Co₂

Source: <http://www.miljostatus.no/tema/klima/norske-klimagassutslipp/klimagassutslipp-olje/>





Can we use local wind power?

Hopefully!

But...





Wind is a highly variable resource!

- Production = demand to prevent black-out!

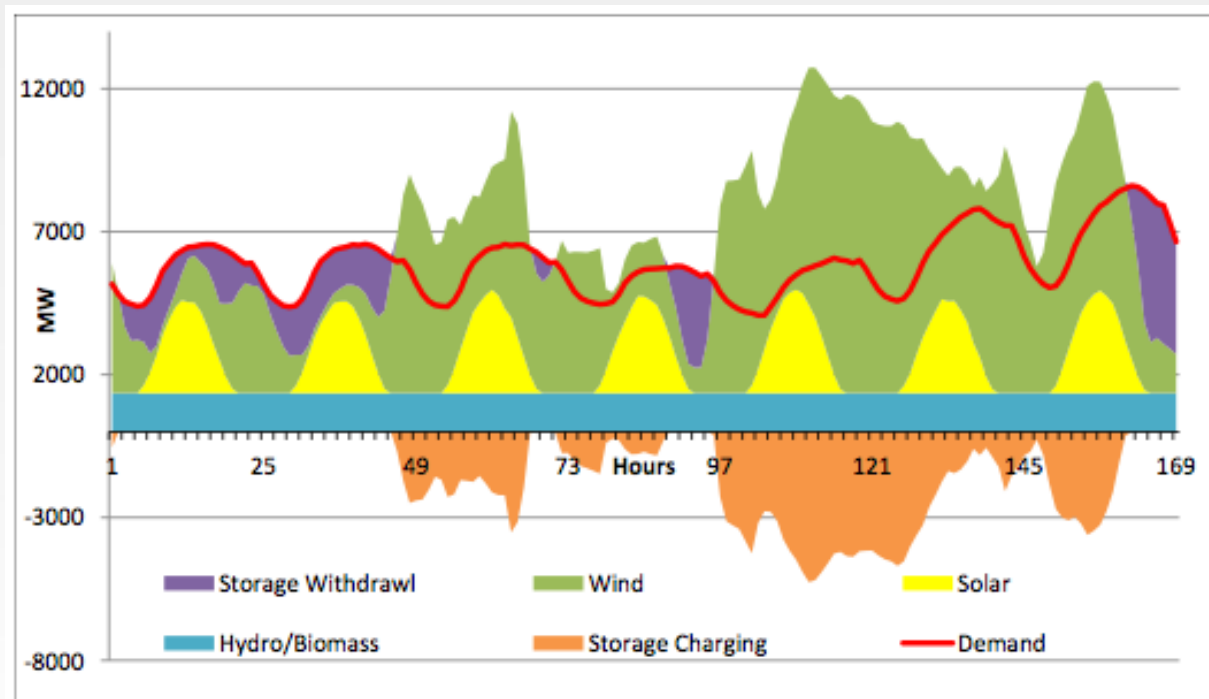


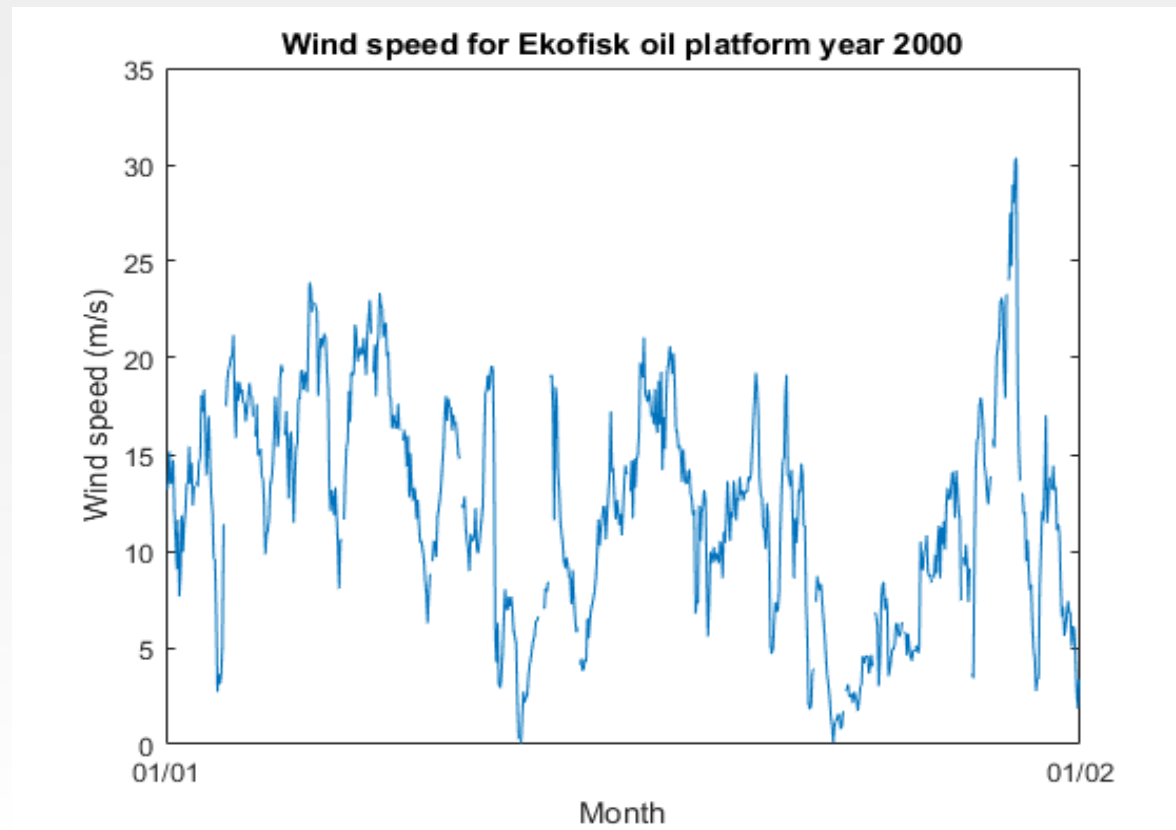
Figure III-7: Hourly supply and demand, with storage. July 11-17, 2007. Source: IEEER.





Wind is a highly variable resource!

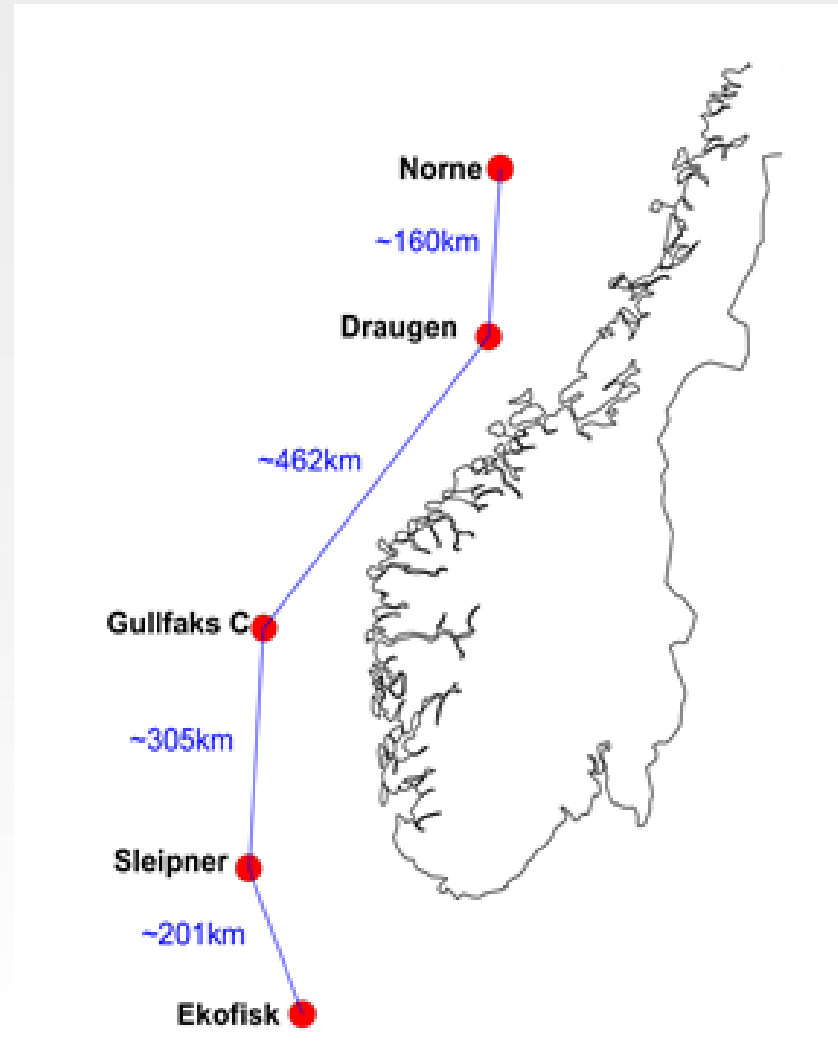
- Production = demand to prevent black-out!





How to deal with this variability?

- Connect geographically dispersed sites
- Theoretically: Install turbines nearby the platforms, link them → reduce variability?
- Five platforms on the Norwegian shelf
- Hourly wind speed
- 01.01.2000-31.09.2016?
- Data from Met Norway
- Wind speed is up/down scaled to 100 m



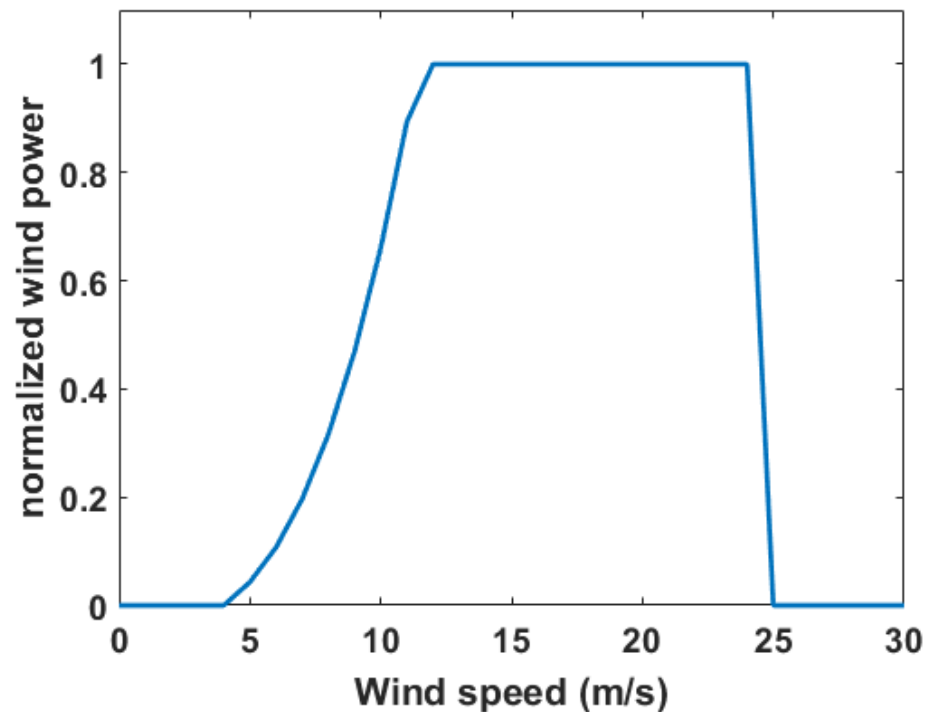


What is the best way to connect platforms on the Norwegian shelf to maximize the mean wind power production, and at the same time minimize the risk for having power production below a critical threshold?





From wind speed to wind power



$$P = \begin{cases} P = 0, & U < 4, U \geq 25 \\ \frac{U^3 - 4^3}{11.4^3 - 4^3}, & 4 \leq U < 11.4 \\ P = 1, & 11.4 \leq U < 25 \end{cases}$$

DTU reference wind turbine

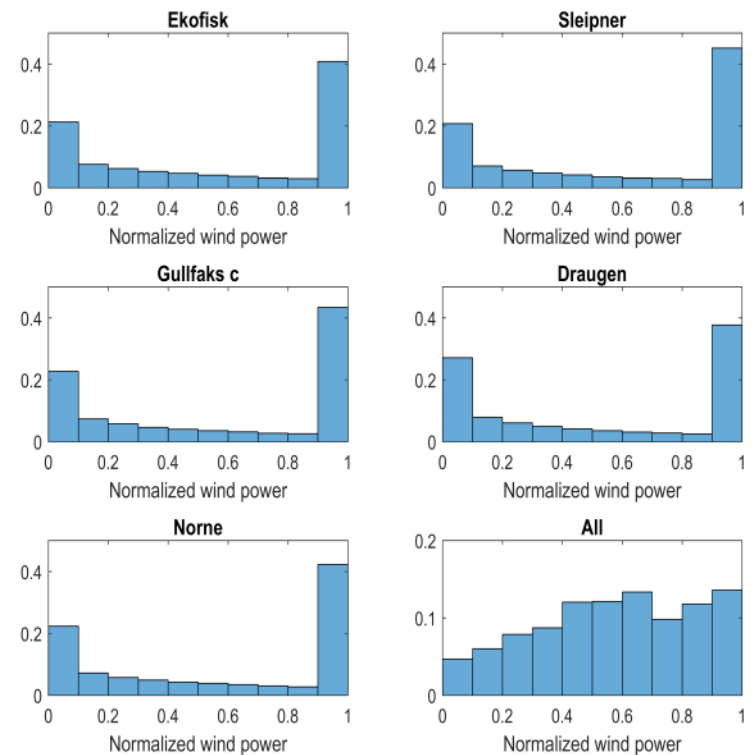
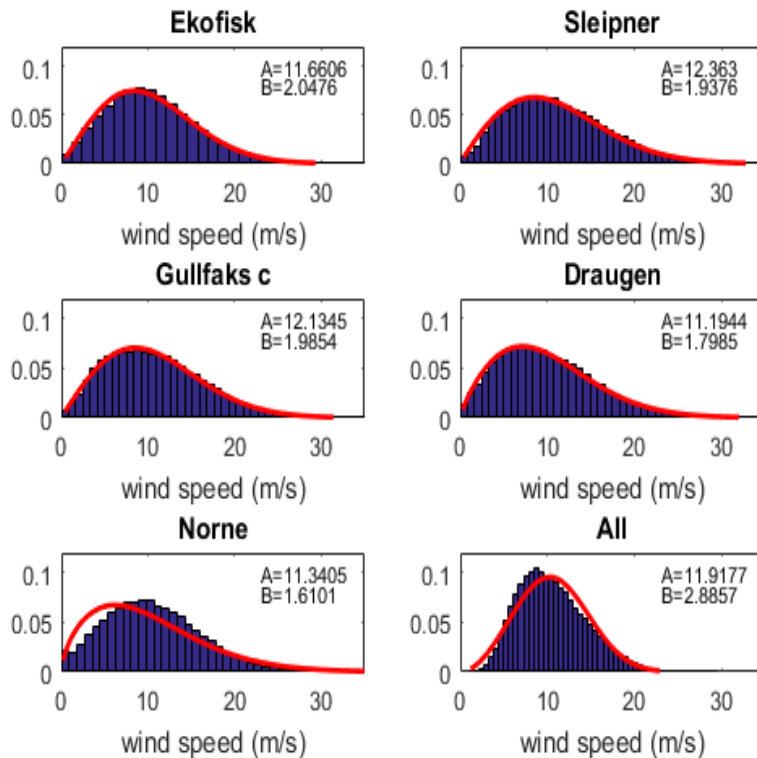




Distributions of WS and WP

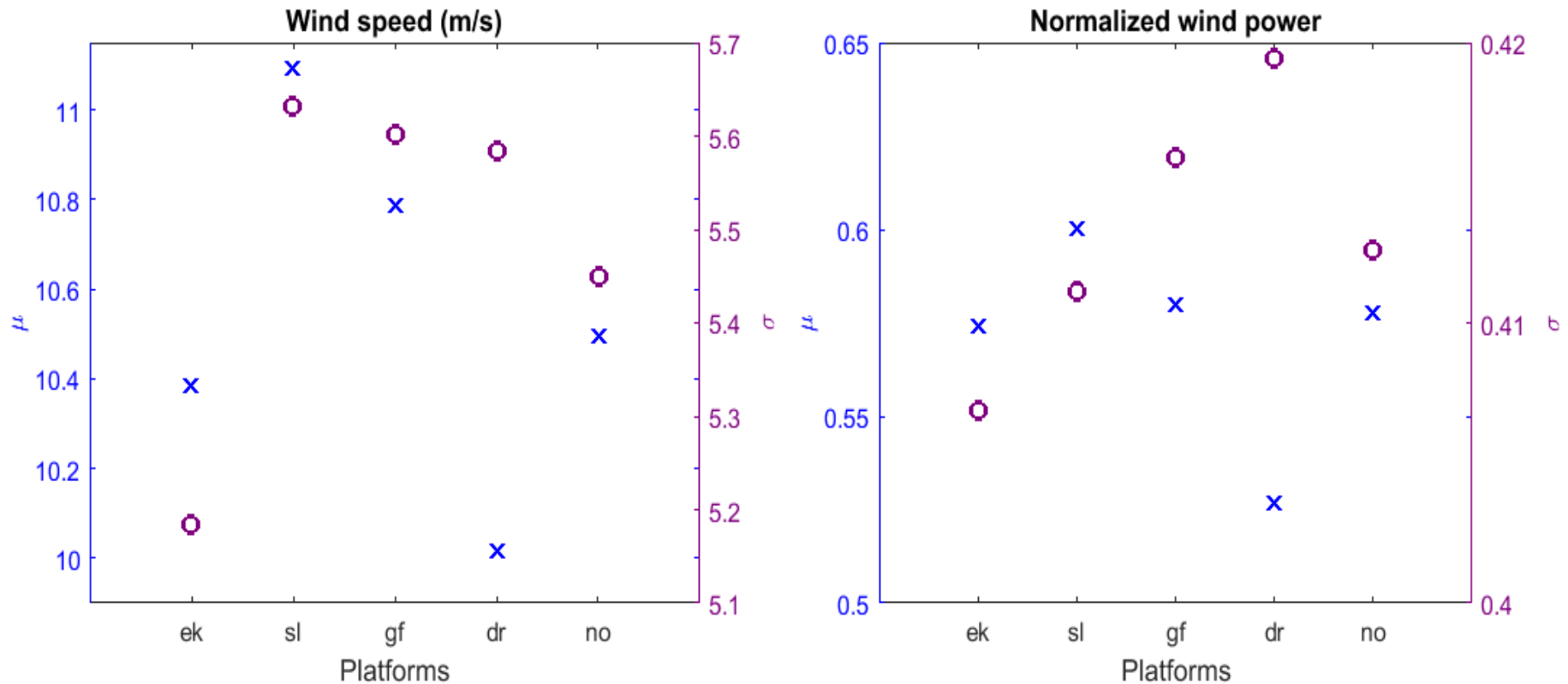
Wind speed

Wind power





Mean and standard deviation

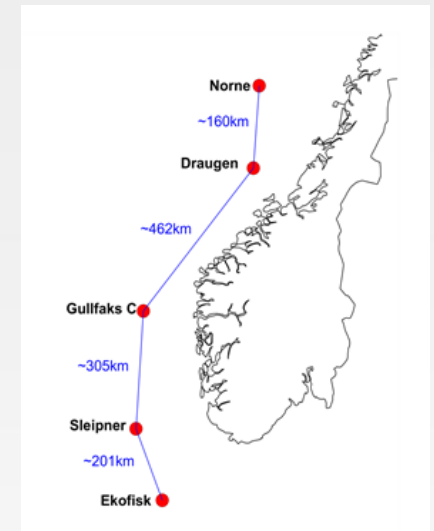
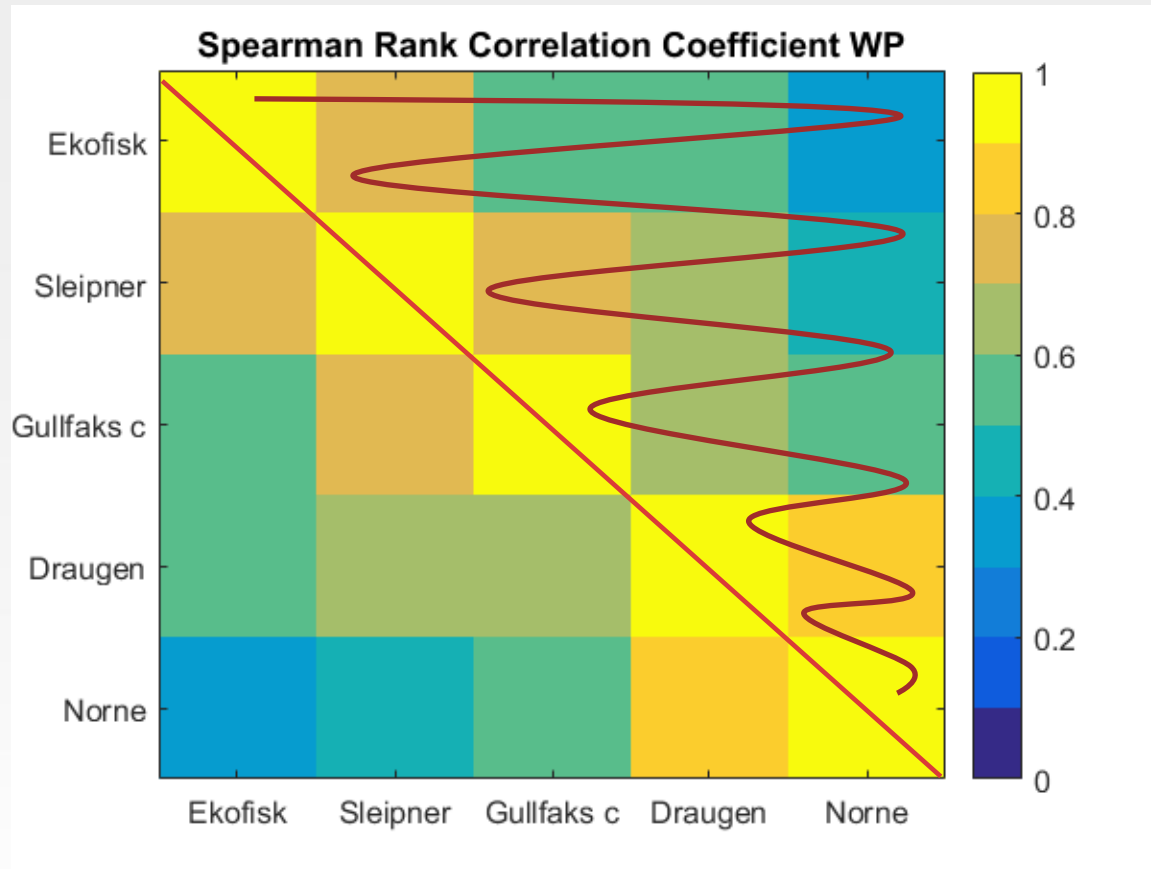


ek = Ekofisk, sl = Sleipner, gf = Gullfaks c, dr = Draugen, no = Norne



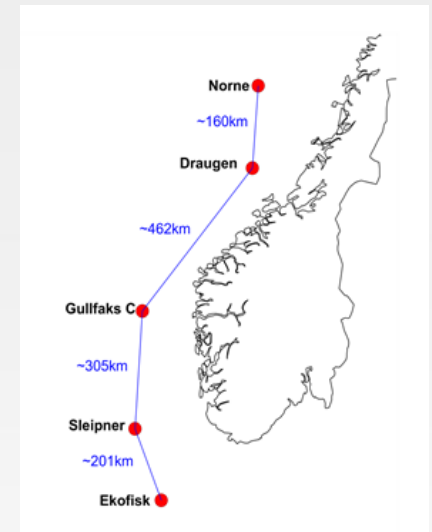
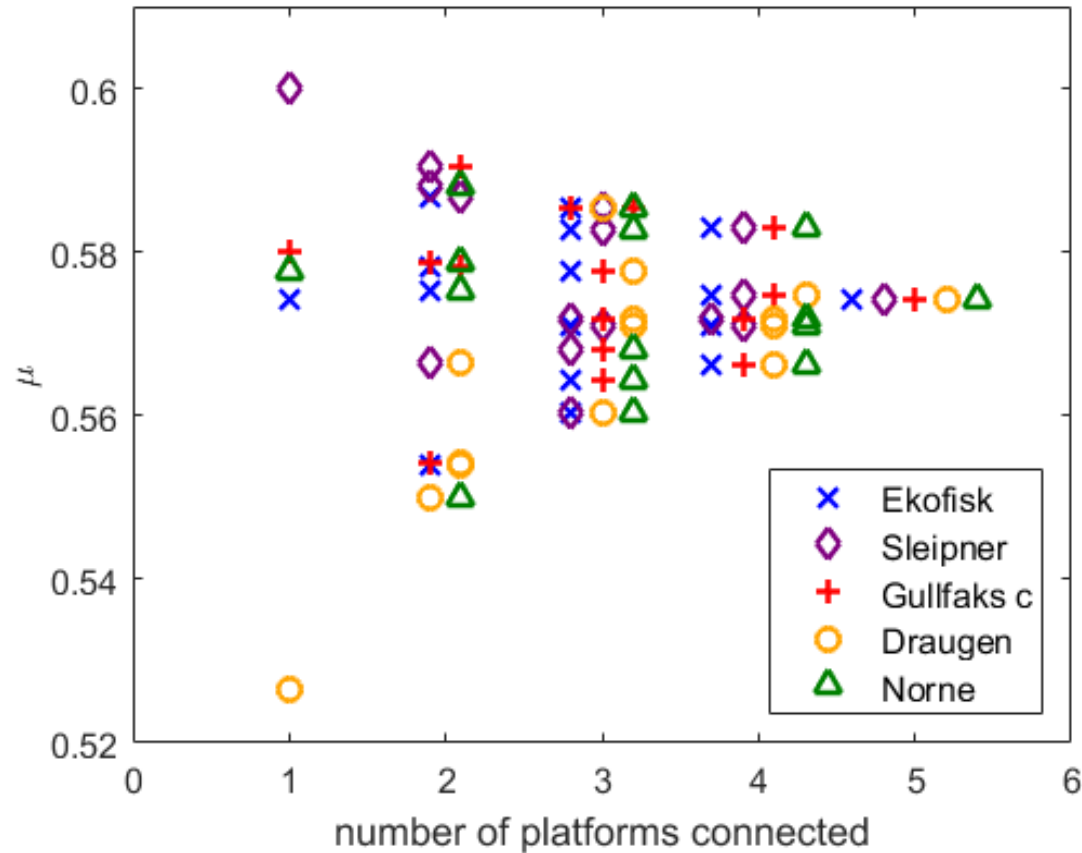


Wind power correlation





Combining platforms?

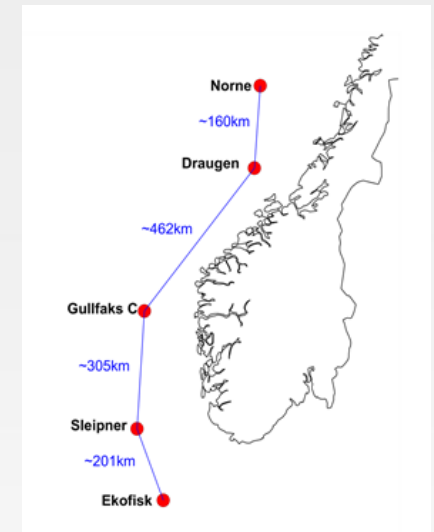
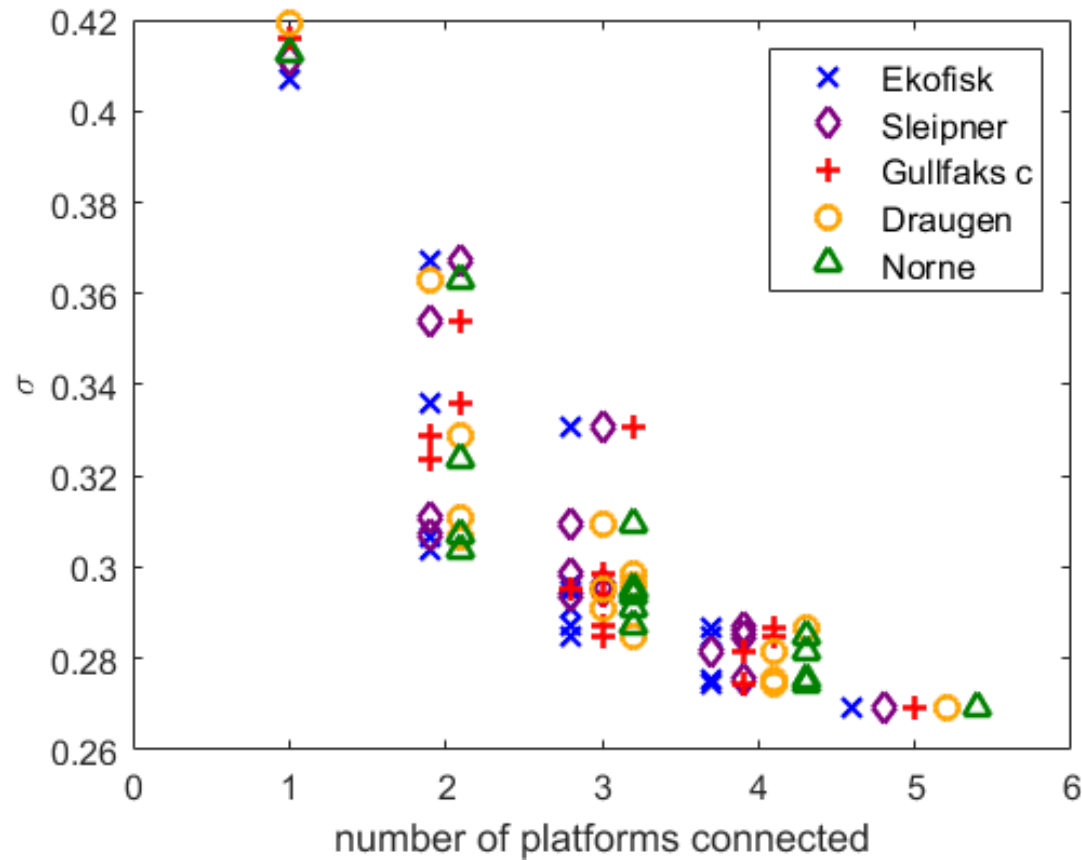


Linking platforms together with electricity transferring cables!





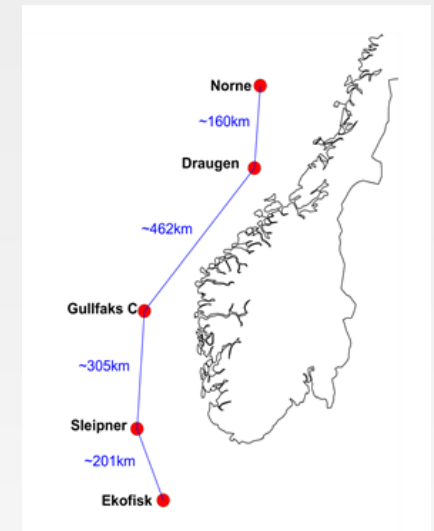
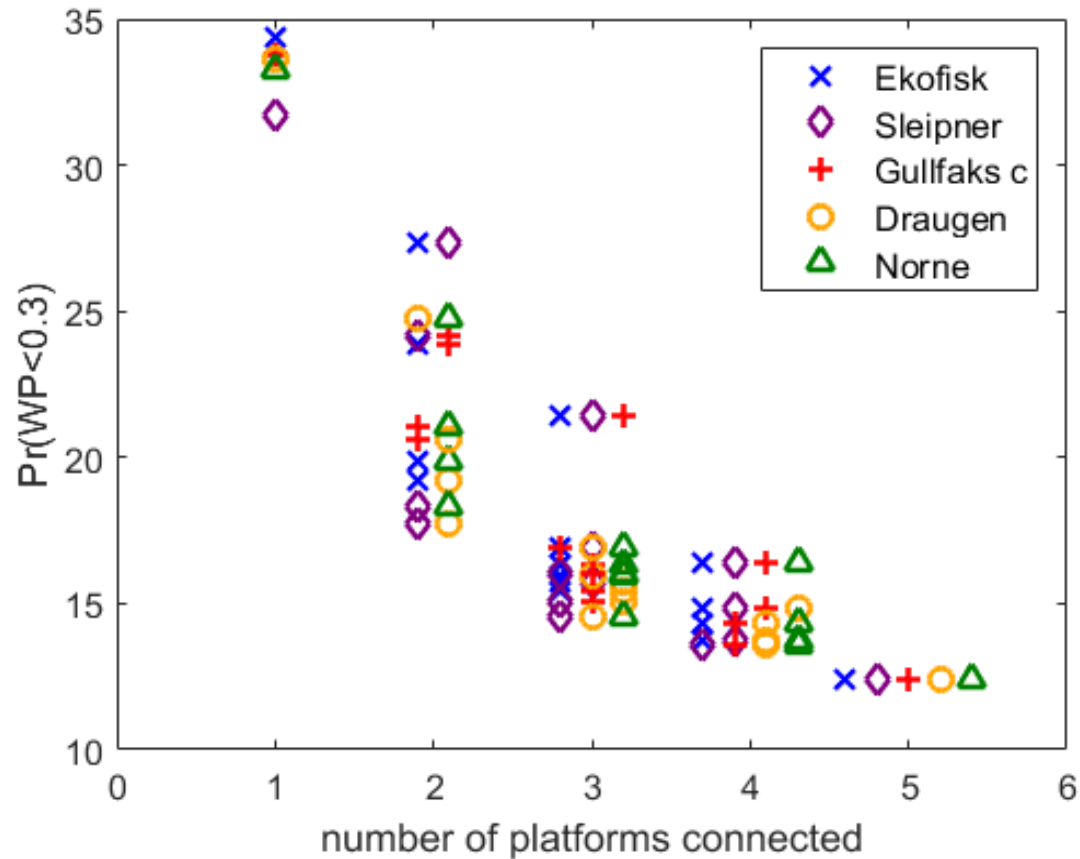
Combining platforms?



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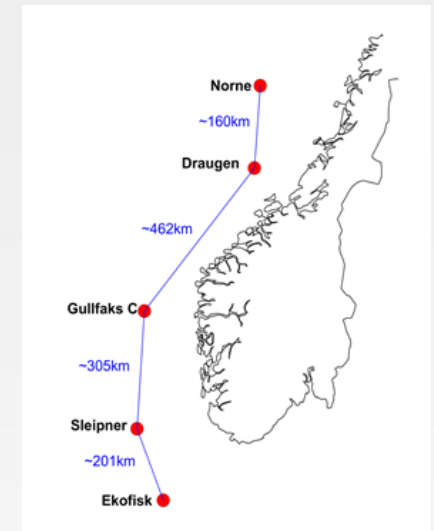
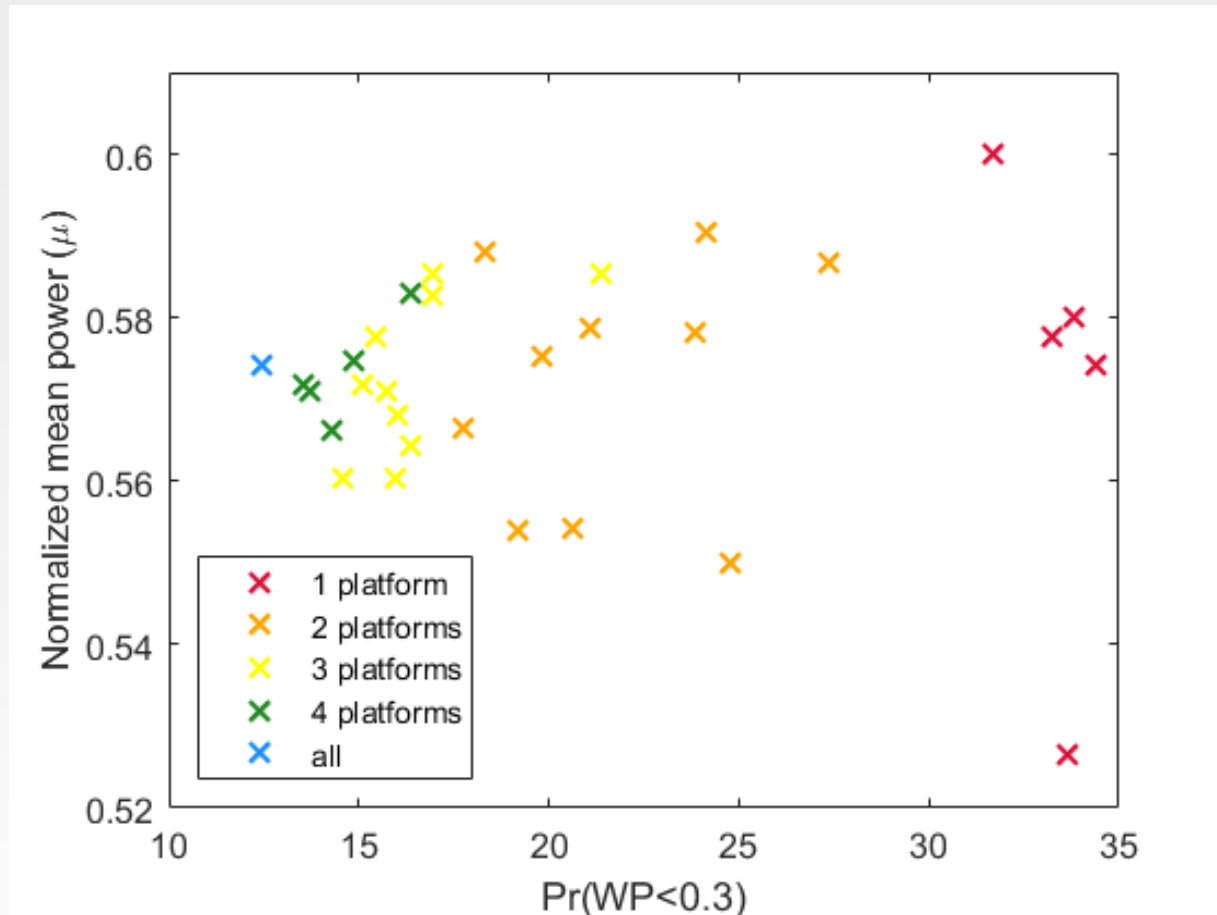
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Combining platforms?

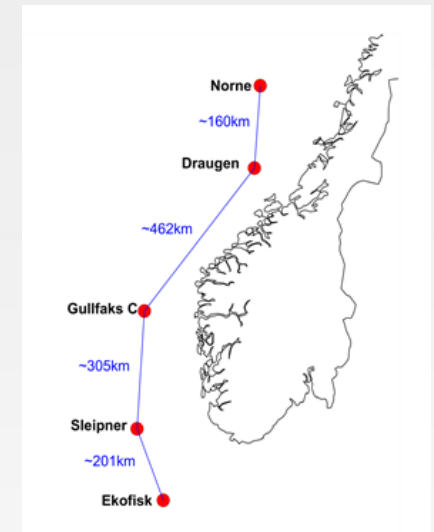
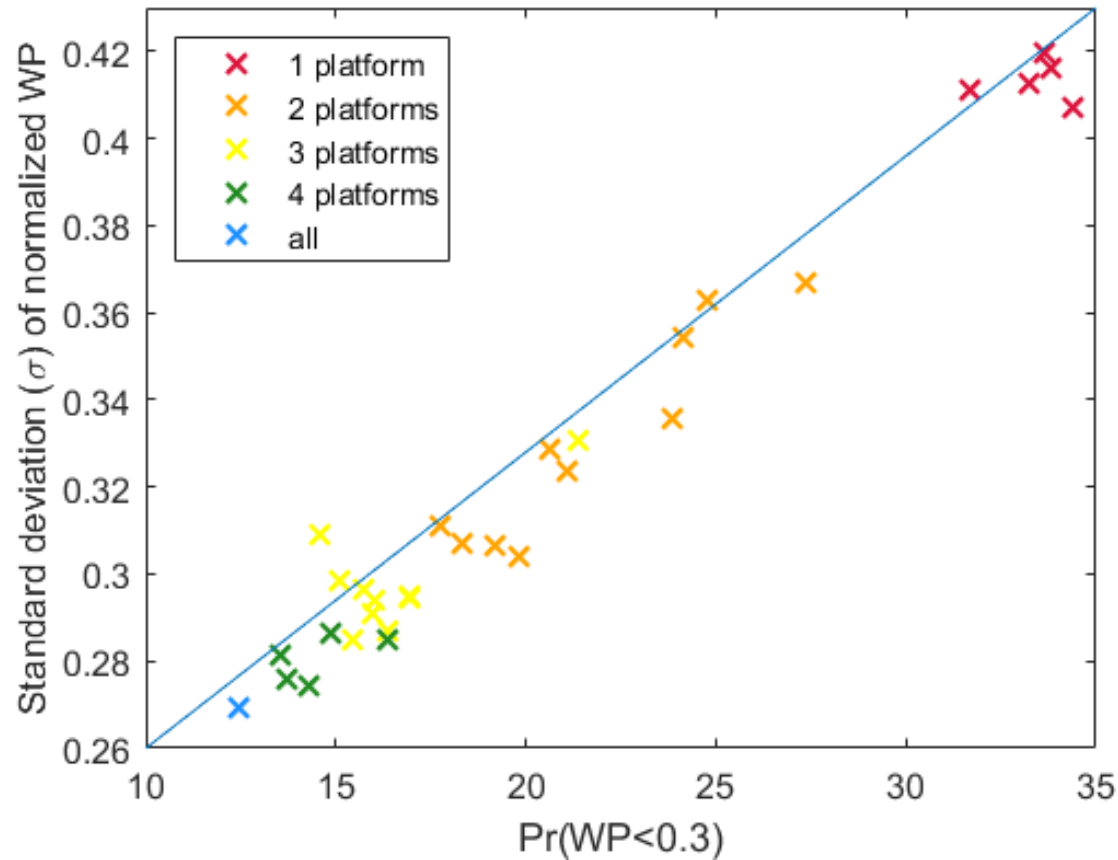


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Combining platforms?



Linking platforms together with electricity transferring cables!





Summary and conclusions

- By connecting platforms:
 - Reduce the variations in the mean power
 - Reduce the standard deviation
 - Reduce the chance of power production below a certain threshold (0.3)
 - But, by adding another platform you will not necessarily produce more or reduce the variability → find the right combinations!





What's next?

- Create a statistical model for the risk of critical low power production (what is critical low?)
- What kind of meteorological features are associated with persistent wind power production below a certain threshold?
- Assess the economics related to the actual transmission lines between sites; is the preferred combination of platforms a realistic combination?





Questions?



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