DTU

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4th AIEE Energy Symposium, Rome, Dec. 10th-12th 2019

North sea offshore grid integration towards 2050 – Barriers and solutions

Background

- EU renewable energy targets for 2030 and 2050
  – Substantial offshore wind potential in the North Sea
- EU integrated electricity market

- Development of transmission capacity and interconnectors between European countries
  – The offshore grid in the North Sea has to be expanded over the coming decades

Country	RES target 2020	RES target 2030*
EU	20%	27%
Belgium	13%	23%
Denmark	30%	42%
Germany	18%	29%
Netherlands	14%	25%
Norway	67,5%	-
UK	15%	27%

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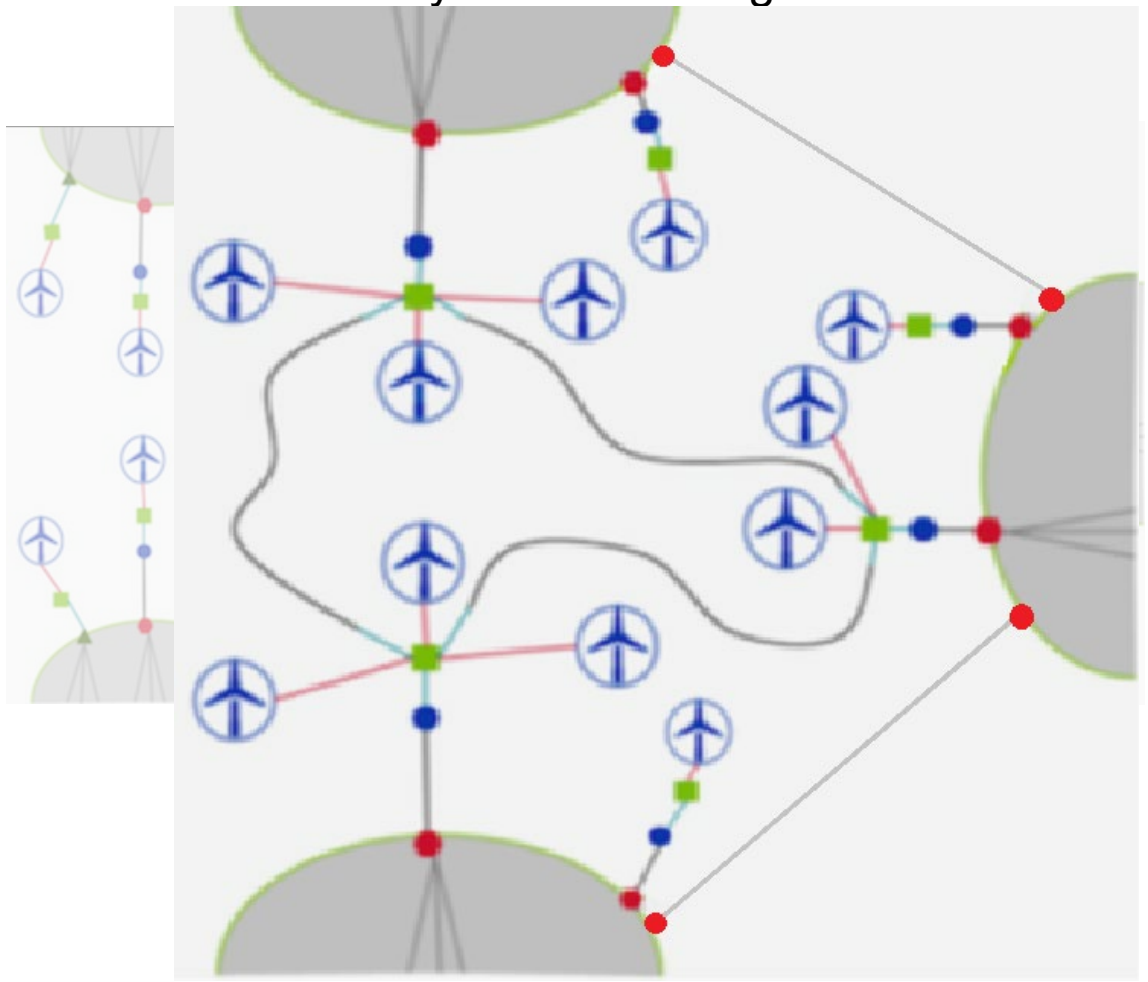
Background II

- What do I mean by “the offshore grid in the North Sea has to be expanded”?



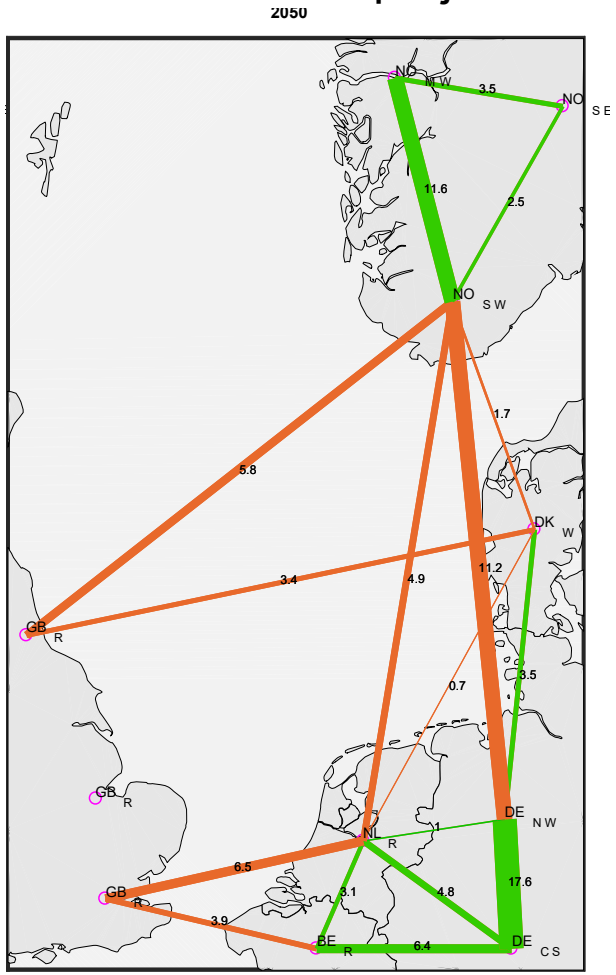
- Several studies have found that there are benefits to further integrating the North Sea grid
  - Interconnectors potentially increase welfare
    - Price convergence
    - Improved efficiency
    - More energy produced from RES.
  - Integrated grids potentially bring further economic benefits
    - Electricity producers can sell at the market with the highest price
    - Less reserve capacity

Background III

- Preliminary results from the NSON-project show…

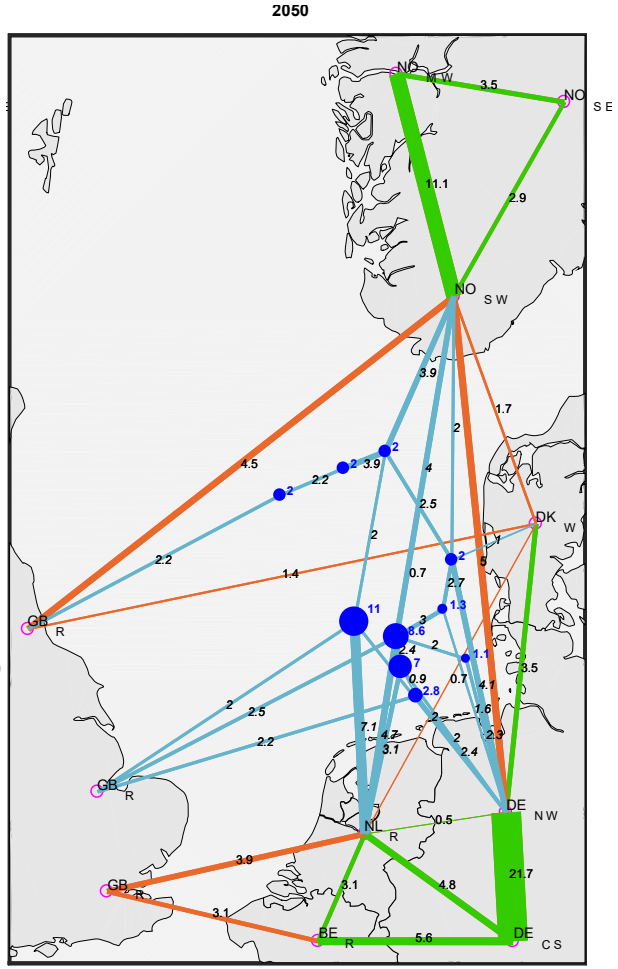
Project-based

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



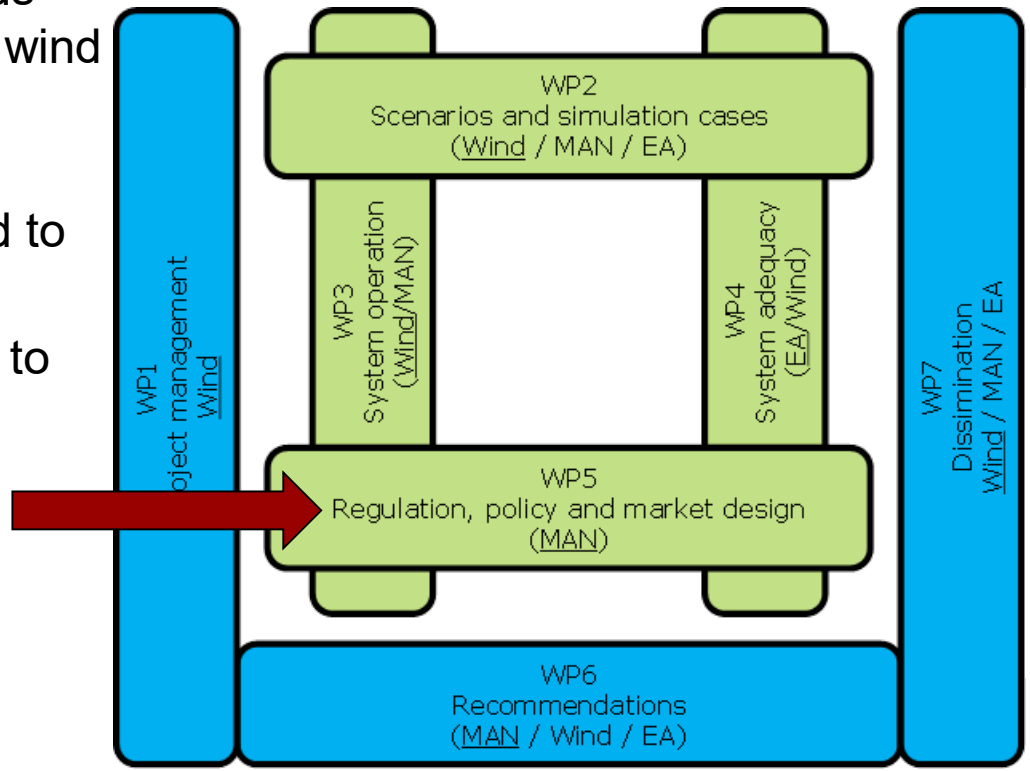
Integrated offshore grid

- 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
- Protection costs for meshed lines not included



Research project: North Sea Offshore Network

- What is the relevant regulation towards the development of massive offshore wind as well as the hybrid integrated grid infrastructure in the North Sea?
- What are the potential barriers related to the relevant regulation?
- What would be the possible solutions to overcoming these barriers?



NSON-DK

Relevant regulation

- **Investment-related regulation**
- Affecting the offshore wind developer
  - Renewable energy support schemes
  - Grid connection costs
  - Priority grid connection
  - Power market operation
  - Consenting procedures
  - Maritime spatial planning
- Affecting the TSO/national authorities
  - Cost-benefit allocation
  - Financing rules

- **Operation-related regulation**
  - Priority dispatch regulation
  - Transmission tariffs
  - Balancing responsibility
  - Onshore connection rules
  - Cross border capacity allocation and congestion management issues

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- Affect the profitability of investing in different countries.
- The developer prefer to invest where they receive the highest return on investment.
- Current regulation does not necessarily assure that the profitability for the OW developer and the lowest levelized cost of energy

- Determine whether an investment in the offshore grid will be undertaken or not.
- Distribution of cost and benefits are not taken into account

Relevant regulation

- The developer will participate in markets with the highest profitability.
- Current regulation does not assure that the highest payoff is coinciding with the highest socio-economic value of the wind energy

- **Operation-related regulation**
  - Priority dispatch regulation
  - Transmission tariffs
  - Balancing responsibility
  - Onshore connection rules
  - Cross border capacity allocation and congestion management issues

Key regulatory issues

- The distribution of connection costs:
  - Connection cost allocation across all involved stakeholders has been identified by as a “critical” risk factor in the development of the hybrid integrated grid.
- Transmission tariffs
  - The design of the transmission tariff significantly affect the business case of the wind farms and hence their location.
- Investment incentives
  - The regulation affecting incentive instruments concerns the recovery of investment cost related to grid investments.
  - The incentive instruments has been studied with respect to developing an integrated European Electricity market, we apply a similar approach in the case of the hybrid integrated grid.

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Regulatory framework condition	Good practices	Denmark	Belgium	Netherlands	Germany	Norway	UK
Connection cost	Super shallow cost recovery	+	o	o	+	o	o
Grid access tariff	Energy-based tariff / no access fee for producers	+	o	-	o	o	o
	No locational signal	+	+	+	+	-	-
HIG-friendly investment incentive	Limits the financial risk on CAPEX	+	+	+	+	+	+
	Full cost recovery of R&D spending	+	o	-	+	+	-
	Clear R&D incentive	-	o	-	+	+	o
	Incentive on OPEX /PBR	-	-	+	o	+	o
	Specifically supports CAPEX	-	o	-	+	-	+
	Limits CAPEX overspending	o	+	+	+	+	-

Relevance to other EU countries

Crucial Barriers

	Barrier	Description	Consequence
Market	Grid connection costs	Different cost allocation methods in different countries, when connecting offshore projects to the grid	Affect which national grids developers wish to feed into.
Technical	Cross border capacity allocation	OWFs are directly connected to interconnectors and not countries. A part of the interconnector's capacity needs to be reserved for the fluctuating output of OW-producers.	Difficult to anticipate the optimal capacity. Countries can take advantage of capacity constraints in order to avoid re-dispatch or countertrade costs.
Political	Cost-benefit allocation	Increased interconnectivity/trade affect producers and consumers in terms of higher/lower prices, hurt fossil fuel producers and affect security of supply	Countries may be reluctant to contribute to offshore grid development if the overall welfare of the individual country is reduced

Possible solutions (work in progress...)

	Barriers	Solution
Market	Grid connection costs	A harmonisation of distribution of grid connection costs
	RES-support schemes	A harmonisation of RES-support schemes
	Administrative process	Standard documentation to reduce administrative burden and insecurity.
Technical	Balancing responsibilities	Standardised framework, to determine in which country an offshore wind farm is part of the balancing market.
	Cross border capacity allocation	Standardised procedure to assure discrimination-free allocation of interconnector capacity.
	Priority grid access	Standardised rules determining how to allocate capacity between RES projects.
Political	Financing offshore assets	A stable regulatory framework to attract investors.
	Cost-benefit allocation	Establish a cost-benefit allocation mechanism that compensates potential losers.

Work still to be done…

- Assessing Best Practice
  – Further analysis on country-level regulation and market mechanisms
    => Possible suggestions to regulatory and market design alterations

- Have a closer look at a potential setup for the cost-benefit sharing mechanism

Summing up

Recent initiatives at the European level

- The European Network Codes
  - grid connections, markets and operation
- Future harmonisation of balancing markets
  - establishment of common European platforms
- Recommendations on cross-border cost allocation mechanism
  - applicable to projects of common interests e.g. interconnection projects and meshed grids
  - uneven impact of projects may discourage some project participants despite increasing overall economic welfare (e.g. granting compensation).

Still remaining

- Potential harmonisation of regulation and support mechanisms
- Potential harmonisation of market mechanisms (balancing/cross-border capacity)
- Actual implementation of a cost-benefit-sharing mechanism

Thank you for your attention!

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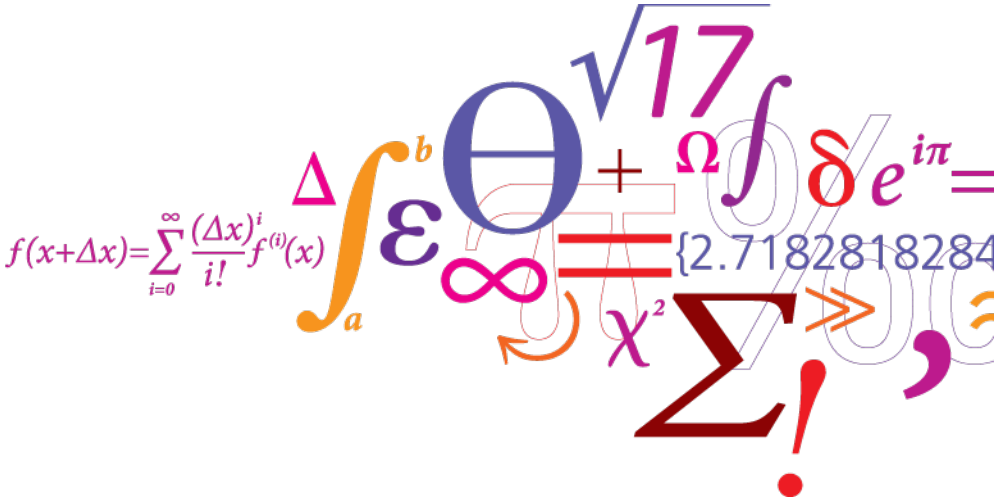


Country specifics – Balancing requirements

Country	Responsibility
Belgium	TSO has to control the balancing Access responsible partners (ARPs) are required to maintain balance within their own area.
Denmark	Balancing is maintained within the Nordic regulating power market in cooperation with the other national TSOs.
Germany	The TSOs are responsible for the secure transmission of energy.
Netherlands	TSO
Norway	The TSO is responsible for ensuring physical balance of the system.
UK	National Grid Electricity Transmission is the system operator with responsibility for system balancing

Country specifics – TSOs and NRAs

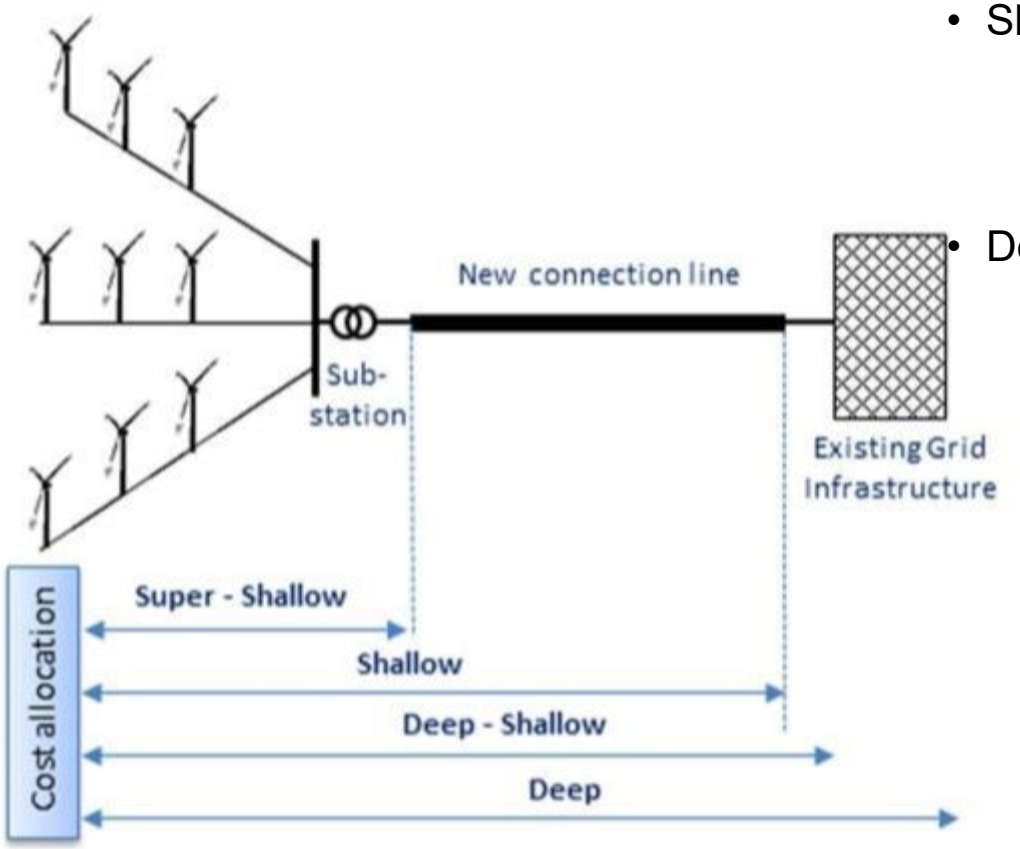
Country	TSO	NRA
Belgium	Elia System Operator SA	Commission pour la Régulation de l'Electrcité et du Gaz (CREG)
Denmark	Energinet.dk	Energitilsynet
Germany	TransnetBW TenneT TSO Amprion 50Hertz Transmission	Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway
Netherlands	TenneT TSO	Authority for Consumers and Markets
Norway	Statnett SF	Norwegian Water Ressources and Energy Directorate
UK	National Grid Electricity Transmission plc System operator for Northern Ireland Ltd Scottish Hydro Electric Transmission plc Scottish Power Transmission plc	Office of Gas and Electricity Markets

Country specifics – RES targets and support

Country	RES target 2020	RES target 2030*	RES support schemes
EU	20%	27%	-
Belgium	13%	23%	Quota system and tradable certificates
Denmark	30%	42%	Feed-in premium/auctions
Germany	18%	29%	Feed-in premium/auctions
Netherlands	14%	25%	Feed-in premium/auctions
Norway	67,5%	-	Quota system and tradable certificates
UK	15%	27%	Quota system and tradable certificates/auctions

*Calculated based on the methodology for effort sharing in RES Directive 2009/28/EC.

Country specifics – Grid connection costs



- Super-shallow
  - All costs are socialized via the tariff, no costs are charged to the connecting entity.
- Shallow
  - Grid users pay for the infrastructure connecting its installation to the transmission grid (line/cable and other necessary equipment).
- Deep
  - Shallow + all other reinforcements/extensions in existing network, required in the transmission grid to enable the grid user to be connected.

Country	Charge Type
Belgium	Mainly shallow
Denmark	Super shallow to partially shallow
Germany	Shallow to super shallow
Netherlands	Shallow
Norway	Shallow
UK	Shallow

González and Lacal-Arántegui (2016)