

30 GW Norwegian wind power in the North Sea

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SINTEF Energi

Teknologi for et bedre samfunn

Topics

- Introduction
- Offshore wind – time-series analysis of 30GW scenario for Norway
- Offshore grid

https://www.northwindresearch.no/

https://oceangridproject.no/

Vil bygge 1.500 havvindmøller

Regjeringen vil tildele områder for 30 GW havvind innen 2040, og åpner for hybridkabler. Rasmus Hansson i MDG etterlyser tydeligere mål et tiår tidligere.

Publisert 11. mai 2022 kl. 08.35 · Lesetid: 4 minutter



Statnett

Fagrapport om havvind i Sørlige Nordsjø II

Fakta og analyse av økonomiske og markedsmessige forhold

North Sea countries commit to 150GW offshore wind development plan

Pamela Largue - May 20, 2022

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Chancellor Olaf Scholz, Belgian Minister Mark Rutte. Image cre

Four European count of offshore wind in t



THE ESBJERG DECLARATION

on The North Sea as a Green Power Plant of Europe

Energy security and the fight against climate change are crucial to the future of the European Union. Recalling the Versailles conclusions on energy, the European Commission's communication on Joint

offshoreWIND.biz

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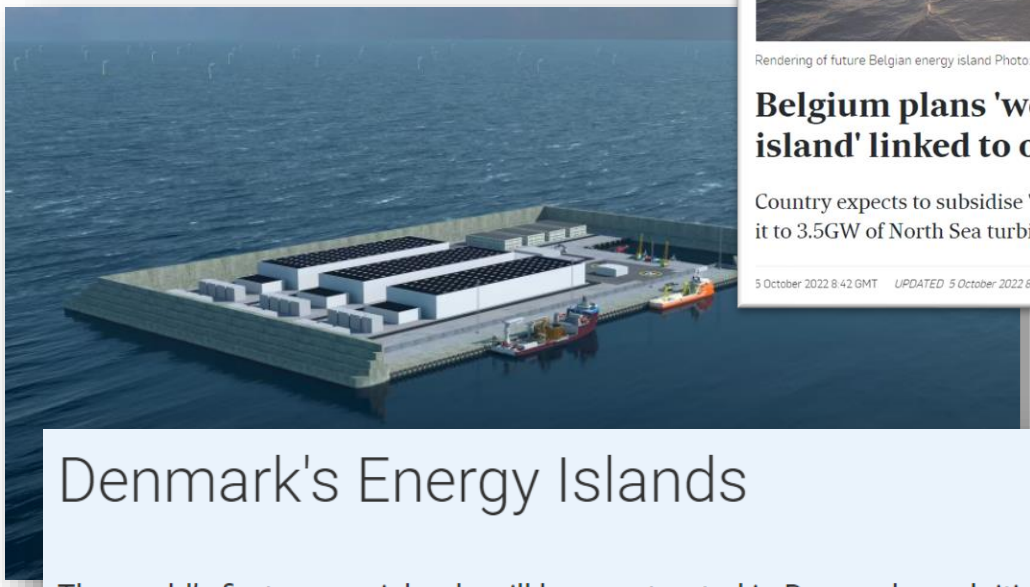
← Back to overview

UK to Raise 2030 Offshore Wind Target to 50 GW, Slash Project Approval Times

April 7, 2022, by Adnan Durakovic

UK Prime Minister Boris Johnson has presented a plan to boost Britain's energy security which includes an increased target of up to 50 GW of operating offshore wind capacity by 2030.

The up to 50 GW of offshore wind capacity, of which the government would like to see up to 5 GW come in form of floating wind, would be more than enough to power every home in the UK, the government said.



Denmark's Energy Islands

The world's first energy islands will be constructed in Denmark, exploiting our immense wind resources in the North and Baltic seas. The energy islands will serve as hubs that can create better connections between energy generated from offshore wind and the energy systems in the region around the two seas.

https://ens.dk/en/our-responsibilities/wind-power/energy-islands/denmarks-energy-islands



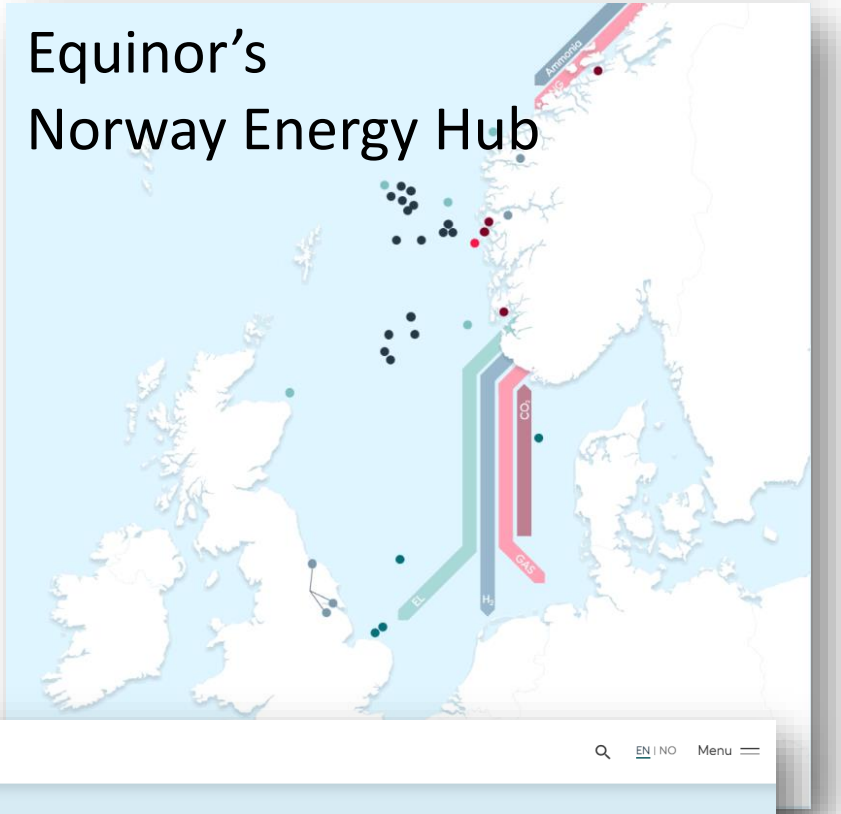
Rendering of future Belgian energy island Photo: Elia

Belgium plans 'world's first artificial energy island' linked to offshore wind by 2026

Country expects to subsidise 'Princess Elisabeth Island' with $100m and link it to 3.5GW of North Sea turbines and interconnectors with UK and Denmark

5 October 2022 8:42 GMT *UPDATED 5 October 2022 8:57 GMT*

Equinor's Norway Energy Hub



equinor EN | NO Menu

3.9 million
boe/d oil and gas production

50–100
kboe/d export of LNG

2 GW
hydrogen

6.5 GW
bottom-fixed offshore wind power

3.5 GW
floating wind

40 million
tonnes per year, CCS storage capacity

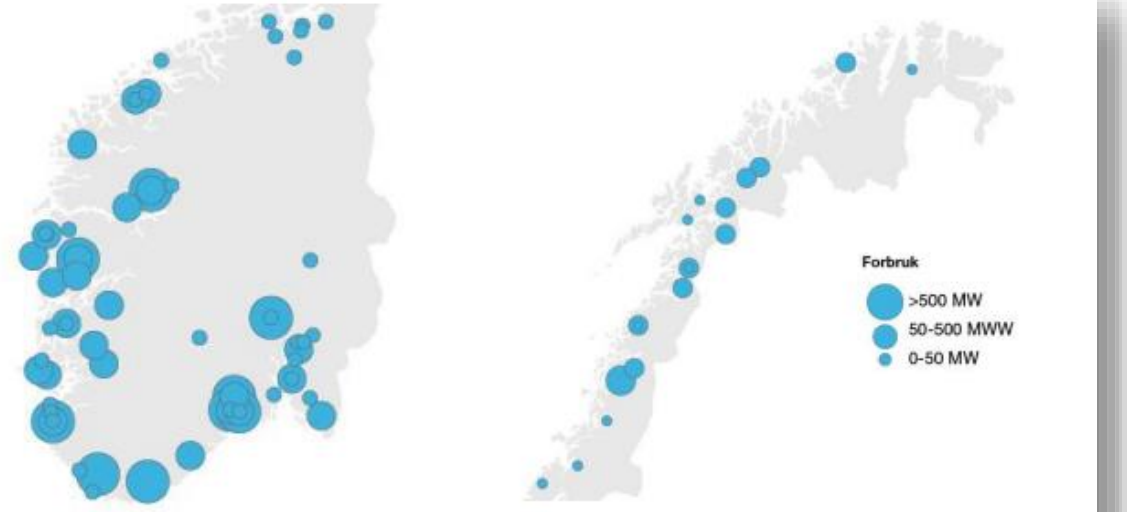
https://www.equinor.com/energy/norway-energy-hub?f1fe2323cba9=3

Increasing power demand

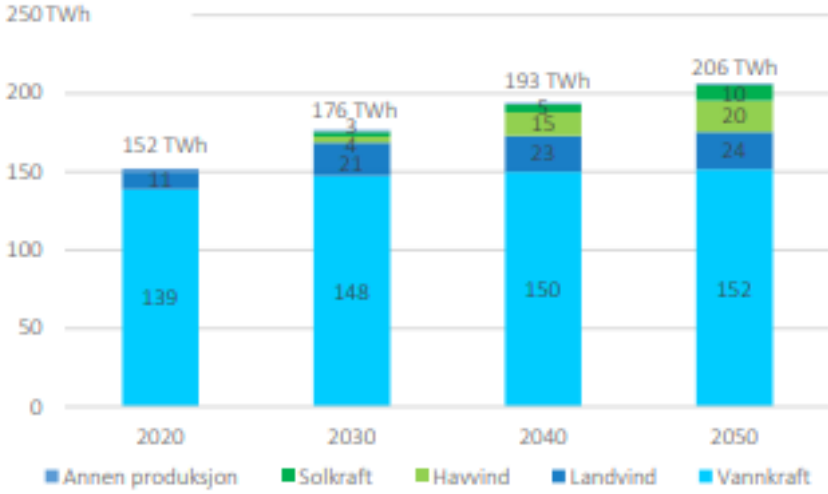
Statnett

Fagrapport om havvind i Sørlige Nordsjø II

Fakta og analyse av økonomiske og markedsmessige forhold



Figur 1-1: Kartet viser omsøkt forbruk inkludert fordeling i perioden 2018-2021.



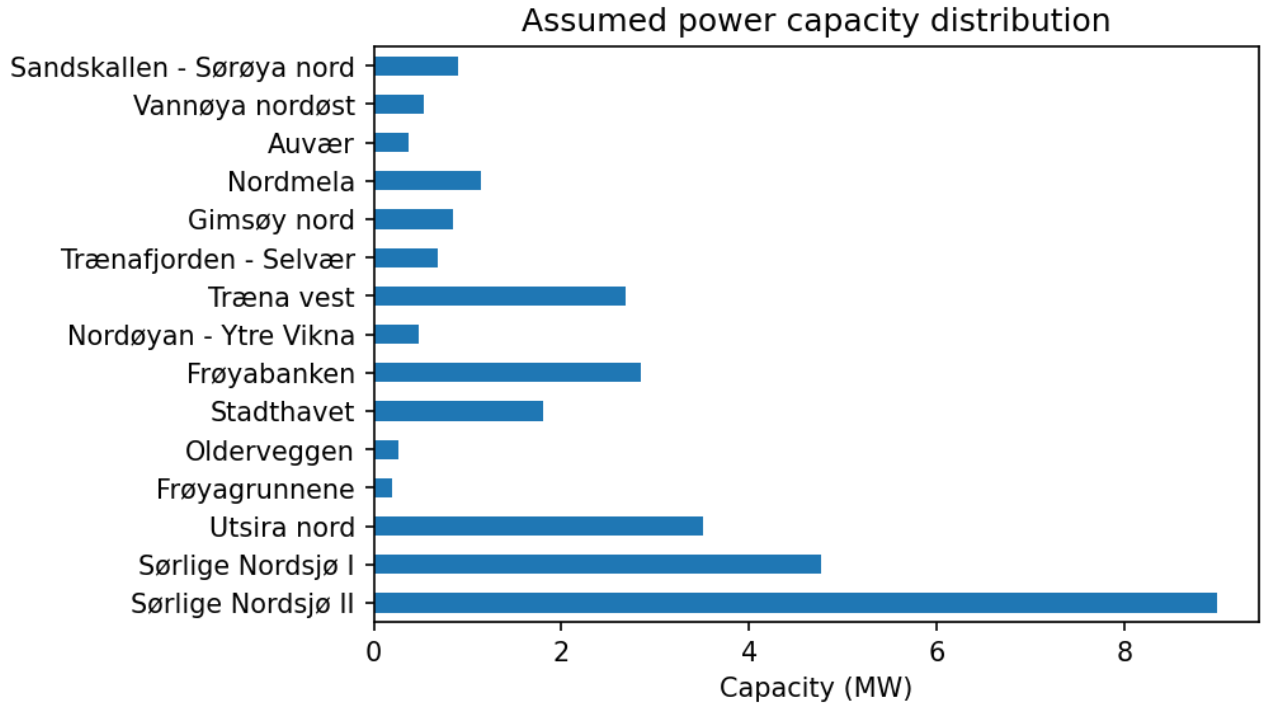
Figur 1-3: Norsk kraftproduksjon i et normalår fra vår basisprognose LMA 2020

https://www.statnett.no/globalassets/for-aktorer-i-kraftsystemet/planer-og-analyser/havvind/fagrapport-om-havvind-i-sorlige-nordsjo-ii.pdf

30 GW offshore wind in Norway
Time-series study



30 GW capacity distributed according to area (NVE 2012 sites):

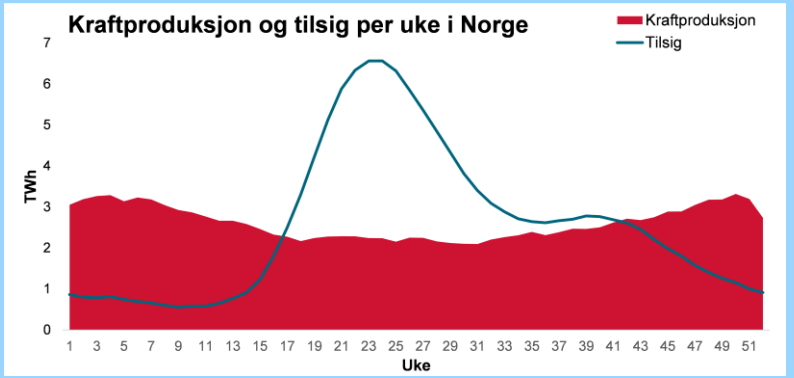


Time-series

- 29 years of hourly wind speed data at selected locations
  - MERRA-2 Reanalysis data
- Converted to wind power
  - effective power curve representing wind farm (Gauss filtered turbine power curve)

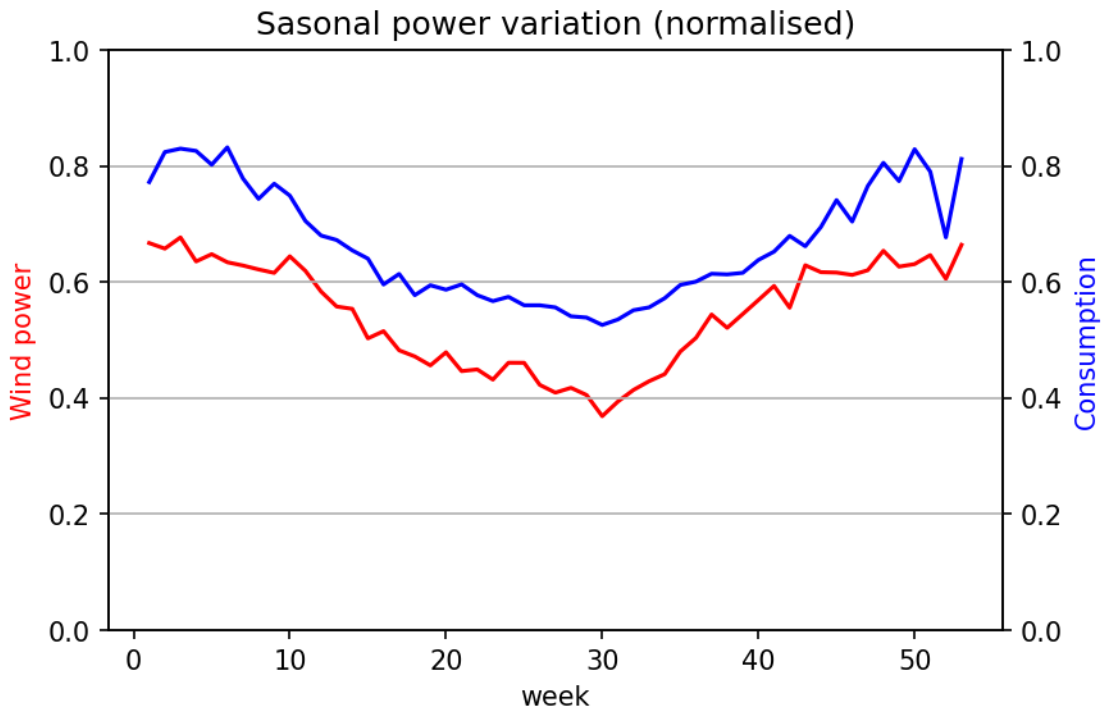
Seasonal variation
Hydro power

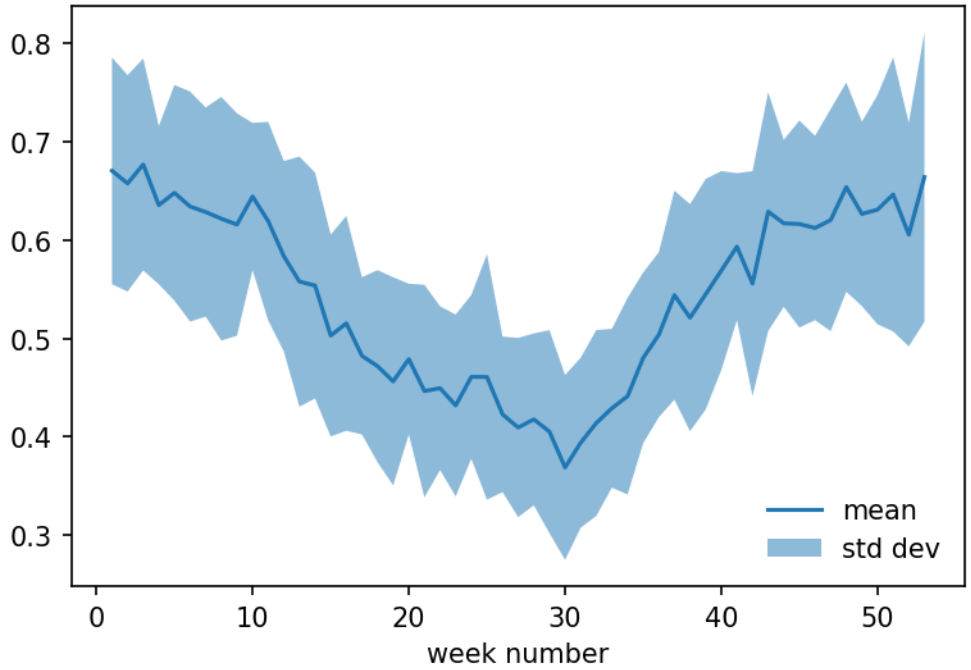
Hydro power:



Seasonal variation Wind power

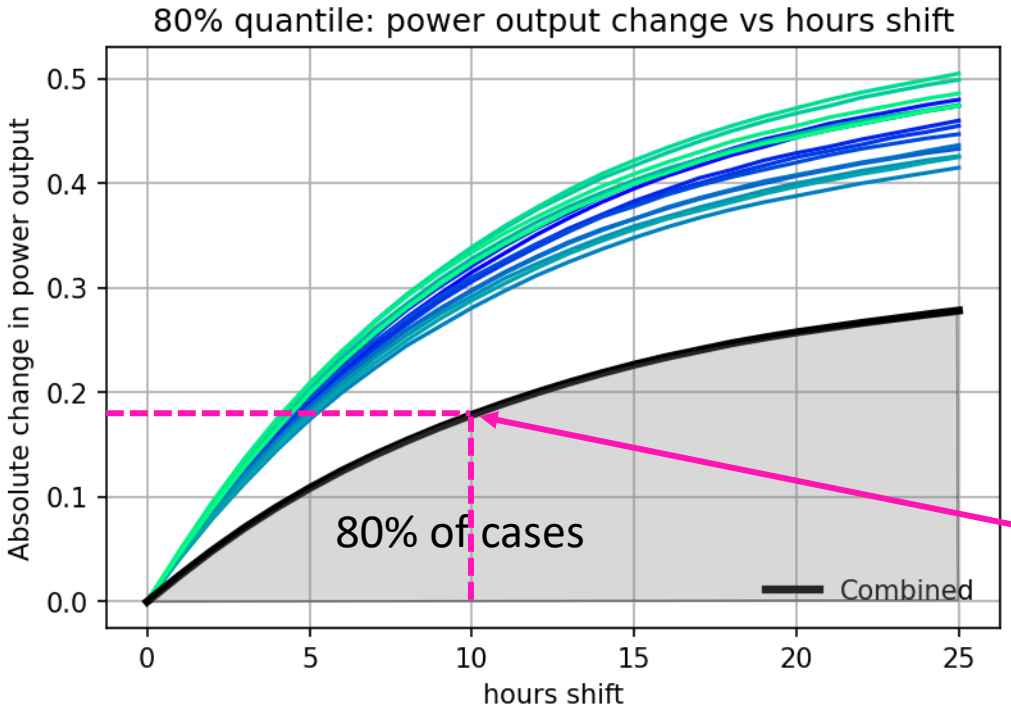
- Average week-by-week wind power profile matches well with consumption profile
- But variations from year to year





Short-time variation (power ramping)

How much does the power output change after a time shift

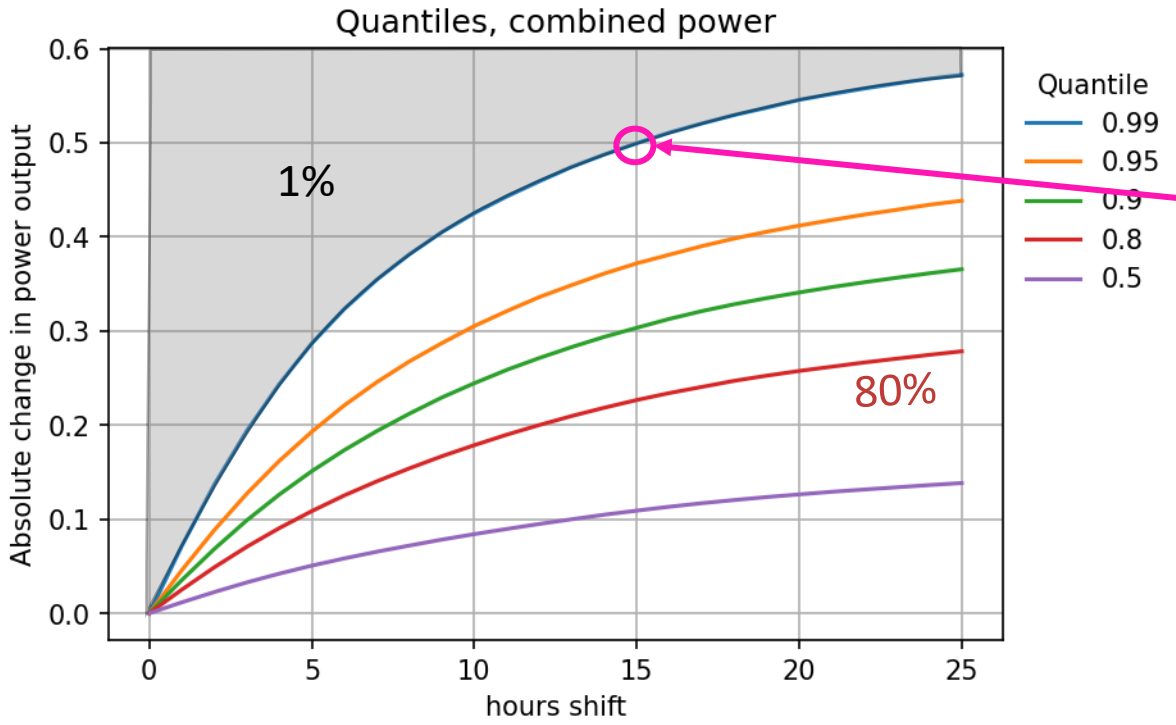


Individual wind farms

Combined output

Example: After 10 hours, the combined power will have changed by 18% of the rated power or less in 80% of the cases (80% quantile)

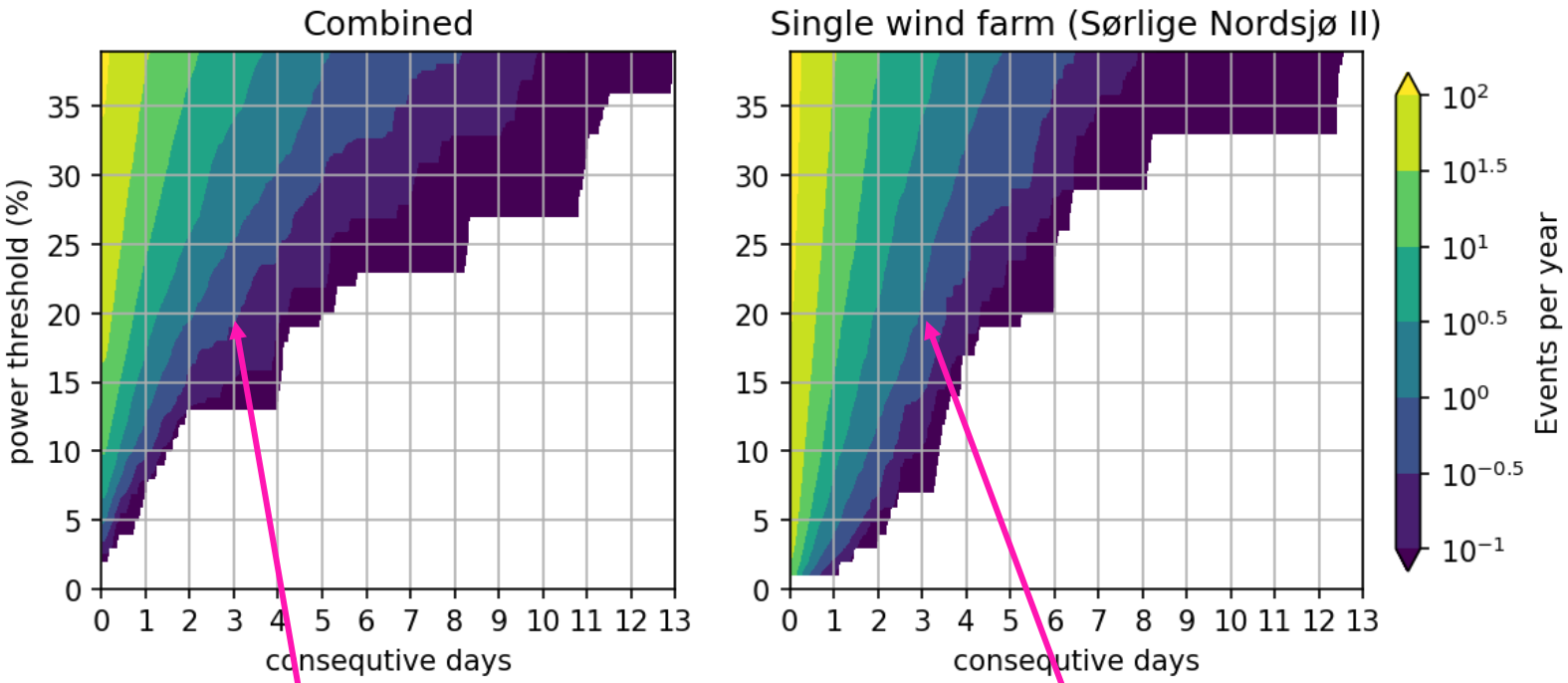
More on ramps (combined power)



Very large ramps within a few hours are not common, but do occur

>50% (15 GW) change during 15 hours: 1% event

How often would there be no wind power?

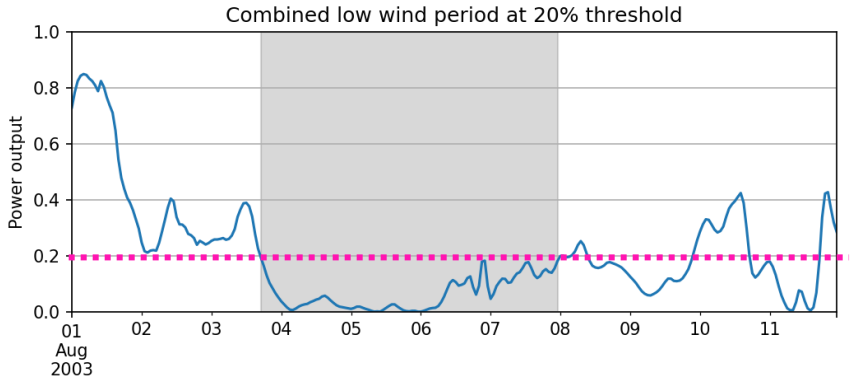


- Several consecutive days of little wind do occur
- Geographical smoothing makes it less frequent for combined power

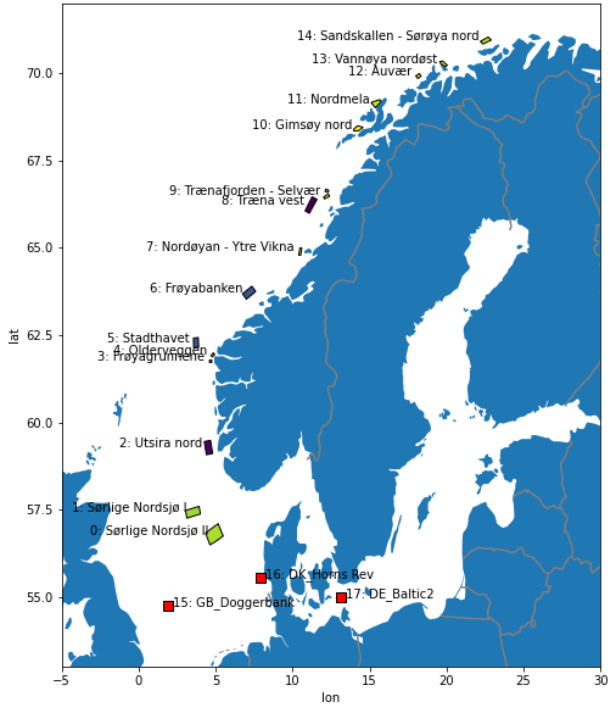
Example: Power<30% for 3 days:

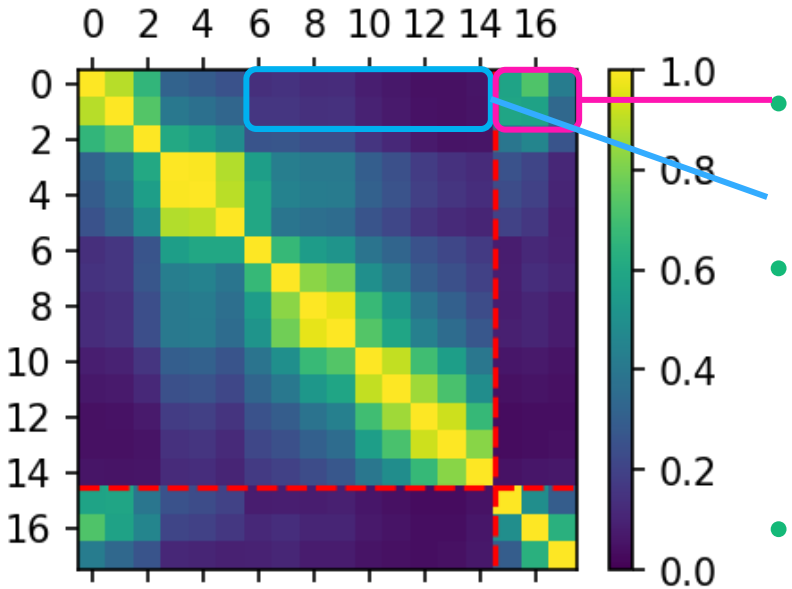
0.3 event per year

1 event per year



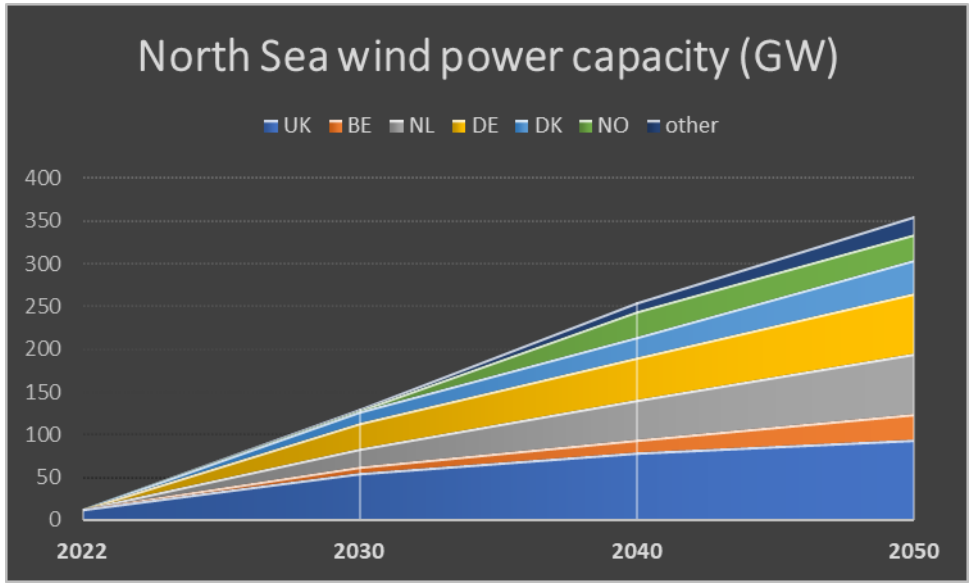
Correlations

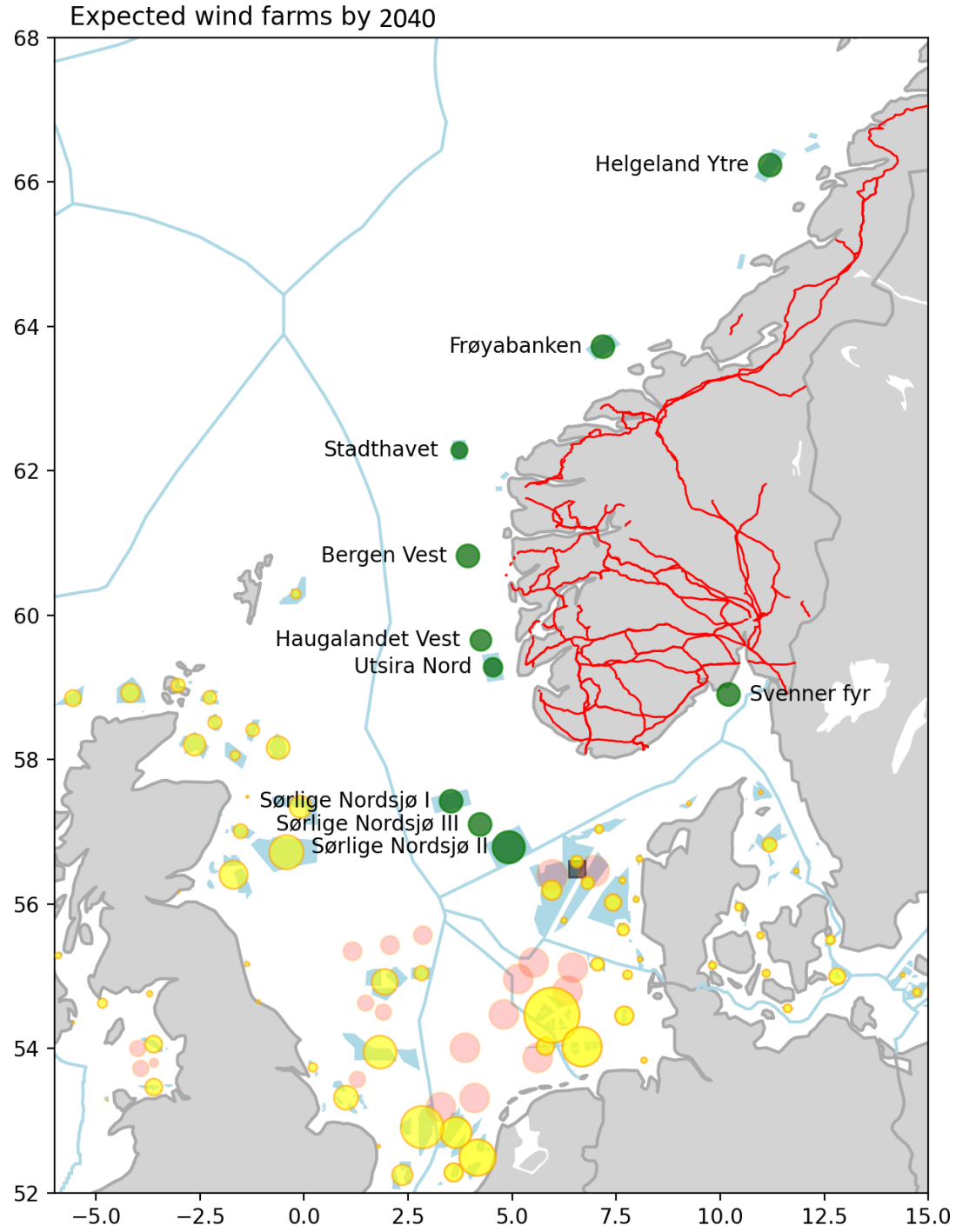




- correlation coefficients – hour-by-hour power output at different wind farms
- Sørlige Nordsjø vs Europe: High (0.34-0.73)
- Sørlige Nordsjø vs Frøyabanken and farther north : Low (<0.15)
- Similar result when looking at day-by-day average values

North Sea wind power 2030, 2040



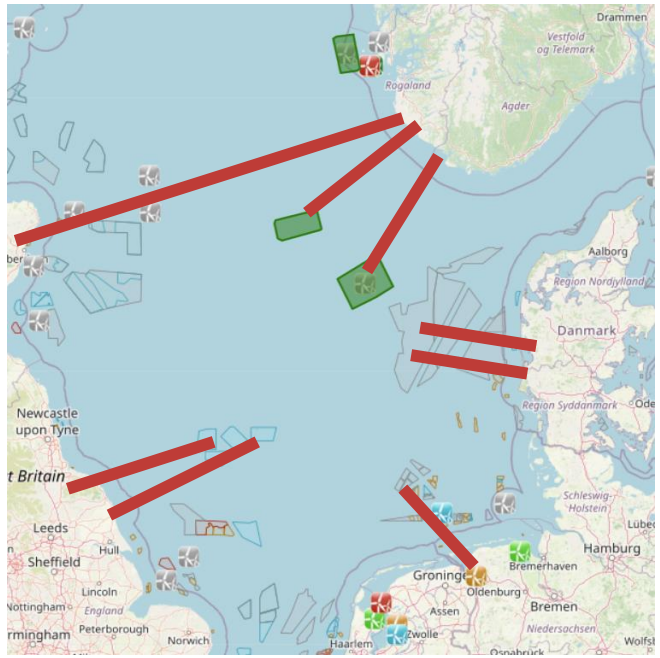


Need an electricity grid!

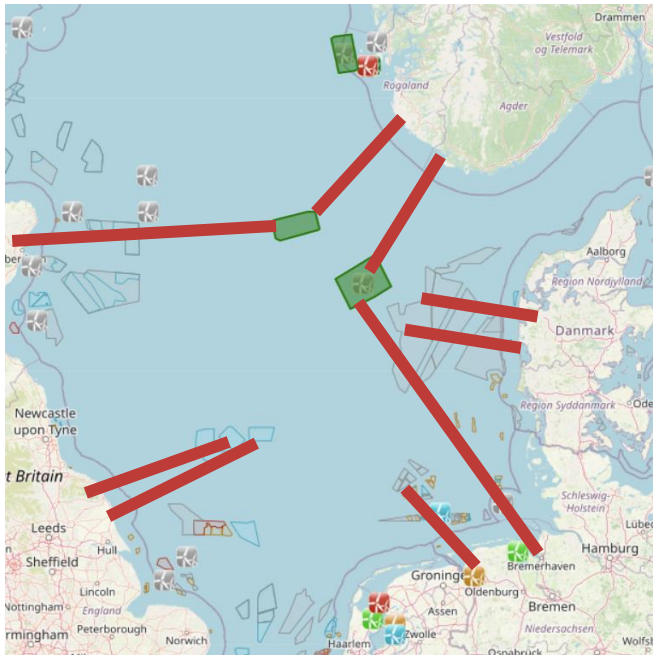
- 30 GW → 130 TWh/year
- Similar size as existing hydro-dominated capacity (built over 100 years)
- 17 years until 2040

Offshore grid alternatives

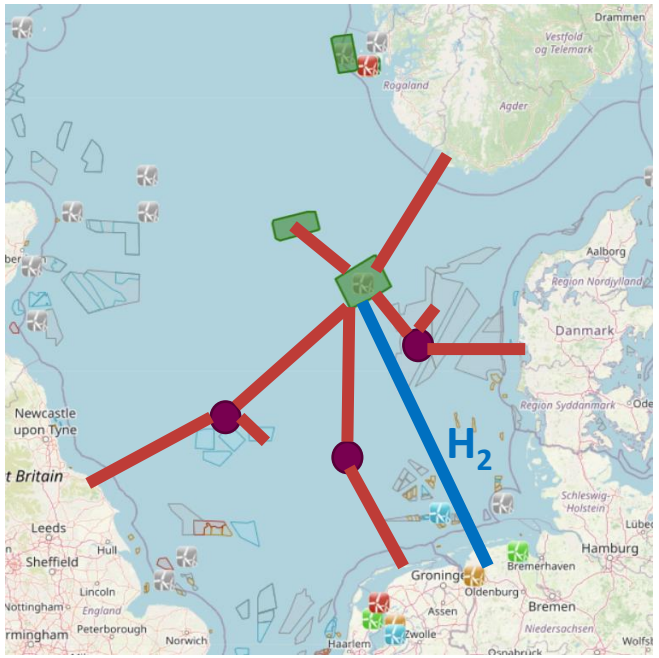
Radial

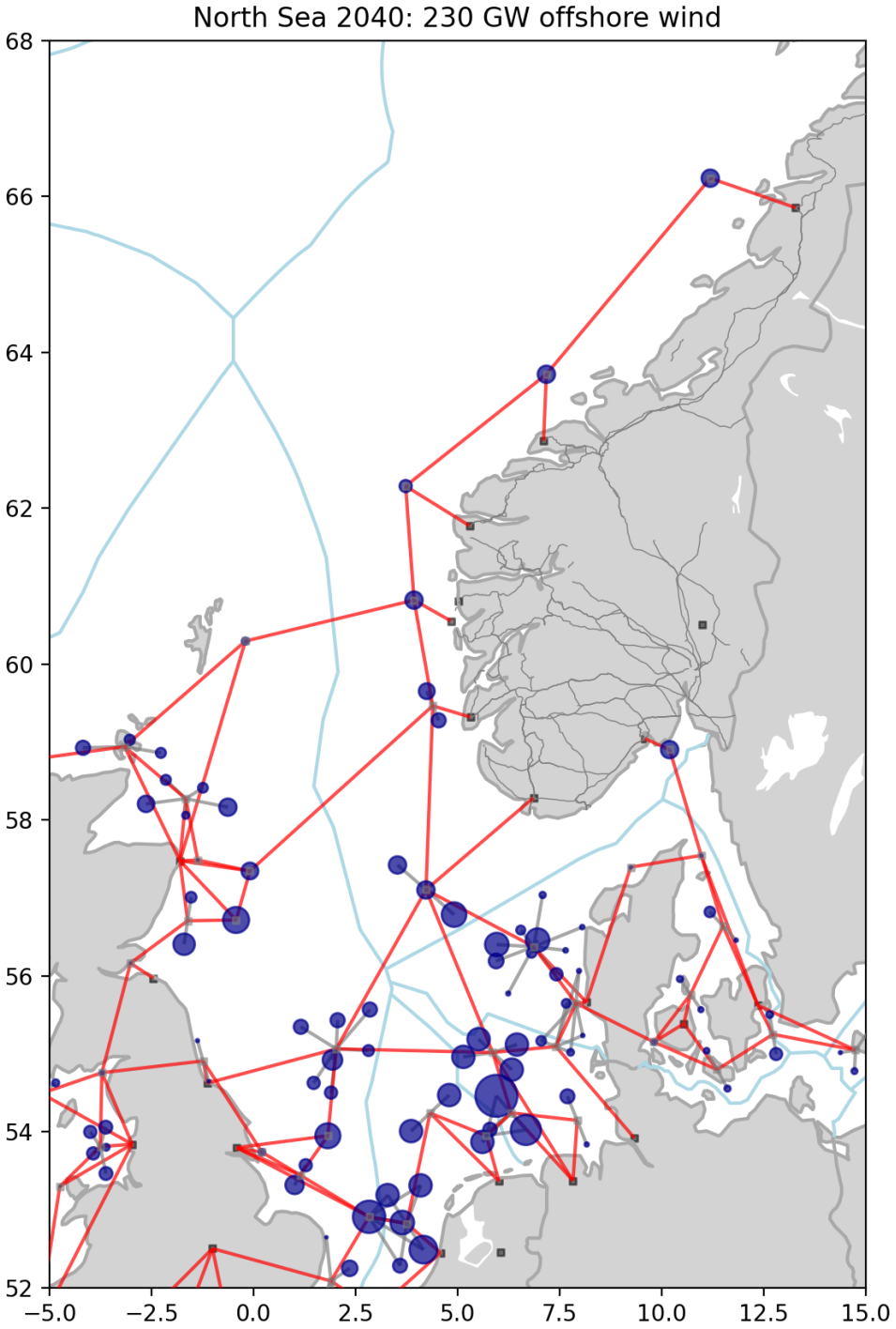


«Hybrid»



Energy hubs



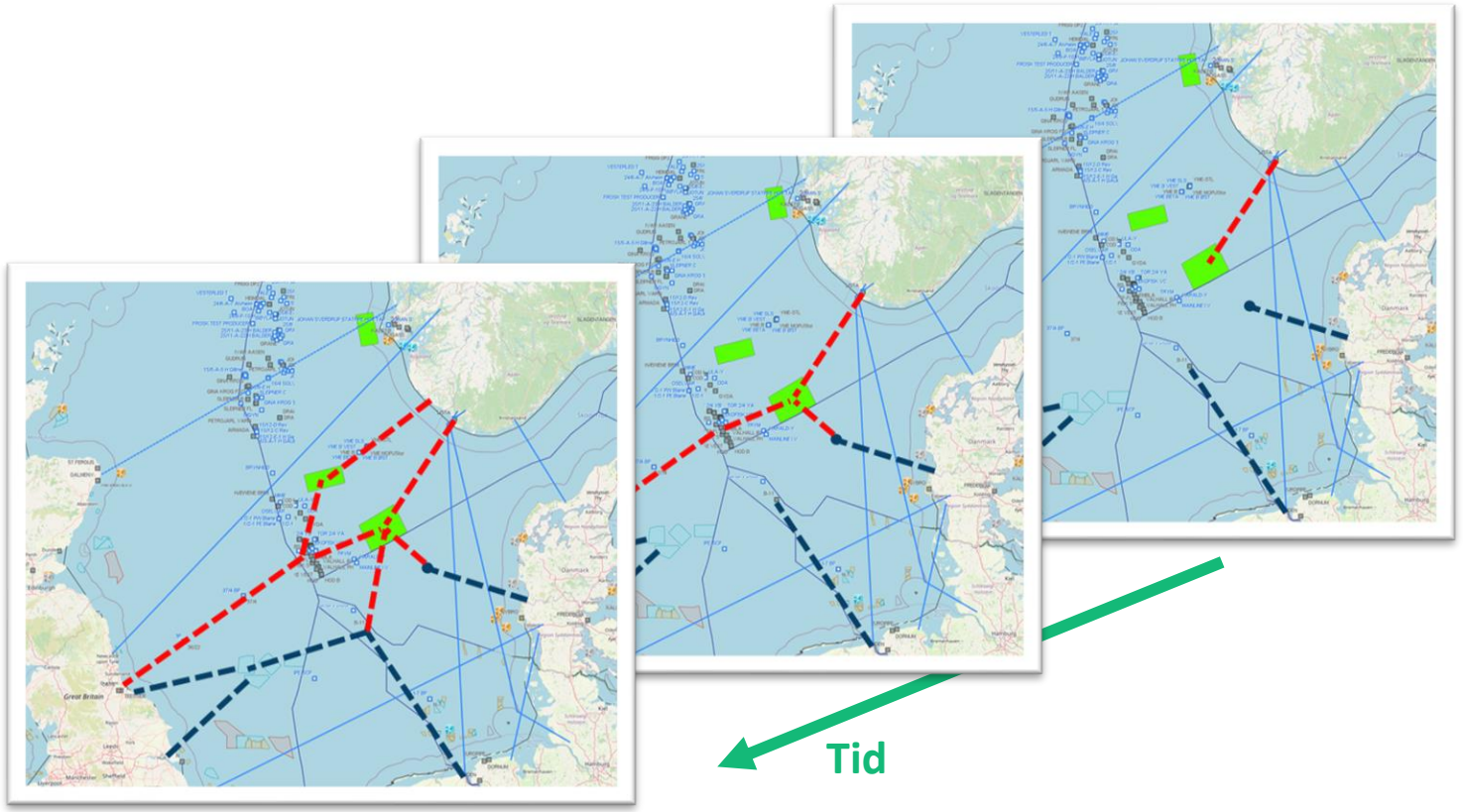


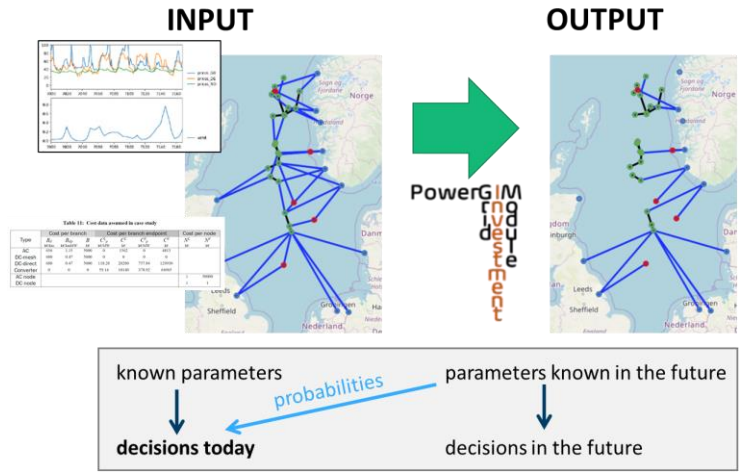
A North Sea Ocean Grid

Anyone's guess how it will eventually look, but:

- Will be built step-by-step
- Low risk-taking
  - Stranded assets
- Easier alternative than new onshore lines?
- A meshed offshore grid is economically optimal, bur requires a fair sharing of costs and benefits
  - countries, consumers, producers

Towards an offshore grid – optimal step-wise decision making



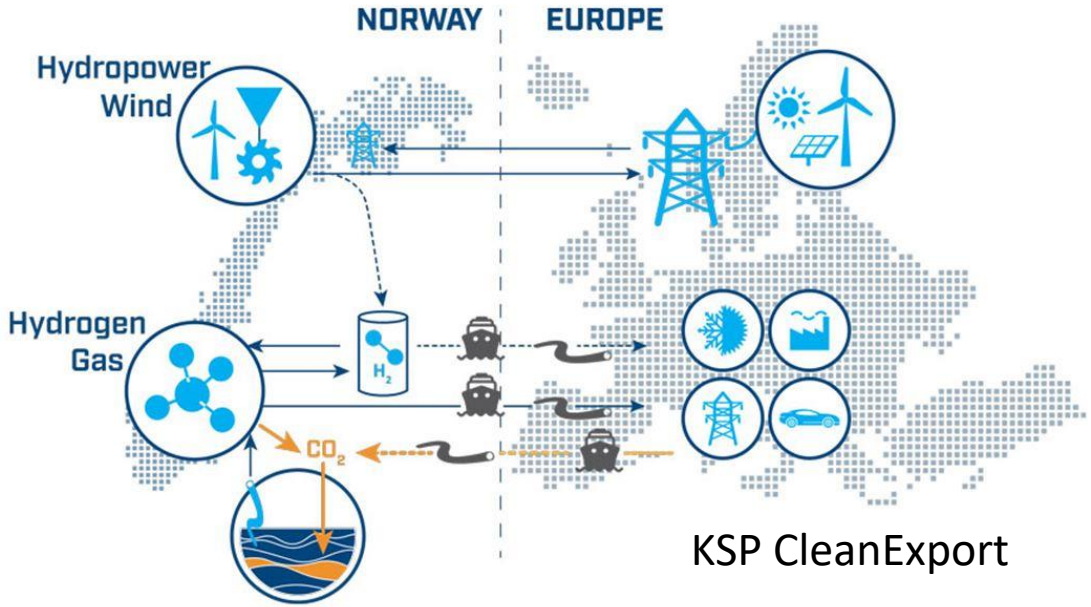


https://github.com/powergama/powergim

OCEAN GRID

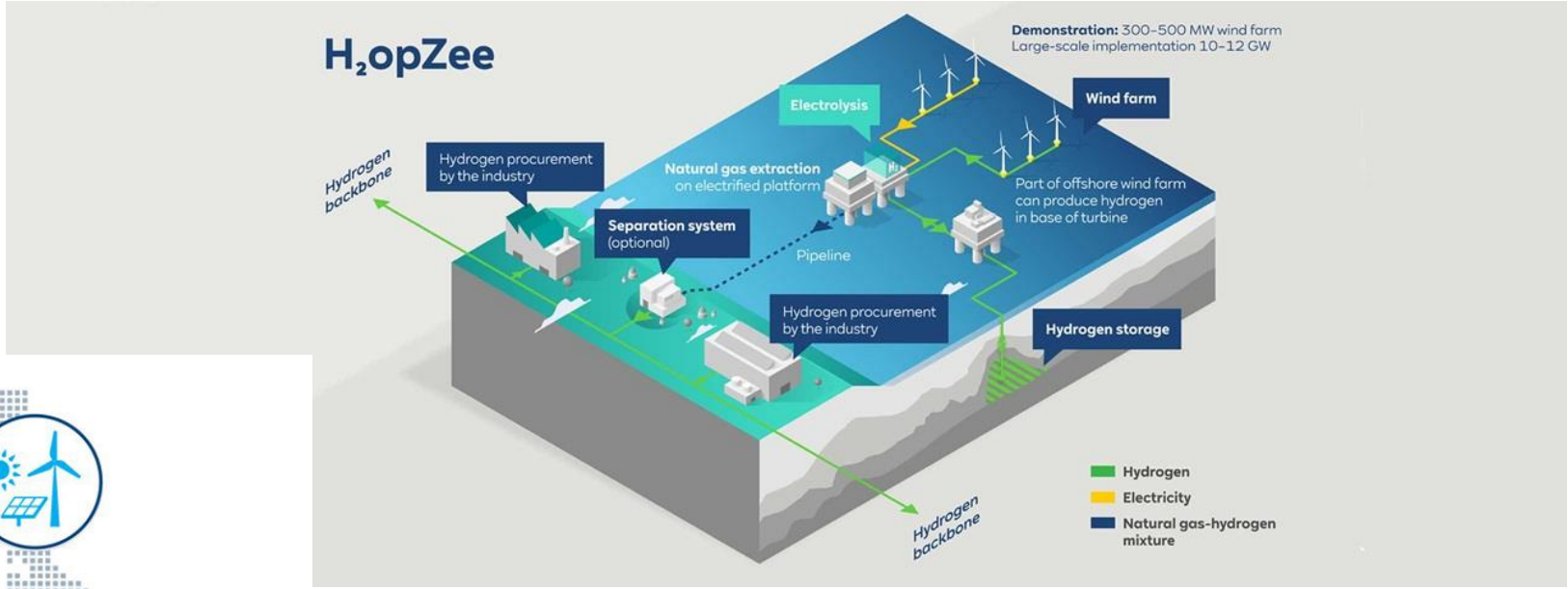
https://oceangridproject.no/

Need flexibility! – integrated energy systems and energy markets



KSP CleanExport

https://www.sintef.no/en/projects/2020/cleanexport/



https://www.rwe.com/en/research-and-development/hydrogen-projects/h2opzee

Summary

- Offshore wind is getting BIG (also in Norway)
- Location of wind farms – trade-offs
  - Demand: distance to European market, Norwegian onshore industry development,
  - Price: achieved price
- North Sea grid
  - Electricity transmission, energy hubs, flexibility

SINTEF

Teknologi for et bedre samfunn