NSON-DK scenarios

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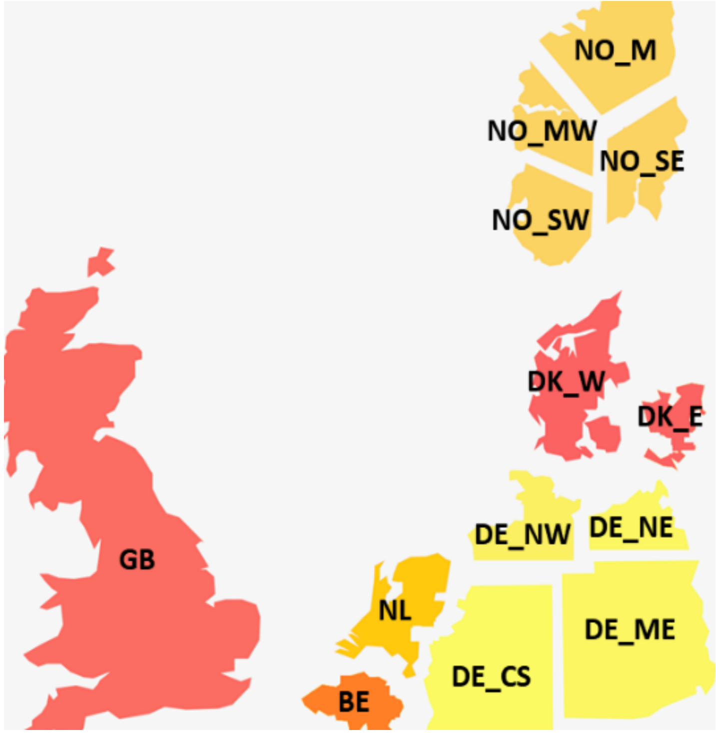
Outline

1. Modelling the North Sea region energy system

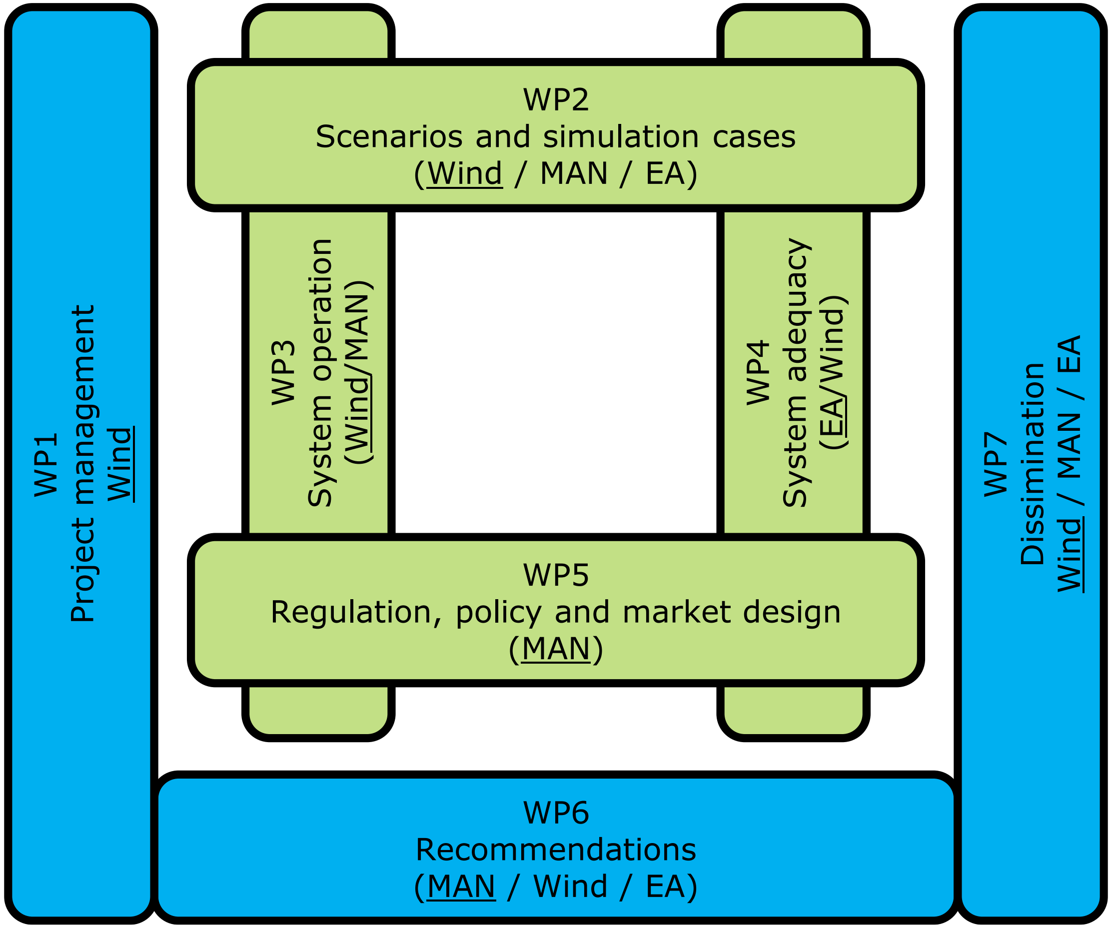
2. Scenarios towards 2050
   - **Project-based** and **integrated offshore grid**
   - Brief look at the impacts of **sector coupling**



3. Conclusions

Work is funded by the NSON-DK project (Danish Energy Agency, EUDP): http://www.nson-dk-project.dk/

NSON-DK scenarios in the NSON-DK project



The energy system modelling

CorRES[1] → Balmorel[2] → Scenarios

CorRES[1]

Variable renewable energy (VRE) time series

Balmorel[2]

Energy system optimization

Scenarios

Scenarios towards 2050

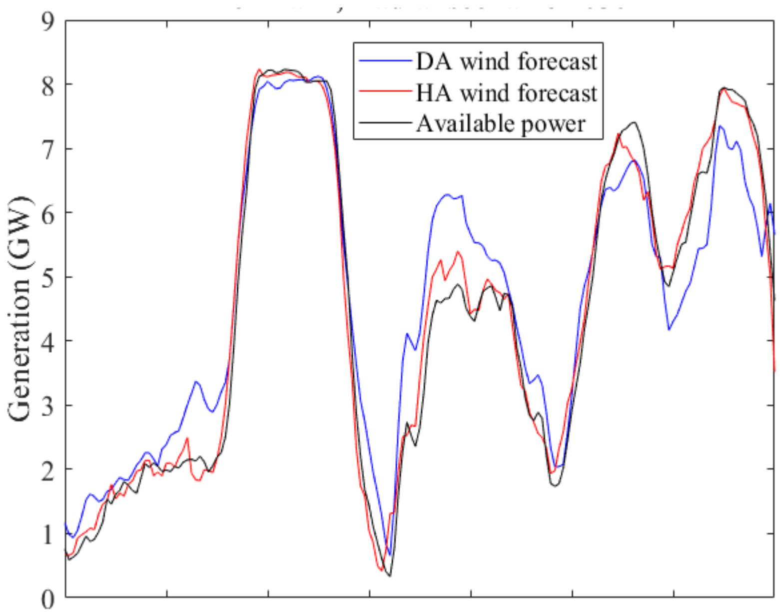
For **project-based** and **integrated offshore grid**

[1]M. Koivisto et al., “Using time series simulation tool for assessing the effects of variable renewable energy generation on power and energy systems”, *WIREs Energy and Environment*, vol. 8, no. 3, e329, May/June 2019.

[2]F. Wiese et al., “Balmorel open source energy system model”, *Energy Strategy Reviews*, vol. 20, pp. 26-34, April 2018.

CorRES

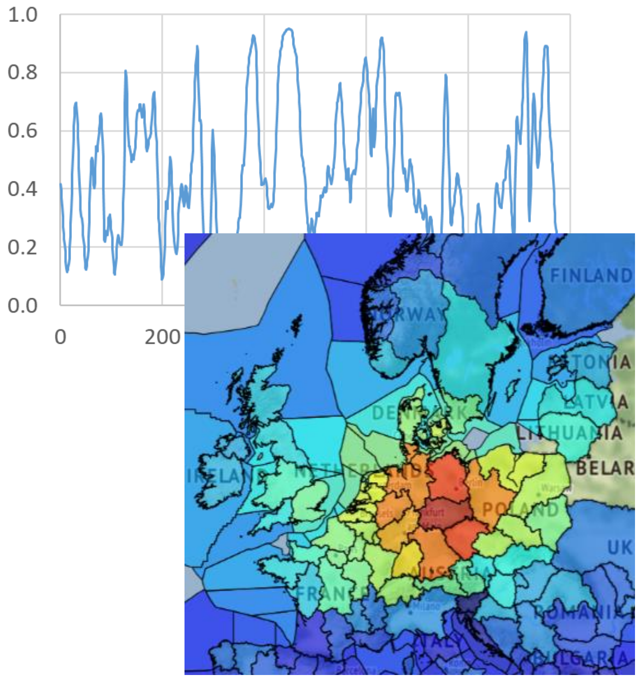
- CorRES (Correlations in Renewable Energy Sources)
  - Simulation tool for variable renewable energy (VRE) generation
  - **Models both wind and solar PV**
  - **Can model future scenarios** (e.g., 2030 or 2050)
- Based on meteorological reanalysis data
  - **37 years of hourly data covering Europe**
- Used in:
  - Research projects
  - Pan-European VRE generation simulations for ENTSO-E
- Can simulate also VRE generation **forecast errors**
  - Used in balancing studies (more on that later)



Example regional simulation of available wind generation and forecasts (DA = day-ahead; HA = hour-ahead)

The energy system modelling

CorRES → **Balmorel** → **Scenarios**



Joint optimisation of the **electricity** and **heating** sectors

Transmission and generation investments

Intertemporal value maximization (i.e., **expected future taken into account**)[1]

Installed **generation GW**

Annual TWh generated

Renewable generation shares

Hourly **prices**

Hourly **dispatch**

[1]Juan Gea-Bermúdez et al., “Optimal generation and transmission development of the North Sea region: impact of grid architecture and planning horizon”, *Energy*, early access, 2019.

The project-based and integrated scenario

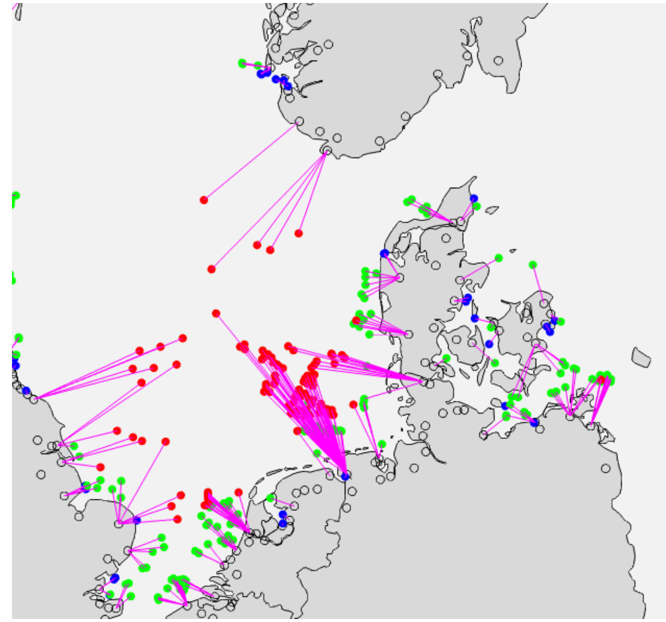
Project-based

- Offshore wind power plants (OWPPs) are connected radially to onshore
- Only radial transmission lines are allowed in the North Sea

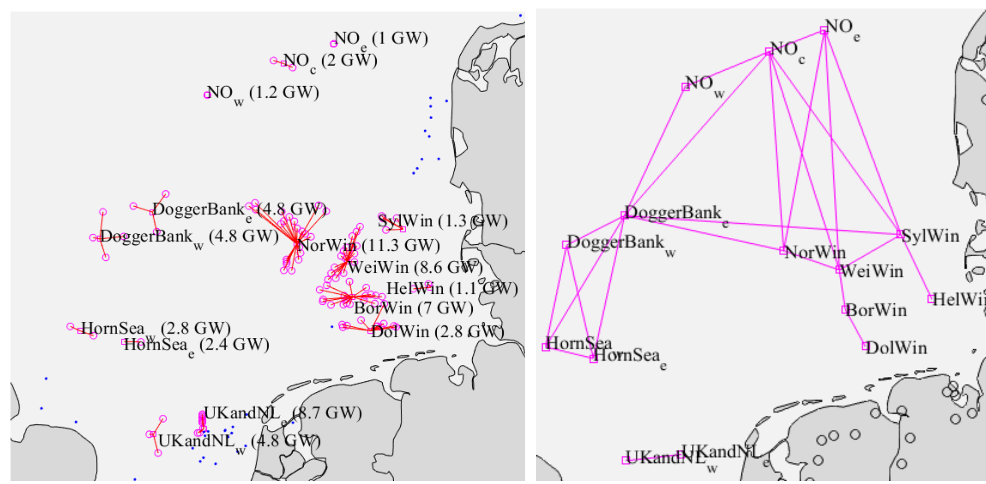
Integrated offshore grid

- North Sea offshore meshed grid is a **possibility in the investment optimization**
- OWPPs can be connected to **hubs**
- Hubs can be connected to each other
- Hubs are connected to onshore

Otherwise the two scenarios are specified with the same cost parameters, etc.

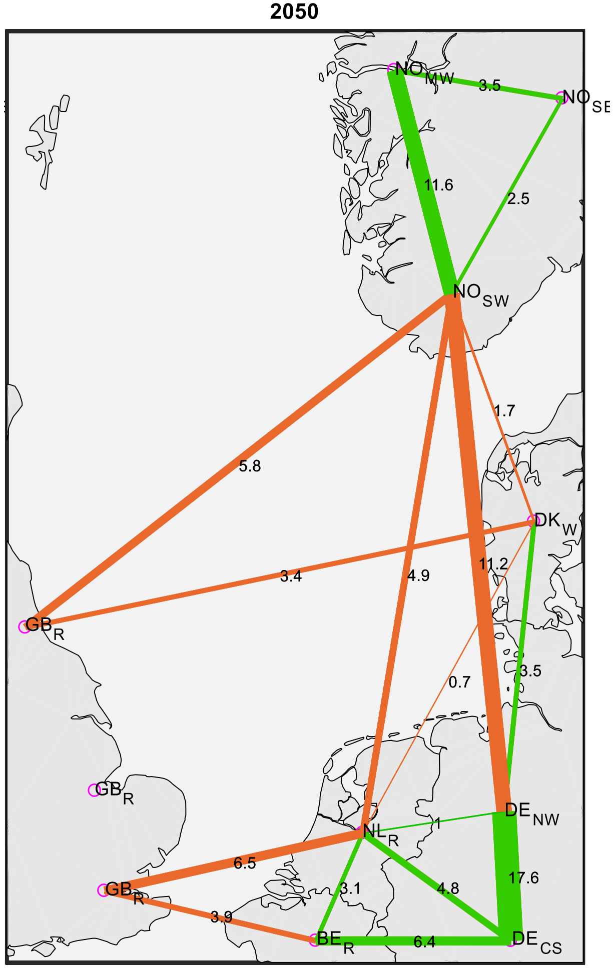


Possible radially connected OWPPs



Possible hub-connected OWPP investments, and some example connections in the meshed scenario

Resulting project-based scenario



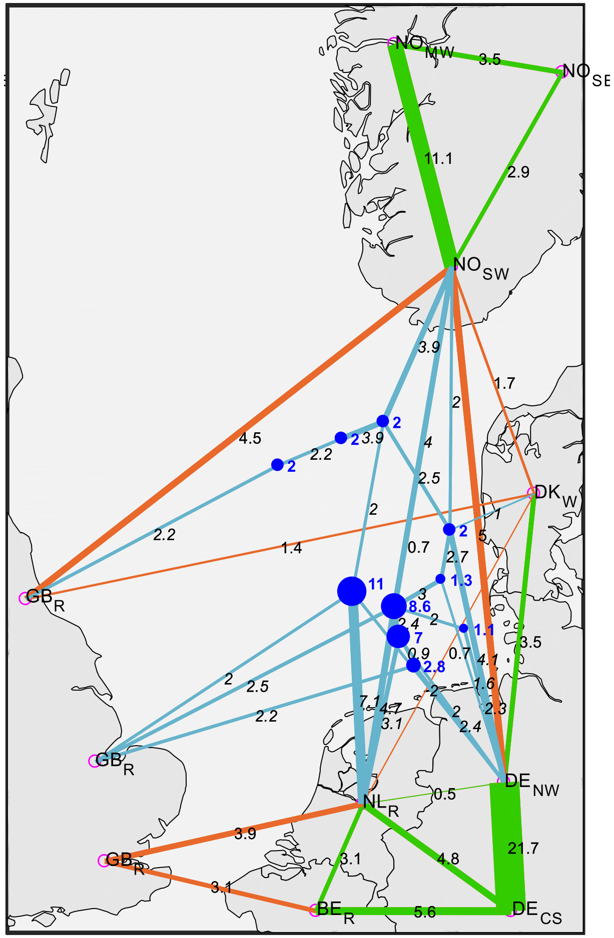
VRE type	Starting point [GW]	2030 [GW]	2050 [GW]
Offshore wind	22	64	**92**
Onshore wind	76	106	114
Solar PV	70	126	182

Generation share	Starting point	2030	2050
VRE	28%	55%	**70%**
Renewable	46%	75%	**88%**

M. Koivisto et al., North Sea offshore grid development: Combined optimization of grid and generation investments towards 2050", *IET Renewable Power Generation*, accepted for publication, 2019.

Resulting integrated offshore grid scenario

2050



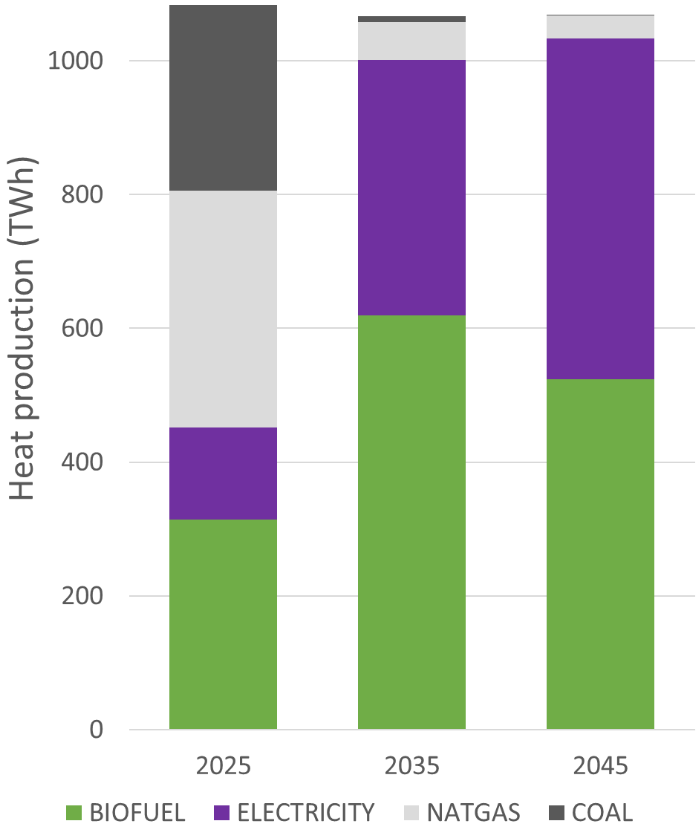
VRE type	Starting point [GW]	2030 [GW]	2050 [GW]
Offshore wind	22	69 (30%)	**102** (39%)
Onshore wind	76	101	106
Solar PV	70	120	176

Percentages show hub-connected offshore wind shares

Generation share	Starting point	2030	2050
VRE	28%	56%	**72%**
Renewable	46%	76%	**89%**

M. Koivisto et al., North Sea offshore grid development: Combined optimization of grid and generation investments towards 2050", *IET Renewable Power Generation*, accepted for publication, 2019.

Impacts of sector coupling (early results)



Scenario year	Electricity generation [TWh]	Renewable share	Offshore wind [GW]
2025	1284	58%	25
2035	1537	94%	126
2045	**1717**	**96%**	**158**

Note: The sector coupled results are **preliminary**

Integrated offshore grid sector coupled scenario is not yet run

Results are aggregates for the same countries as shown on previous slides

Conclusions

- **Investment optimization towards 2050 was run**
  - Simultaneously optimizing generation and transmission investments
- **Integrated offshore grid scenario**
  - Shows an **increase in offshore wind of ~10 GW**
  - Shows also (slightly) lower system costs
  - **A mixture of radial lines and transmission via the hubs** was found optimal
- **Sector coupling** has potential to increase offshore wind significantly
  - Renewable energy generation share gets close to 100%