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STUDY ON BALTIC OFFSHORE WIND ENERGY COOPERATION UNDER BEMIP

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Study objectives

- Study supporting the creation of an initiative to support the development of *offshore wind power* under BEMIP*
- Main aim: Gather information on conditions for offshore wind
  - Assess offshore wind potential and identify locations in the Baltic Sea Region,
  - Opportunities for and obstacles to coordinated development of offshore wind in the BSR
- Develop a roadmap for the implementation of a coordinated offshore wind strategy in the region

** The project is a response to the inclusion of renewable energy within BEMIP, and to the Working Group on renewable energy's mandate to the European Commission to launch a study that will establish the basis for future cooperation.*

Based on the identified potentials and costs, the role and value of Baltic offshore wind power in the European power market, and its impact on onshore grids is evaluated

Ressource and potential

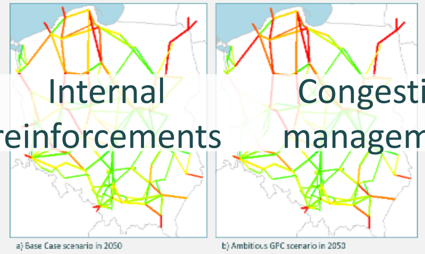
- Identification of areas for offshore wind farms
- Wind resource assessment
- Potential capacity
- Cost estimation

Market model

- Balmorel energy market model
- Investments, Generation mix, power trade, generation cost, market value
- The model accounts for CAPEX and OPEX of generation capacity, including fuel and carbon costs, and connections

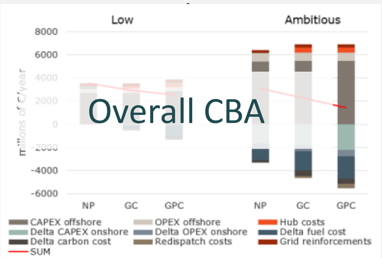
Grid model

- TheGRID model investigates internal congestions
- Cost of congestion management and the value of reinforcements
- Based on the same assumptions as used in Balmorel



CBA

- Cost benefit analysis of different deployment scenarios for Baltic Offshore Wind
- Combines
  - Cost for Baltic offshore wind
  - System effects



Areas for offshore wind deployment identified based on existing plans and layered screening process

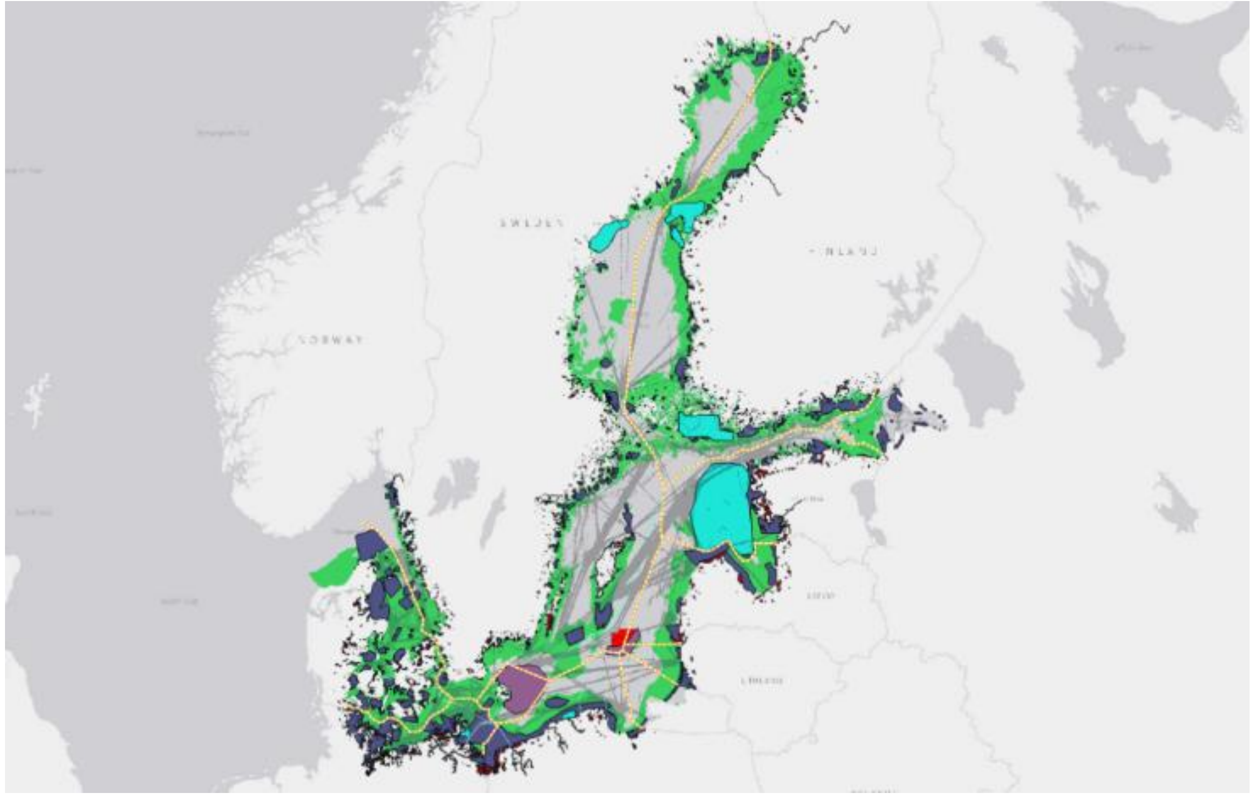
Existing offshore wind farms

Existing areas marked (data base)

New areas

identified through a screening process based on the following criteria:

- Wind conditions (minimum 7 m/s)
- Water depth (max 50 m depth).
- Minimum area (based on space needed for min. 500 MW)
- Planning issues (nature projection, shipping, fishing etc.)

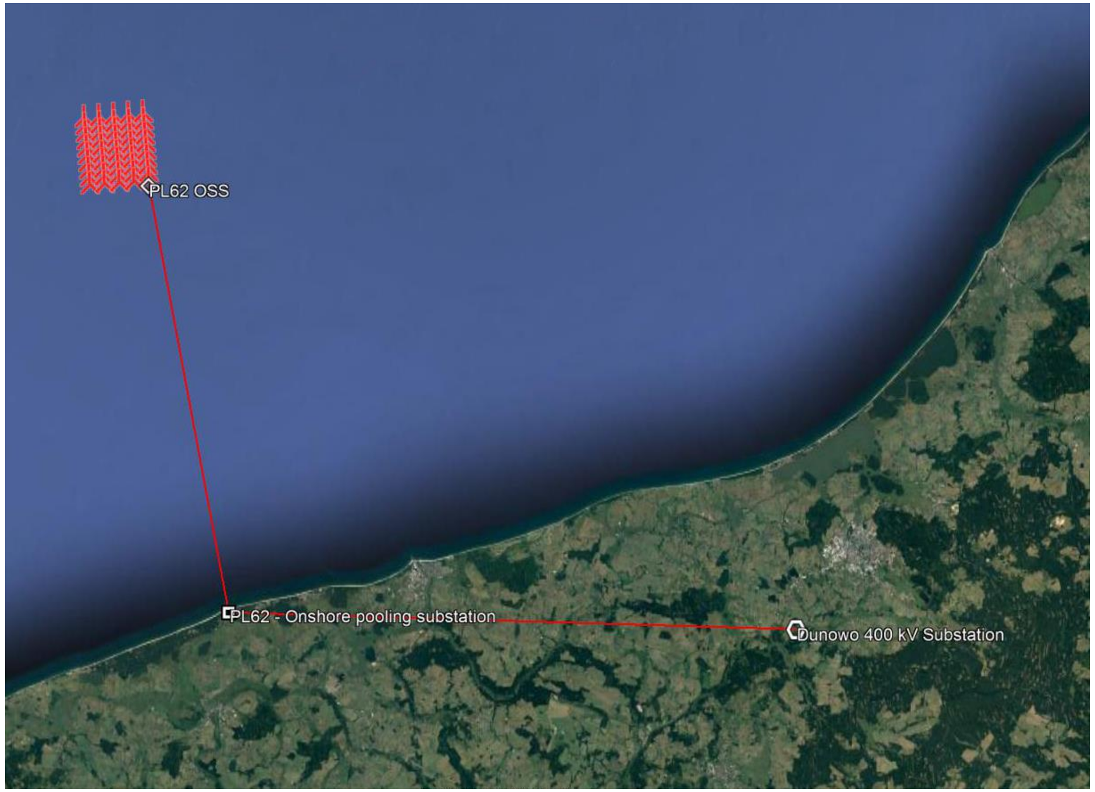


Potential defined by wind turbine type, layout and simple connection

Reference wind turbine type
10 MW, monopile foundation

Wind farm layout (blocks/clusters)
Array 5x10

Grid connection point at closest point on shore

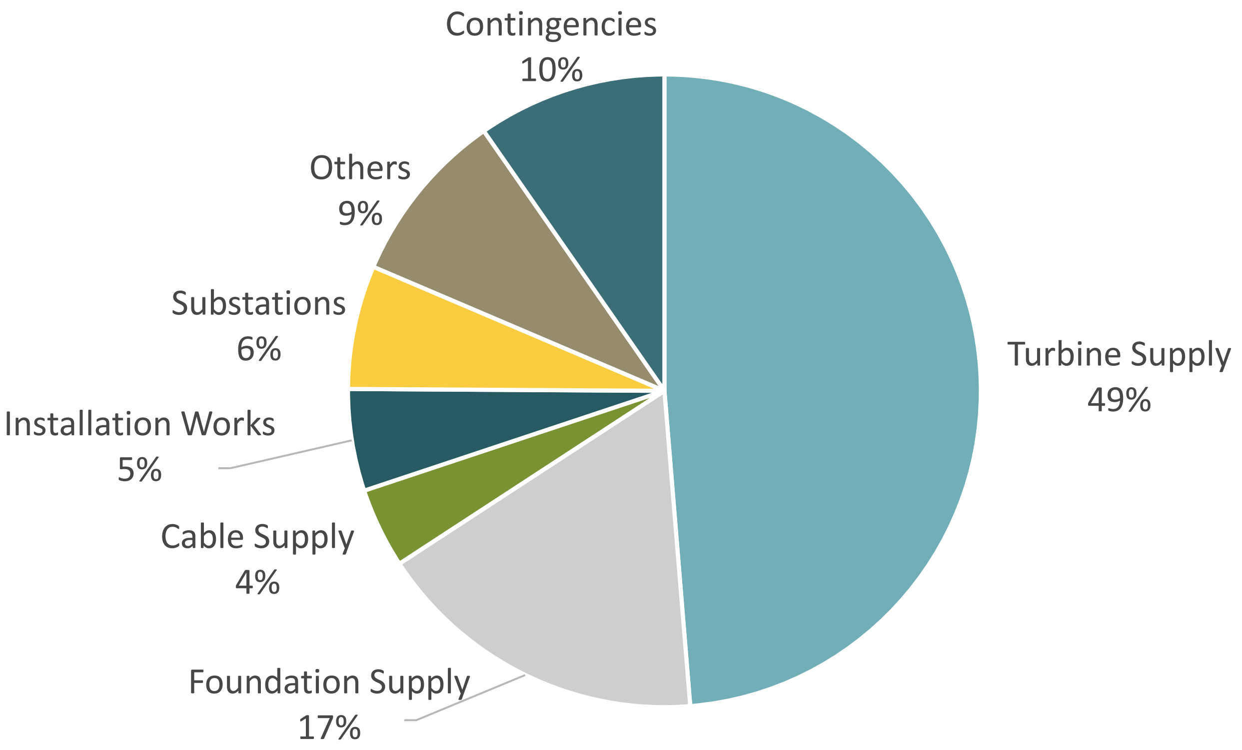


CAPEX elements: 500 MW offshore wind farm – no icing

CAPEX breakdown

CAPEX Breakdown	Cost €m
Turbine Supply	655
Foundation Supply	230
Cable Supply	55
Installation Works	70
Substations	85
Others	120
Contingencies	130
Total	1,345
CAPEX/MW	2.7

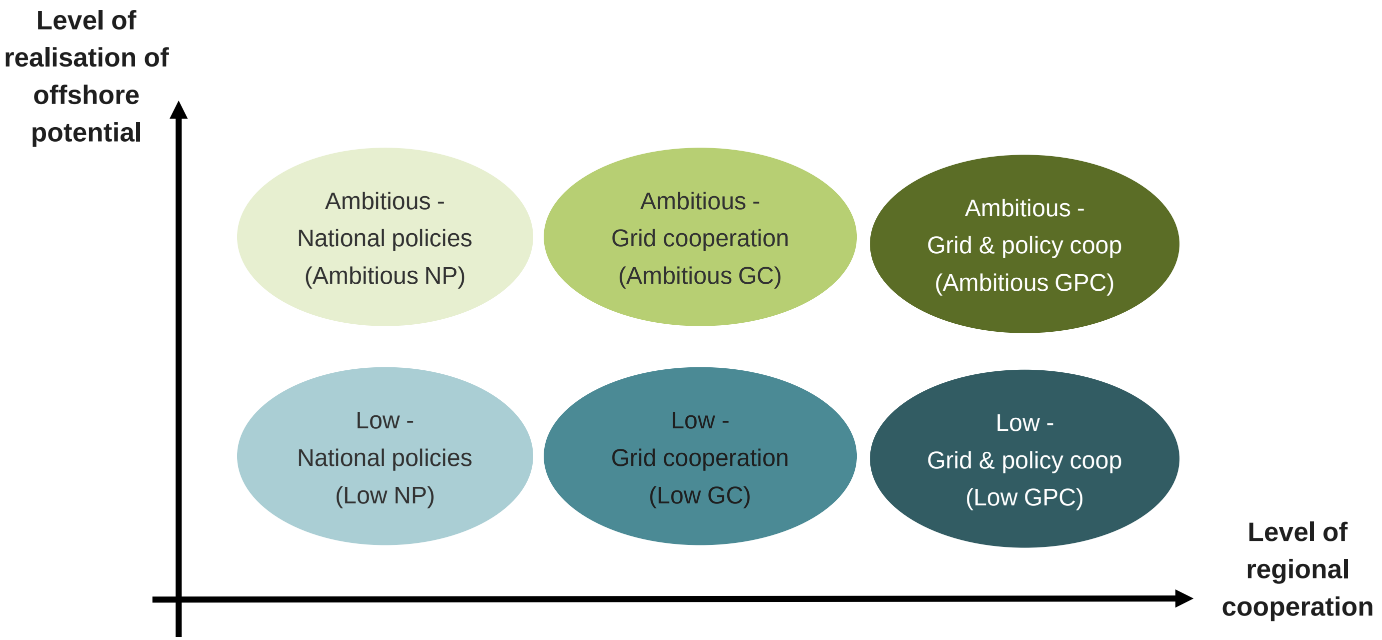
Share of CAPEX elements



We have modelled the power system under six different scenarios to explore the impact of different levels of offshore wind deployment and regional cooperation

Six scenarios

Three levels of cooperation – two levels of offshore deployment



Common assumptions for all scenarios

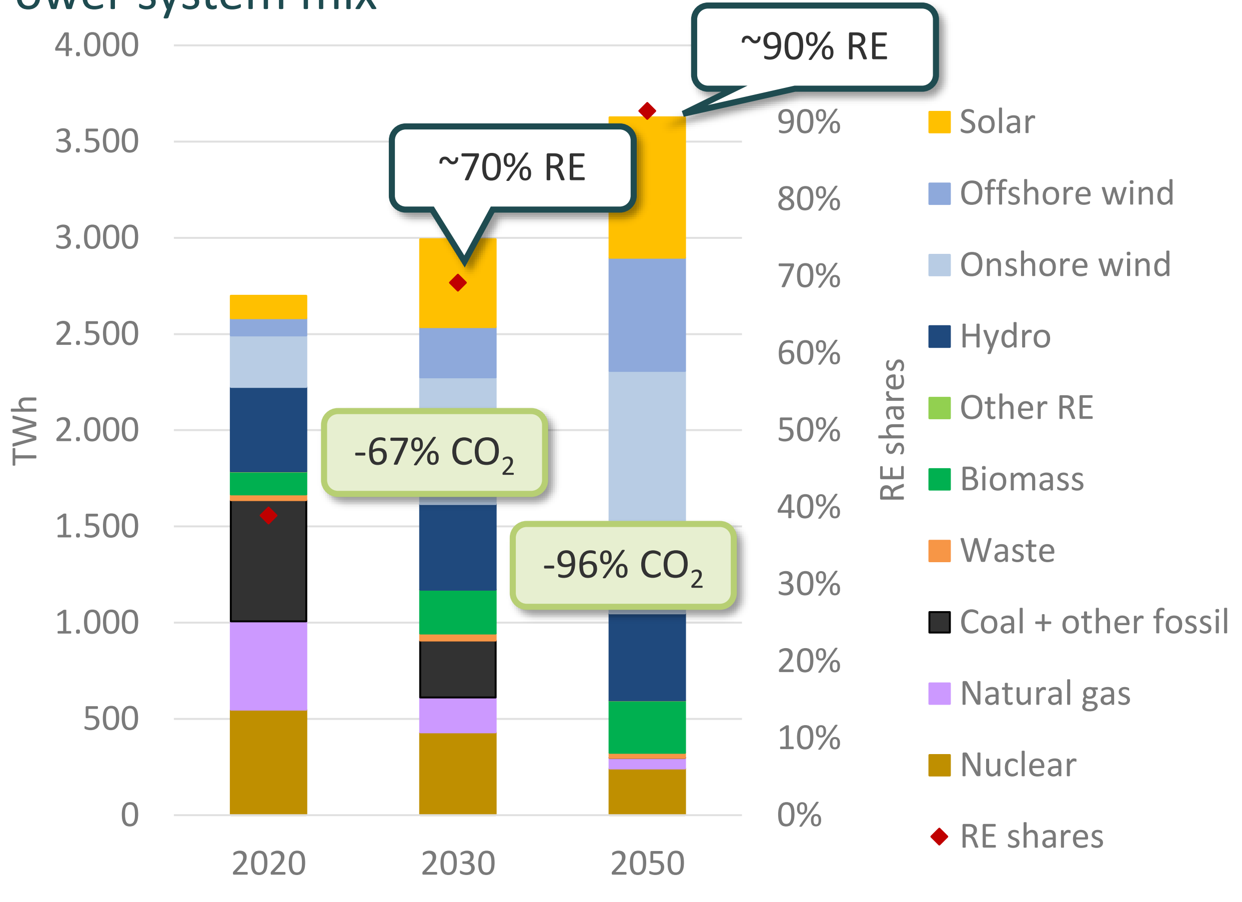
- Minimum RE development based on ENTSO-E TYNDP
- Fuel and CO_2-prices
- Available resources
- Technology development

Policy and market developments imply a radical transformation of the power sector, which provides the context for the offshore wind results

Power system development and key assumptions

- **Significant increase in RE shares and emission reductions**
  - High share of wind and solar power
  - Offshore wind power accounts for around 16% of total generation in 2050
- In the long run, **new demand will be covered by RE**
  - Offshore wind can play a key role
- **How well variable renewable energy is integrated** determines the value of wind and solar power in general
- Even though assumptions were set prior to the European Commissions Long Term Energy Strategy, we consider the pathway shown here to be compatible with the long term decarbonisation target

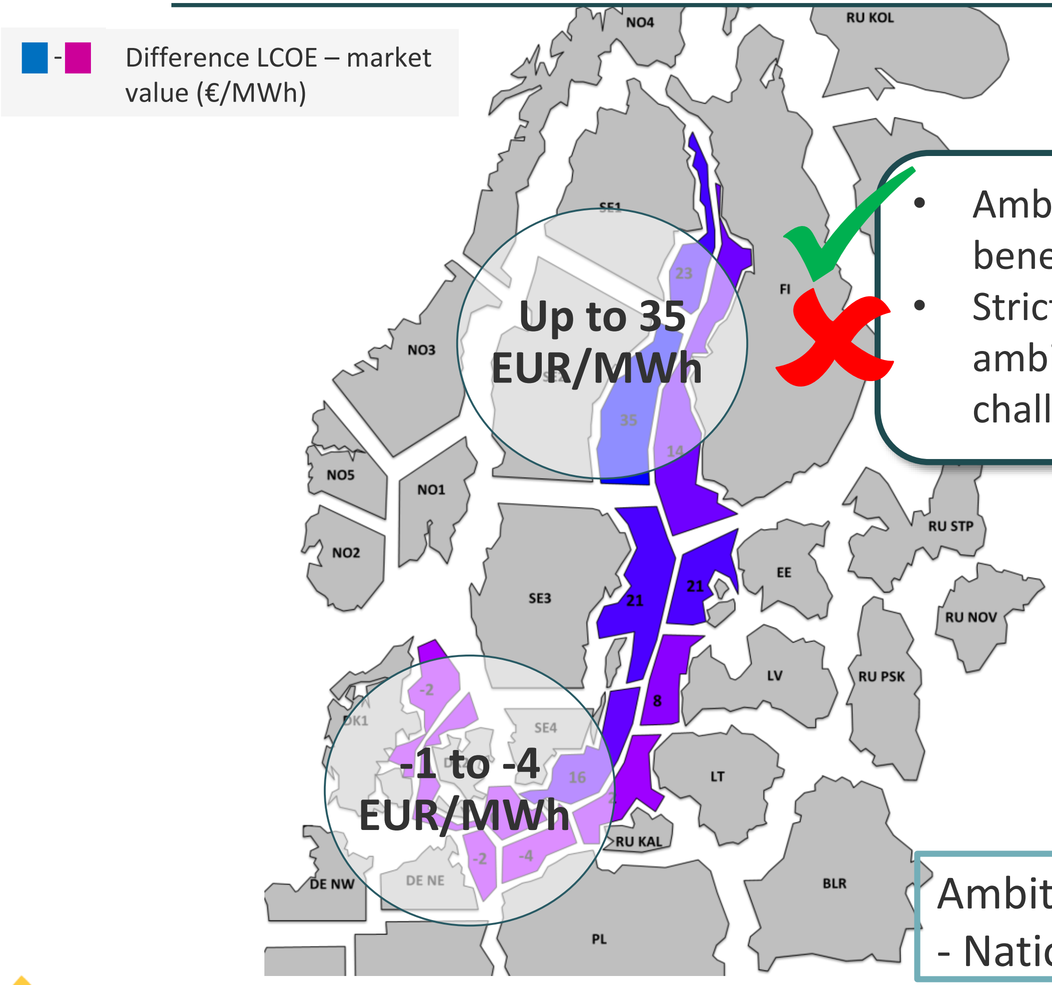
Power system mix



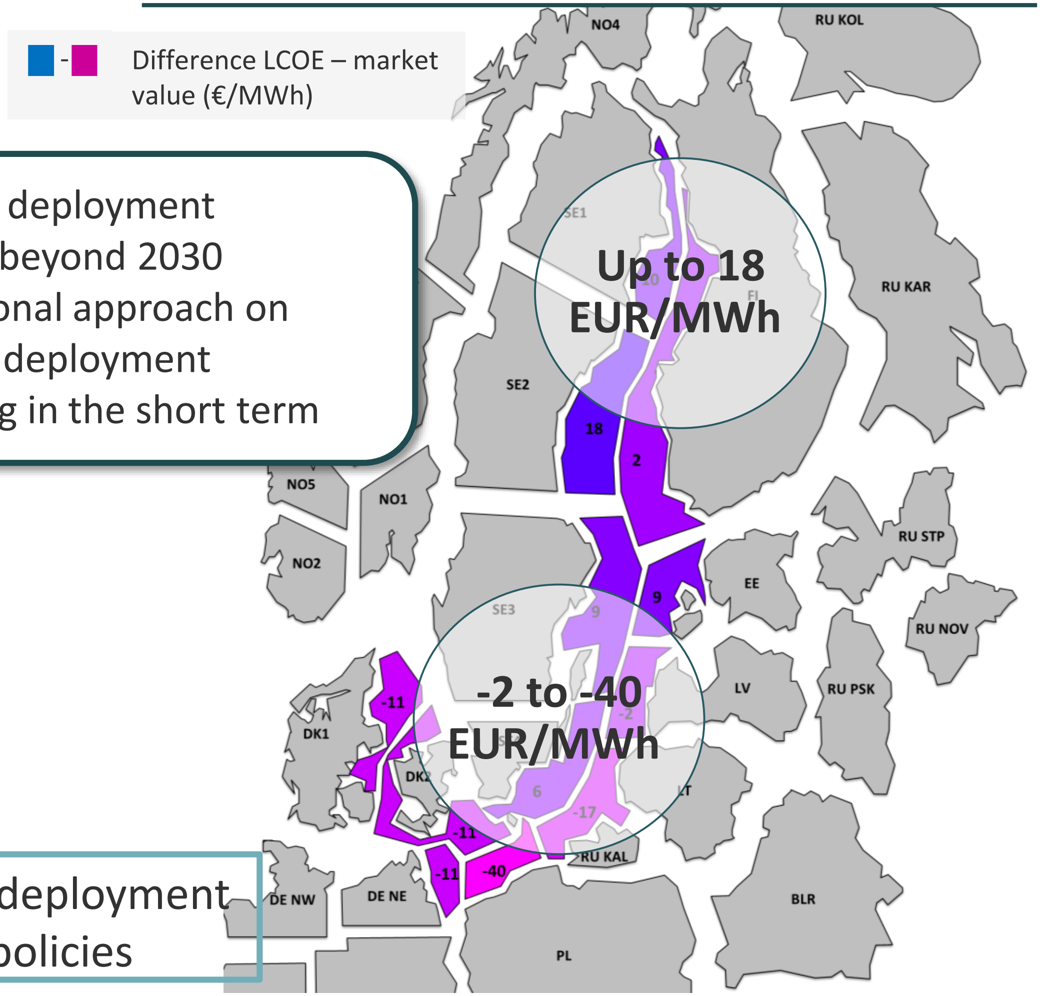
Power system mix shown for Low national policies scenario

The difference between estimated costs and returns varies across the Baltic Sea

Difference LCOE minus market value 2030



Difference LCOE minus market value 2050



- Ambitious deployment beneficial beyond 2030
- Strict national approach on ambitious deployment challenging in the short term

Ambitious deployment - National policies

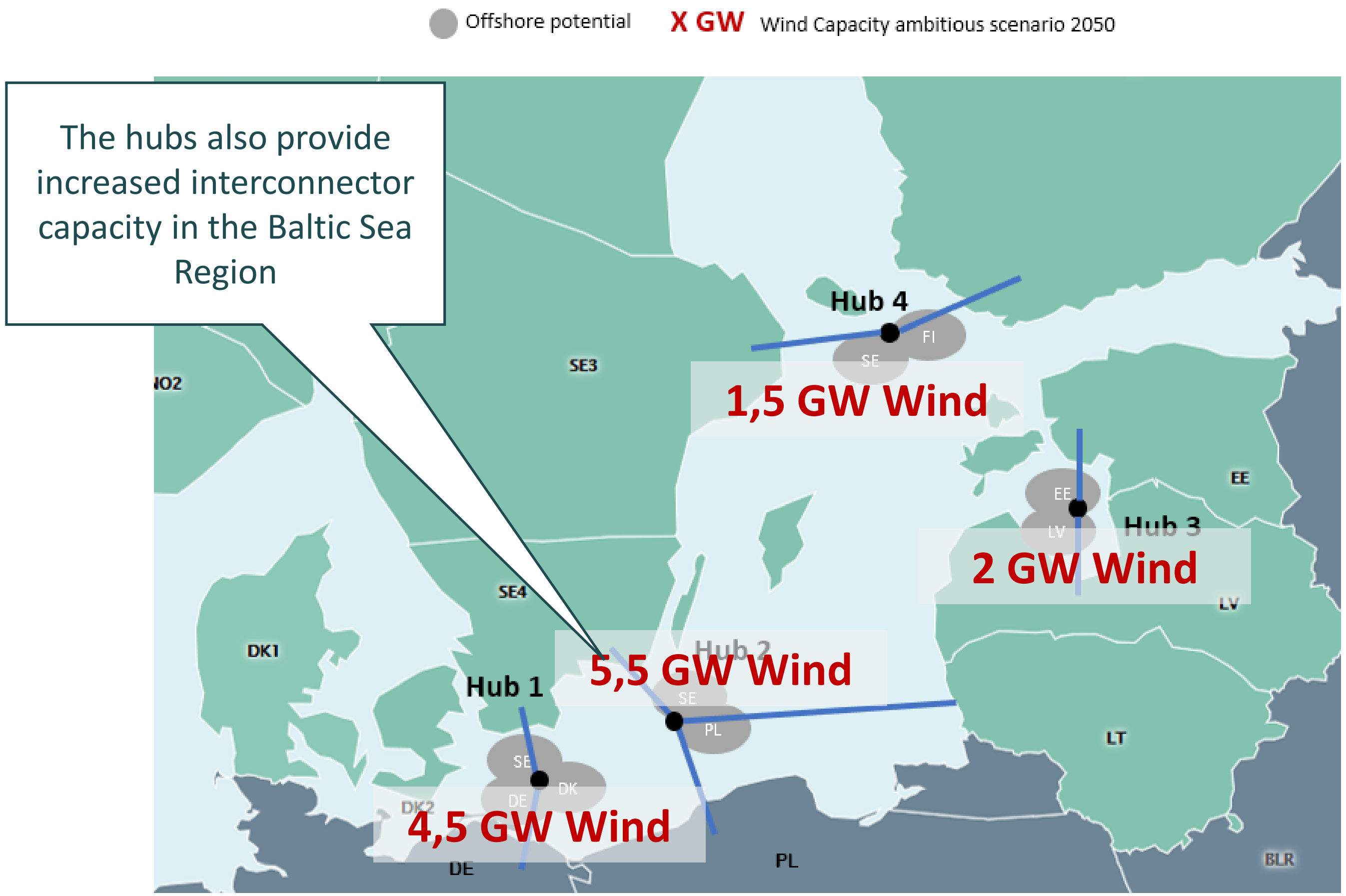
Difference between LCOE and market value shown for Low National Scenario

In the GC and GPC scenarios the effects of offshore grid and policy cooperation is evaluated

Regional cooperation

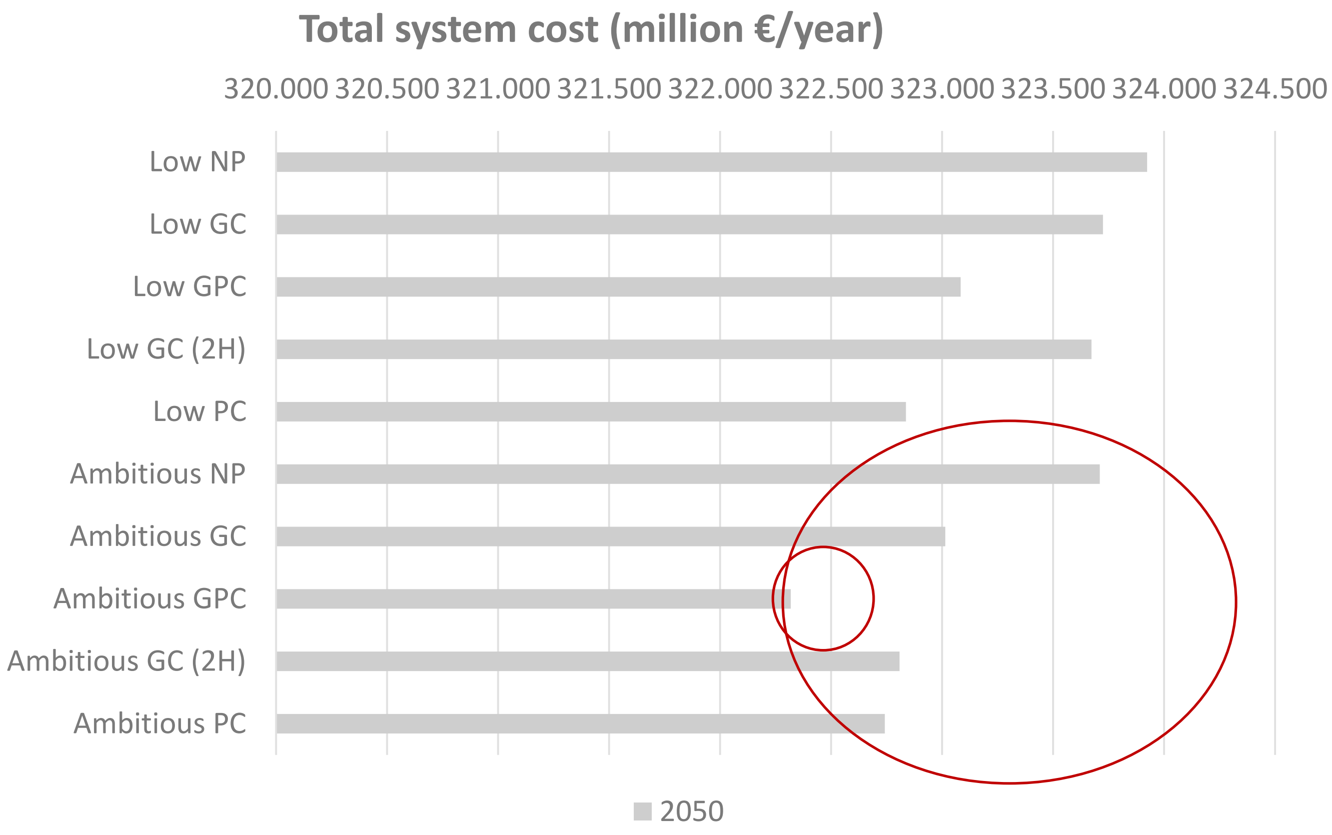
1. Grid cooperation (GC)
   - Cooperation on 4 offshore hubs, connecting both offshore wind power and power systems
   - Around 45% of Baltic offshore wind power deployment at hubs
   - Remaining offshore wind power deployed according to national policies
2. Grid and policy cooperation (GPC)
   - Cooperation on 4 offshore hubs
   - Mechanisms to choose best sites for deployment of offshore wind power across the entire Baltic Sea

Ambitious scenario



Baltic offshore wind power can significantly reduce total generation costs in the long run

Total generation costs by scenario 2050



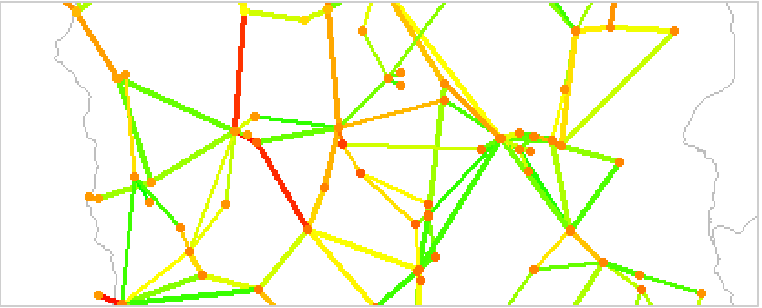
Observations

- Total generation cost:
  CAPEX (all new generation), incl. connection to onshore grid + OPEX, incl. fuel and emission
- Policy cooperation is always beneficial, and can enable cost-efficient ambitious deployment levels in 2030
- Ambitious deployment beneficial if combined with policy cooperation
- Grid cooperation challenging in 2030, but promising in an ambitious deployment scenario
- Ambitious deployment beneficial in 2050
- Grid and policy cooperation cost effective

TheGRID model used to analyse the impact of offshore investments on redispatch costs

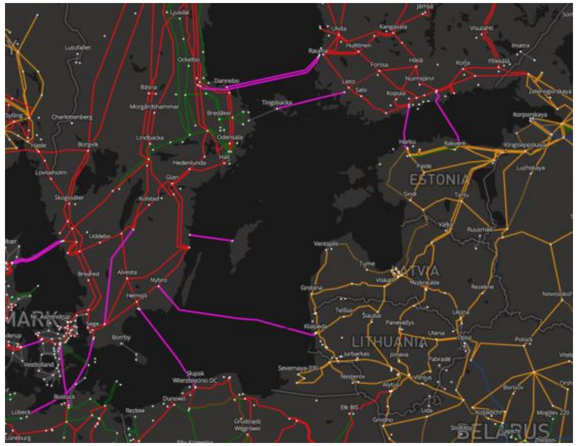
Assumptions and approach

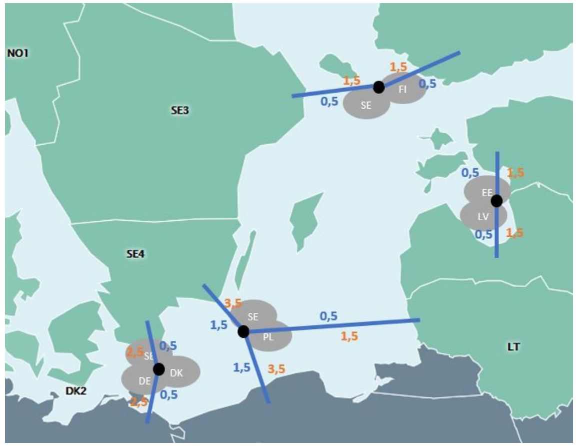
- In the grid model, we have included all countries bordering the Baltic Sea: Estonia, Lithuania, Latvia, Poland, Germany, Denmark, Sweden, Finland, Norway
- All scenarios are compared with a base case scenario without offshore wind

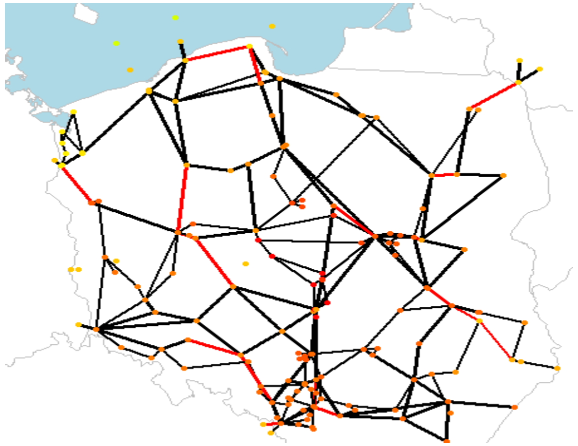
2020	2030	2050
	entsoe	
Current grid topoplogy, ongoing and known projects	TYNDP National plans	Analysis of grid congestions and shadow prices in a base case given expected increase in demand and changes in generation mix

Network impacts under each of the scenarios are analyzed

Detailed Grid Model of all BEMIP countries	Modelling simple and advanced offshore connections	Detecting congestions due to offshore wind deployment	Cost Benefit Analysis
▪ Detailed grid modelling of all BEMIP countries solved using a linearized power flow. ▪ Assessing the same offshore wind connections as in rest of modelling.	▪ Aligned assumptions with the power modelling results ▪ Modelling of advanced connection options	Identify, for all scenarios, a list of: ▪ Areas with congestion ▪ Congested lines ▪ Cost estimates for upgrades ▪ Critical offshore projects driving congestions	▪ Report detailing the cost and benefit elements of the possible grid investments

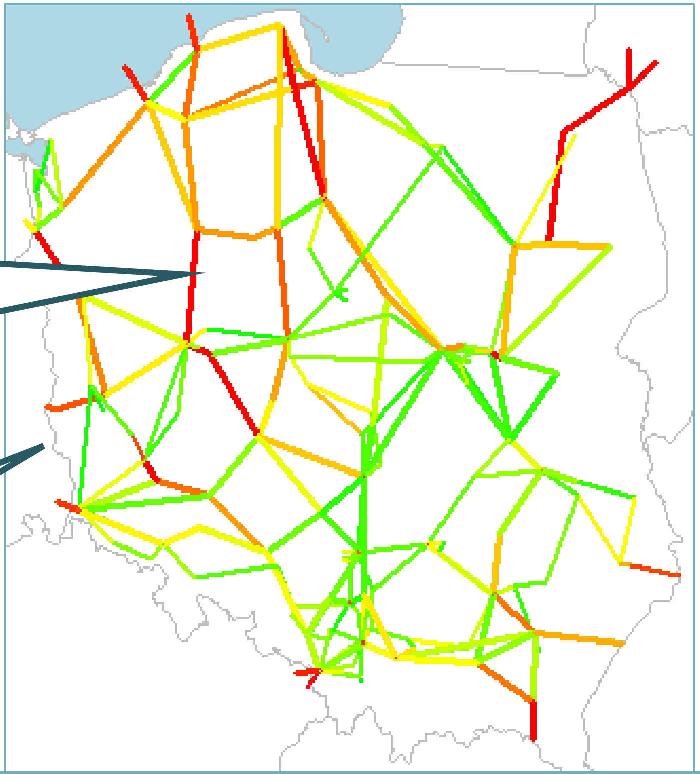






Towards 2050, grid constraints emerge in all scenarios. Increased cooperation reduces strain on existing interconnectors

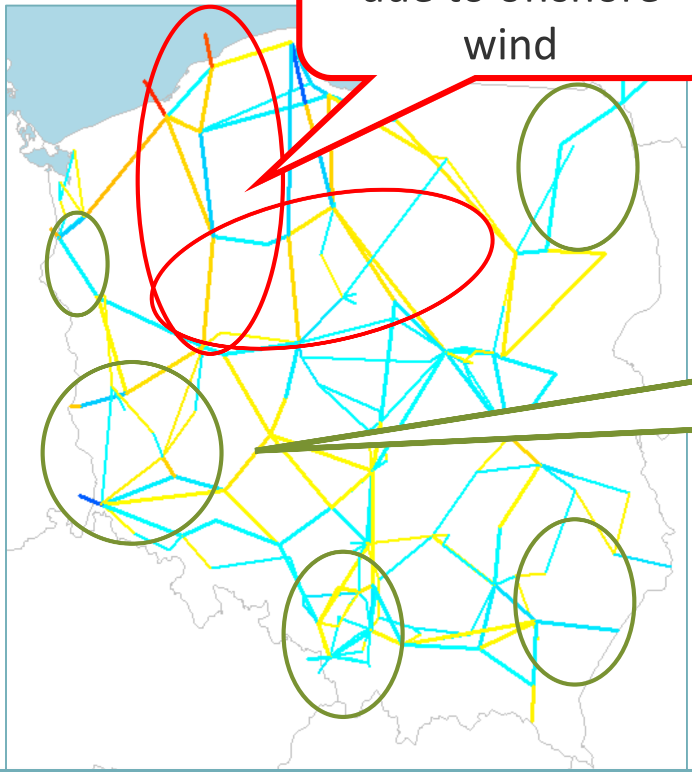
Base Case scenario (2050)



Grid strained in 2050 due to increasing demand

Interconnectors overloaded

Increased strain due to offshore wind



Changes in the Ambitious GPC scenario (2050)

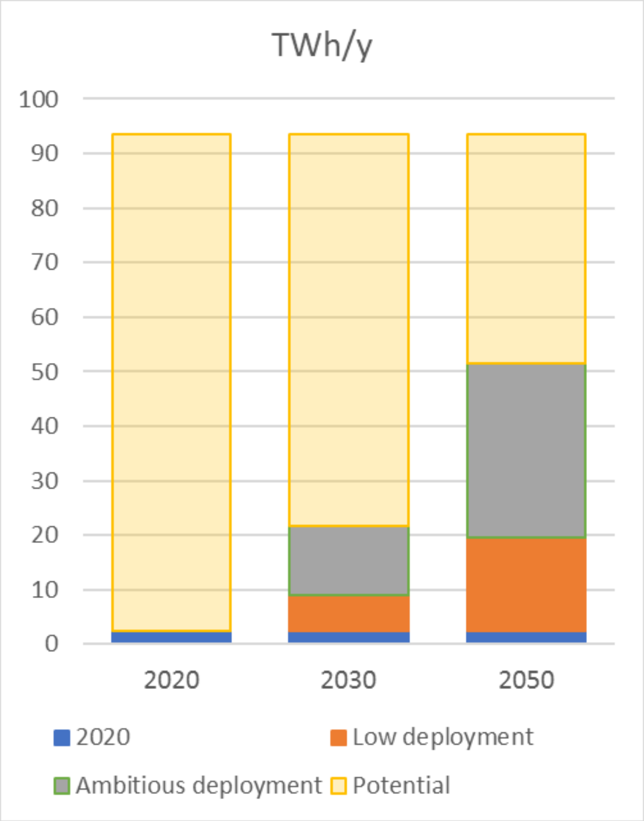
Reduced strain at existing interconnections

Colour code
blue: less utilised
yellow: more utilised

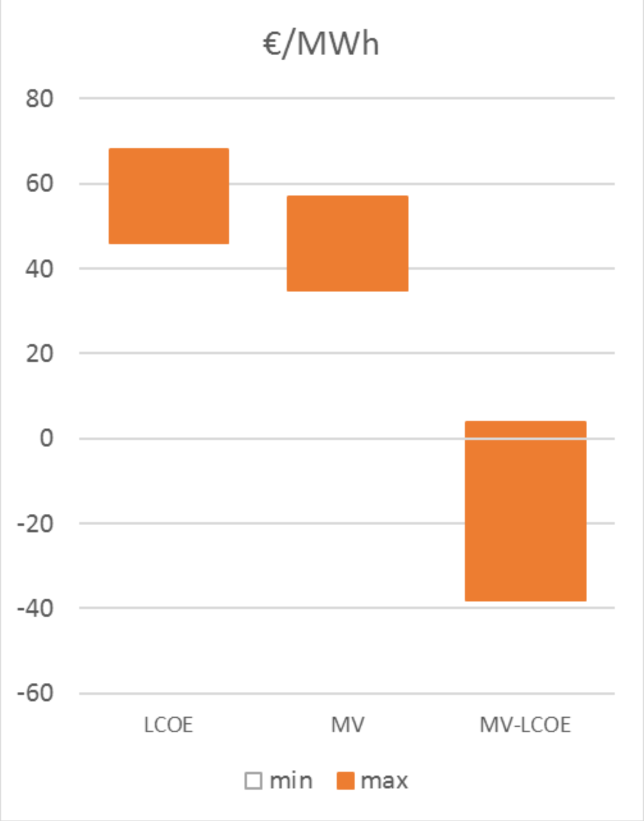
The main driver for grid upgrades in Poland and the Baltic States is **increasing local demand**, *not* offshore wind capacity.
Both additional import capacity and additional offshore capacity can create challenges for the grid.

Clear scope for *better utilization* of offshore wind energy through a regional approach

Realistic offshore wind potential surpasses realistic deployment levels



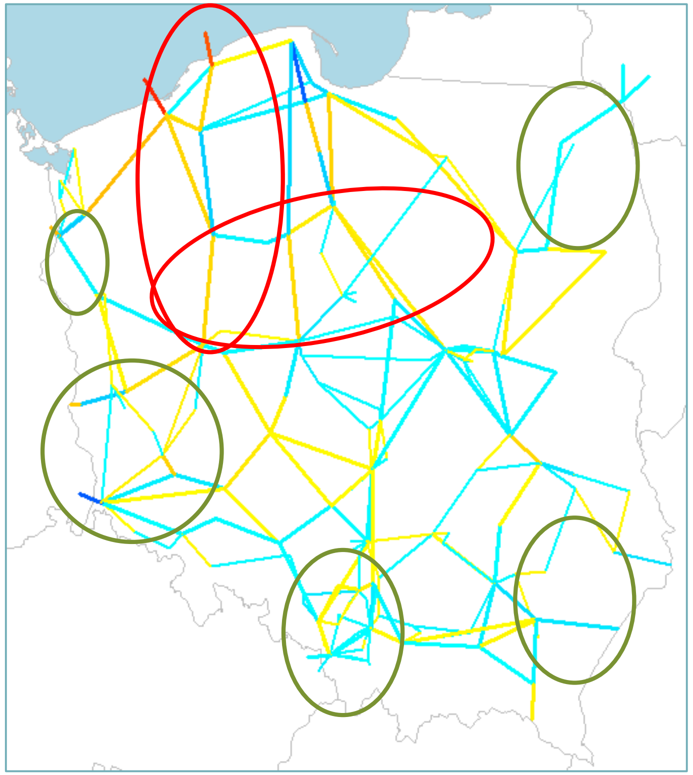
Varying LCOE of offshore wind and differences in market value between jurisdictions (2030 numbers)



Efficient regional deployment shifts large volumes between jurisdictions (2030 numbers)

The cost impact on onshore grid costs is manageable by *coordinated long-term planning*

Changes in congestion patterns imply changes in optimal grid investments



The energy transition – RES generation and electrification – requires reconfiguration of onshore grids towards 2050

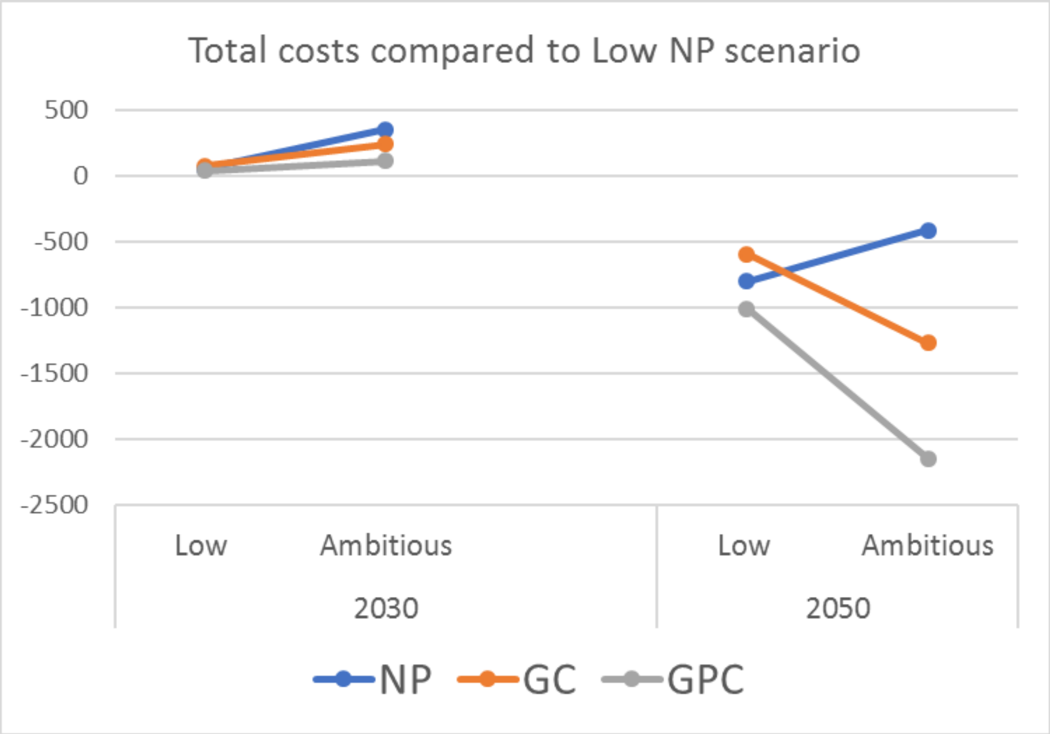
Ambitious deployment of offshore wind power changes flow patterns and thus the optimal grid configuration

Onshore grid costs do not have to increase significantly if regional offshore wind power ambitions are taken into account in long-term grid planning

However, in a future with ambitious offshore wind power deployment, grid costs to some extent also shift between TSO areas

Clear scope for *increased* offshore wind power ambitions through cooperation

CBA – Costs compared to Low NP scenario



Potential efficiency gains

Offshore wind costs: Clear reduction in costs through cooperation

Total system costs: Clear reduction in the long term

- Offshore wind competitive
- Market effects increase the efficiency of renewable energy utilization in general

Highest total benefits realized in the ambitious scenario with cooperation on grid *and* policies

Possible additional returns to optimized hub configurations

Results show clear benefits of regional coordination of offshore wind power development

- Baltic offshore wind power could be a cost-effective form of renewable generation for the BEMIP states, depending on cost developments and the CO2 price level, and on the degree of regional coordination and cooperation.
  - Grid parity is reached in some areas already by 2030 and makes a cost-efficient contribution to power generation in the region.
  - Levelized costs fall and the market value increases due to, inter alia, increasing EUA prices.
- Effort sharing policies would more efficiently realise the offshore wind power potential of the region as a whole
  - Notably because offshore wind's market value varies markedly across the region. The southern end of the Baltic Sea is more attractive for development owing to its proximity to centres of demand.
- Offshore wind power and network investment planning should be considered together.
  - Significant investment in network capacity is needed in the region to accommodate the shift to low-carbon resources and increases in demand driven by electrification in heating and transportation.
  - Connection of offshore wind farms and offshore hubs increase congestion around the point of connection, but support lower utilization elsewhere in the grid.
  - Efficient integration of offshore wind in the Baltic Sea Area requires careful consideration and coordination of interconnectors as well as internal grid development.

Administrative barriers for coordination differ by country, remedies include better planning data, sharing of best practices on licensing and enhanced TSO coordination

Spatial Planning and Data Management	▪ Several shortcomings at the national level on data management, ranging from a lack of data to fragmented data spread across many providers ▪ Data quality is often an issue
Licensing Procedures	▪ Complex and unclear processes (sometimes even if a one-stop shop is nominally in place) ▪ Ineffective stakeholder engagement that fails to identify objections early in the process ▪ Long or repetitive appeals processes that increase investor uncertainty
Insufficient regional grid planning	▪ TSO-level cooperation on offshore grid planning not sufficiently supported ▪ No standing group tasked with considering the network requirements & potential solutions related to offshore wind hubs

Regulatory and market barriers – unlevel playing field and lack of coordination

Support mechanisms	▪ Some BEMIP countries plan tendering processes for offshore wind power, while others do not ▪ Support levels differ
Grid regulations and tariffs	▪ Marked differences in liability for transmission investment costs ▪ Connection charges and G-tariffs differ between control areas ▪ Different regulatory models for TSO investments including interconnectors
Regional Coordination	▪ Practical barriers related to the difficulty in coordinating network activity among a variety of developers and numerous TSOs ▪ Unclear framework for allocating costs and benefits of offshore transmission assets
Common long-term vision	▪ Need to identify crucial regional investments in offshore wind generation ▪ Need to coordinate and integrate regional long-term grid planning ▪ Create appropriate measures and incentives to realize regional targets

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