Optimisation of offshore grid considering step-wise investments and uncertainty

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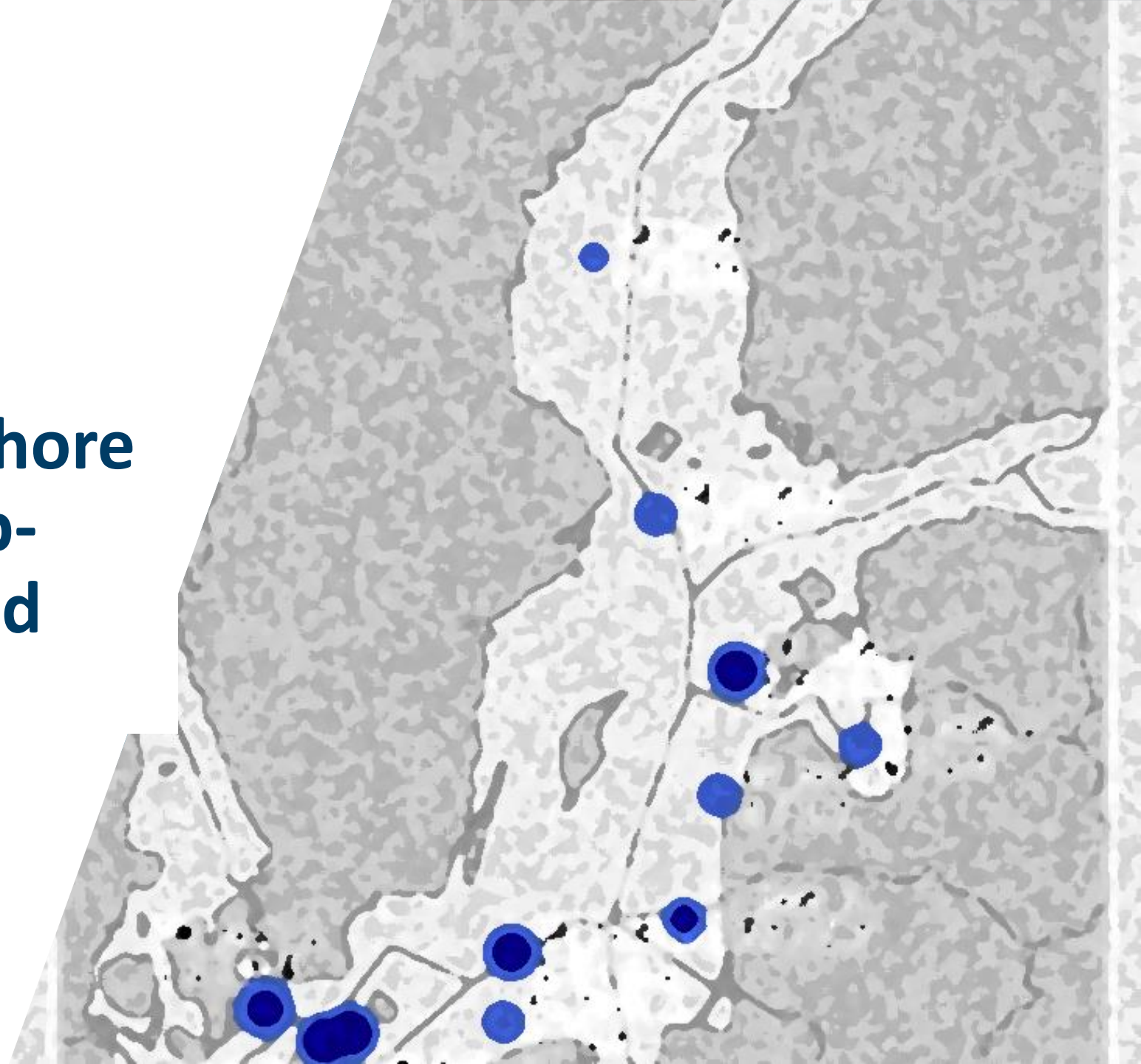


The BaltHub project

2021-2022
Funding: Nordic Energy Research

- BaltHub analyses the cost-effectiveness of Baltic Sea energy hubs using integrated energy system analysis of the Baltic-Nordic region and beyond
- Partners:
  - DTU (DK)
  - SINTEF (NO)
  - Tallinn University of Technology (EE)
  - Kaunas University of Technology (LT)
- Models:
  - CorRES
  - Balmorel (LP)
  - PowerGIM (MILP)

Results from Balmorel study

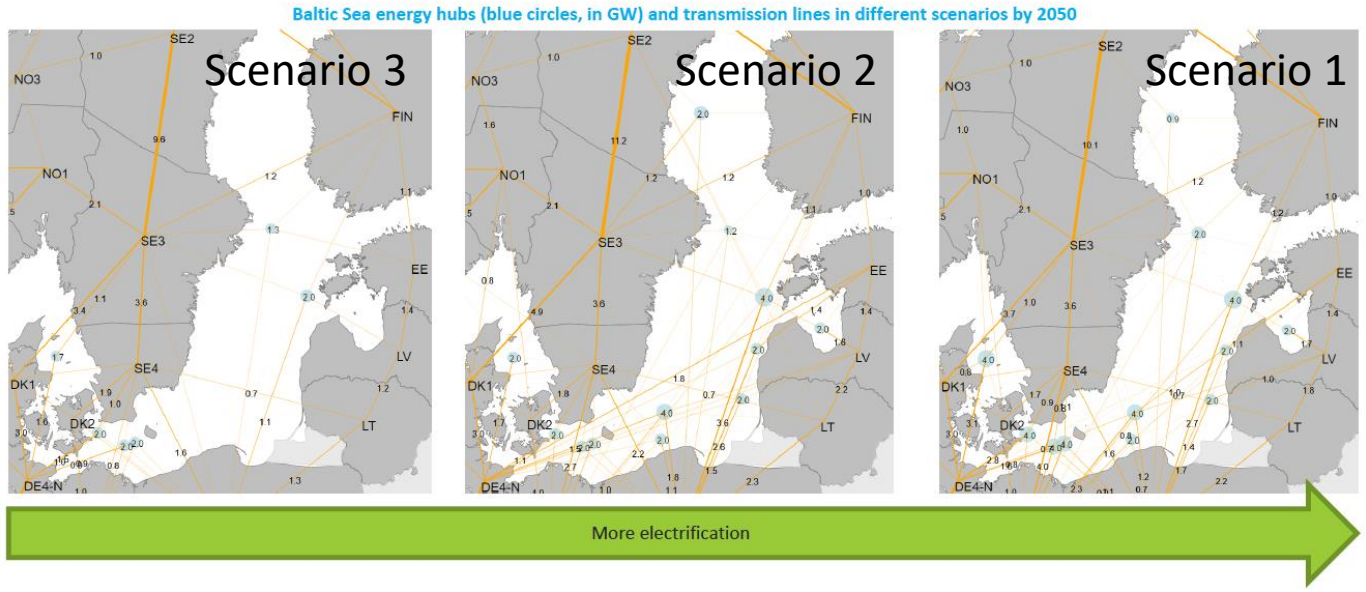


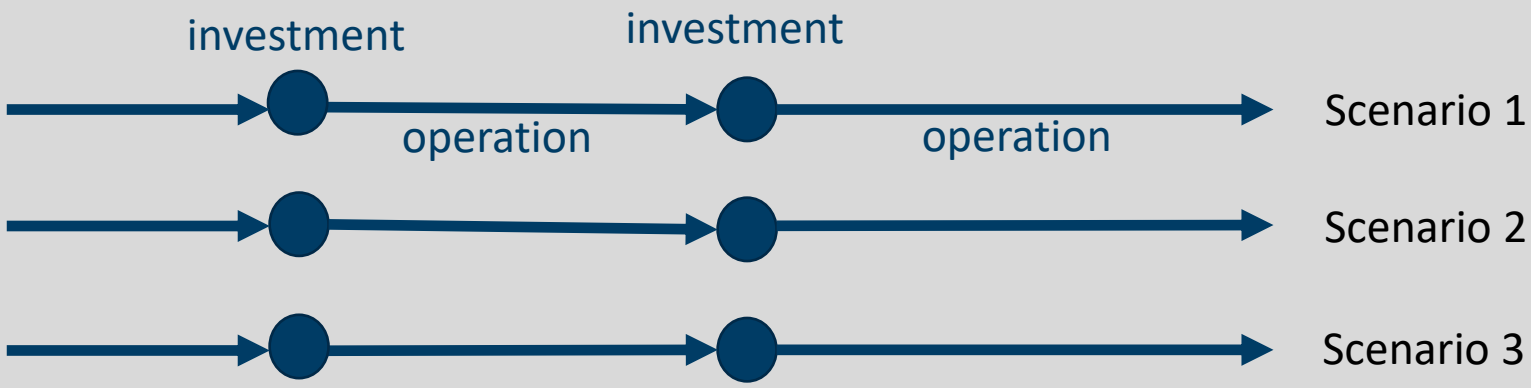
TABLE I. STUDIED SCENARIOS IN TERMS OF ELECTRIFICATION.

	Scenario	Electric heating (household & industry)	Electric mobility	Hydrogen demand (industry & transport fuels)
3	**Heat only**	Optimized	-	-
2	**Heat and Elec. Mobility**	Optimized	Operation optimized	-
1	**All Electrified**	Optimized	Operation optimized	Operation optimized

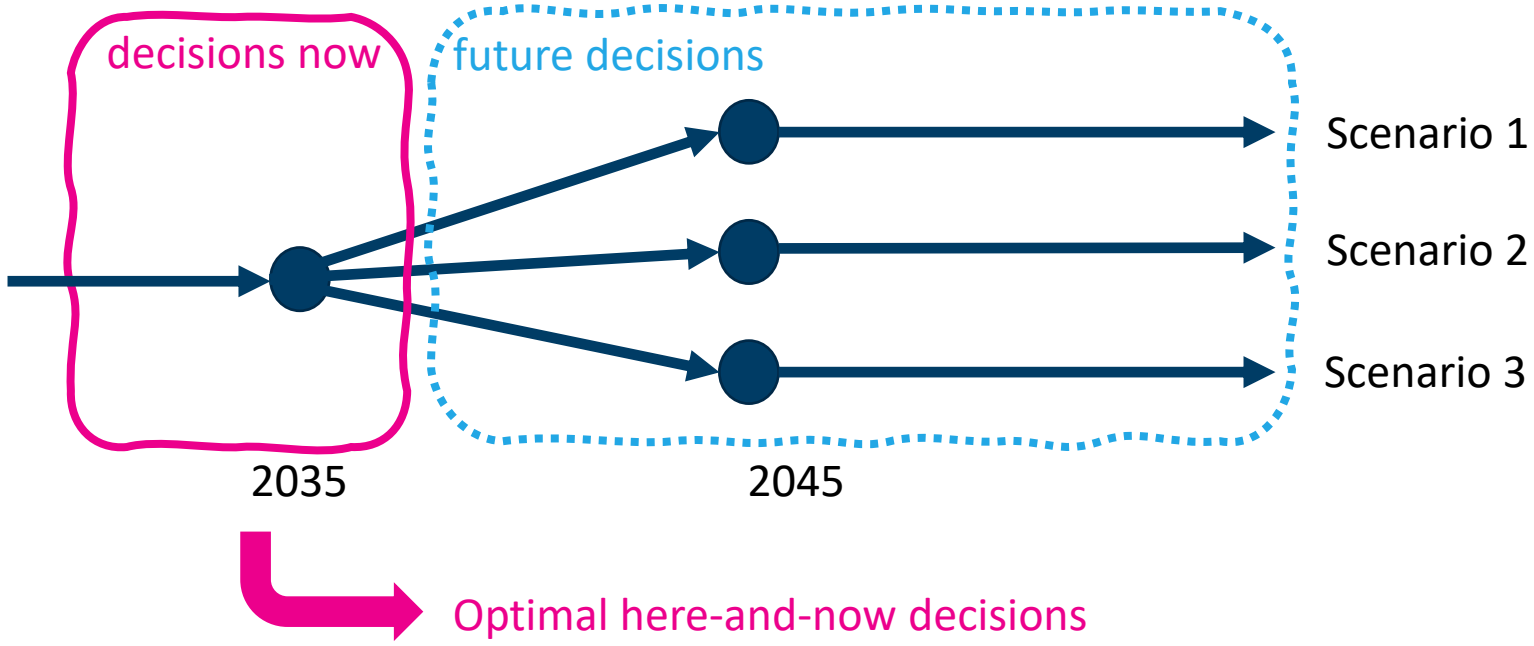
Optimisation under uncertainty
Research Question and Goal

- **Research Question**: How can optimal offshore infrastructure investment decisions here-and-now be made when the development towards 2050 is uncertain?
- **Goal**: Identify optimal here-and-now investment decisions considering step-wise development and uncertainties
  - Using the PowerGIM optimisation model
  - Using results from Balmorel study

Balmorel study
3 development scenarios



PowerGIM study
3 future scenarios



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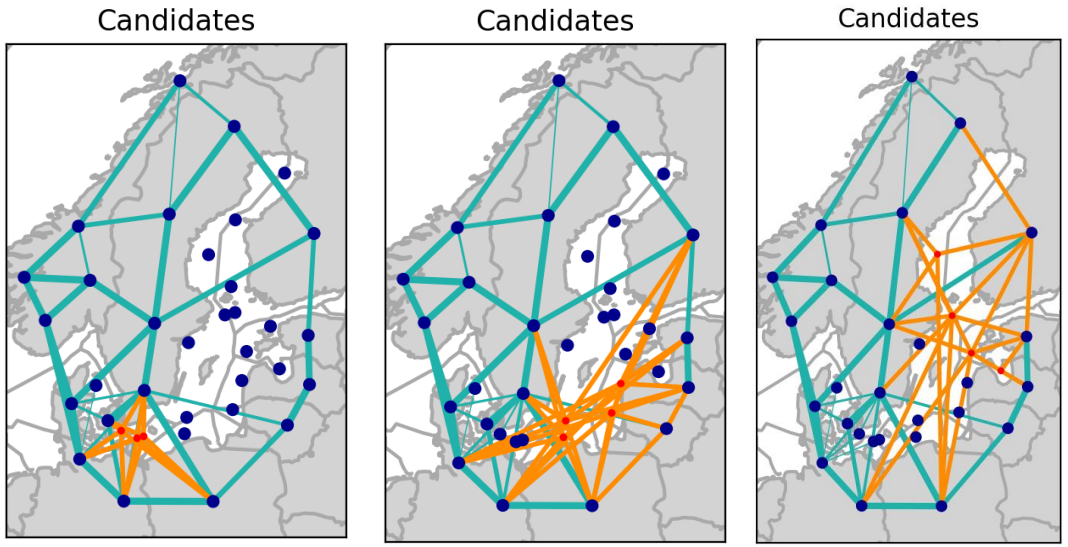
What the PowerGIM study tries to address

- Consider investments in offshore electricity grid infrastructure (hubs and HVDC connections) (variables)
- Other developments are considered as (uncertain) assumptions (input parameters)
  - Using the 3 scenarios studied in Balmorel
  - Power demand, power prices, offshore wind capacity, grid expansions outside selected region of interest
  - Variability in operating conditions (demand, prices, wind availability): Representative time series
- We consider decision for 2035 offshore grid investments within a selected region to be the “here and now” decisions of interest.

Assumptions



Baltic Sea divided into 3 regions of interest, analysed separately

3 regions of interest analysed independently

Outside region of interest: Assumptions based on Balmorel results (grid, prices, wind)

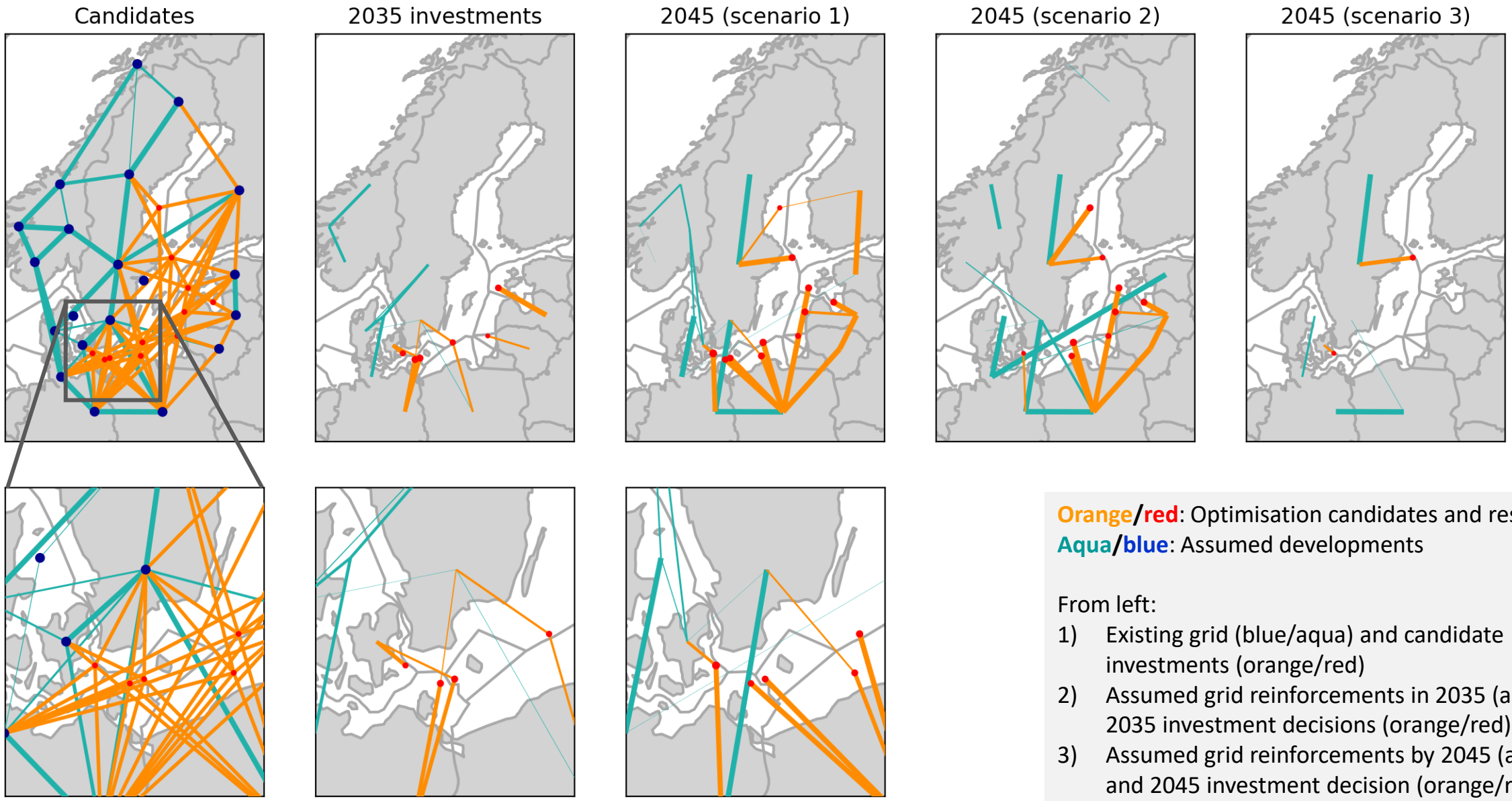
Uncertainty: Scenario 1, 2, 3 from Balmorel

2035 is considered “here and now”

Investment decisions in hubs and transmission for 2035 is done without knowing wind power capacities.

- Corresponds to a situation where a grid owner (TSO) decides grid build-out before knowing generation capacities to be installed

Combined results for the three regions put together in a single plot:

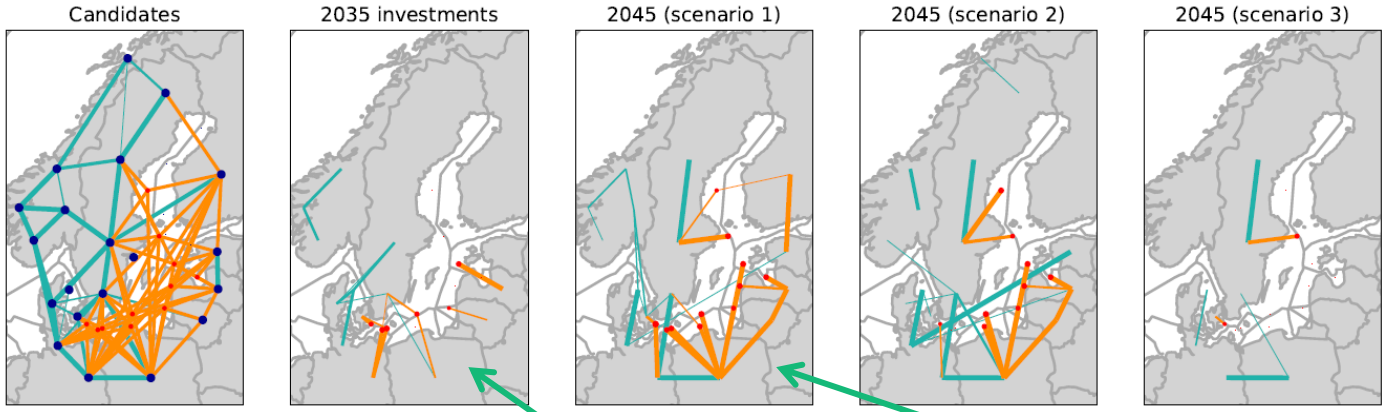


Orange/**red**: Optimisation candidates and results
Aqua/**blue**: Assumed developments

From left:

1) Existing grid (blue/aqua) and candidate investments (orange/red)
2) Assumed grid reinforcements in 2035 (aqua) and 2035 investment decisions (orange/red)
3) Assumed grid reinforcements by 2045 (aqua) and 2045 investment decision (orange/red), depending on scenario

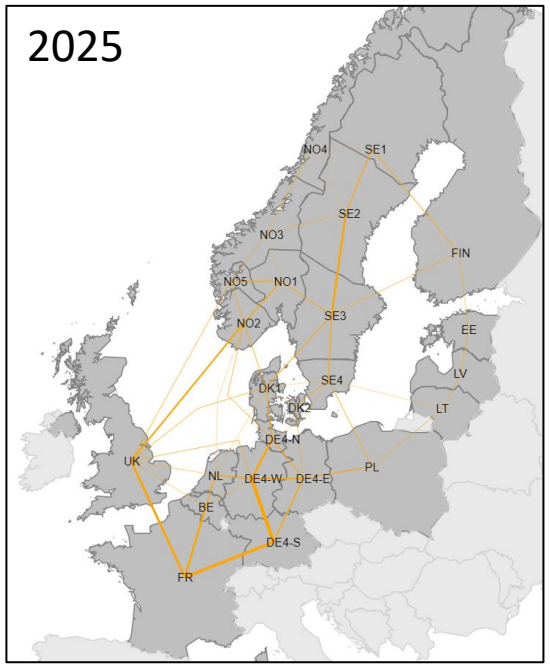
Comparison with Balmorel results

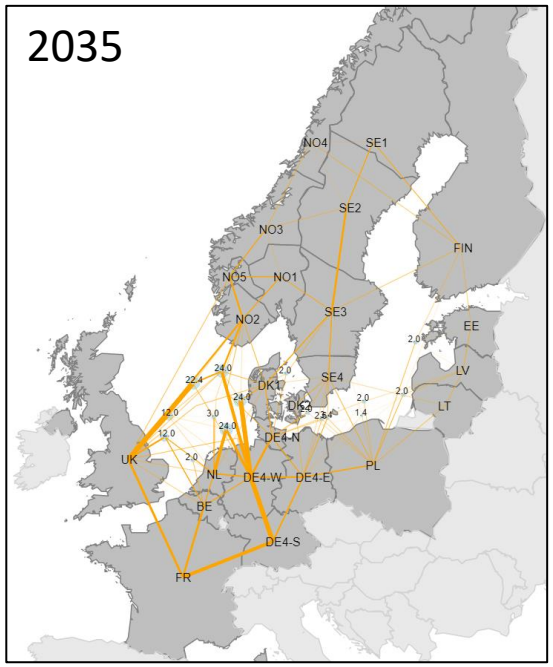


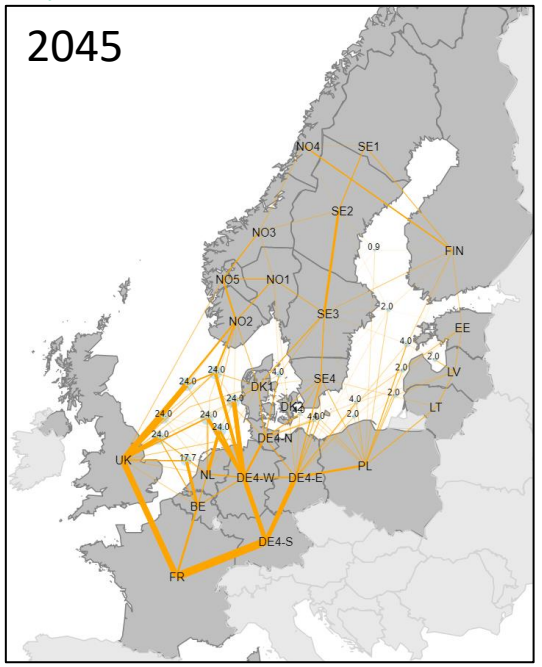
Much less offshore grid infrastcuture than in the Balmorel results

As expected with a MILP vs LP model

Balmorel (scenario 1)

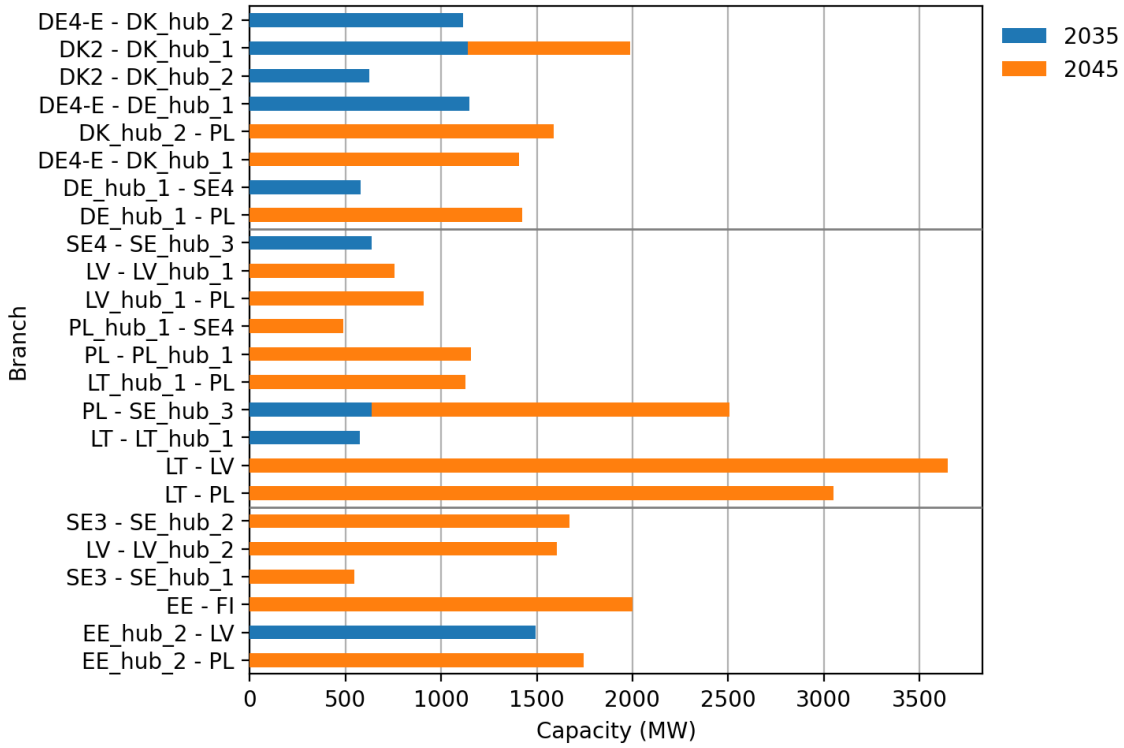




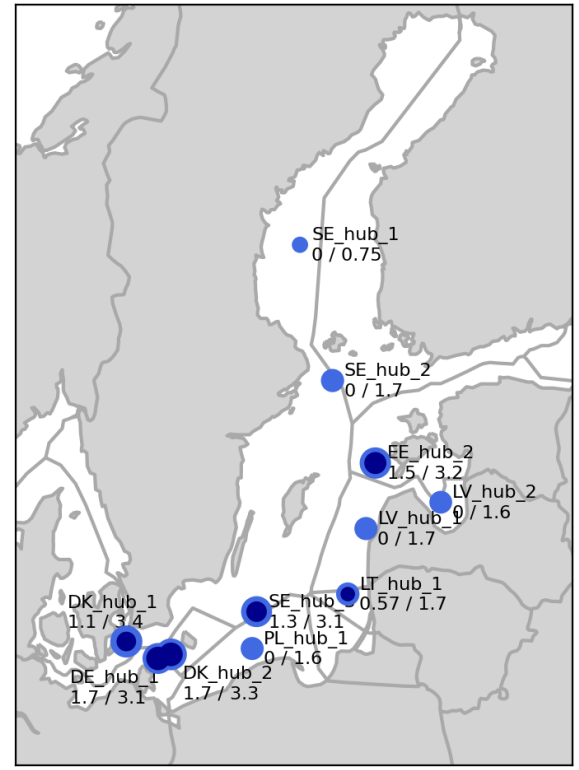


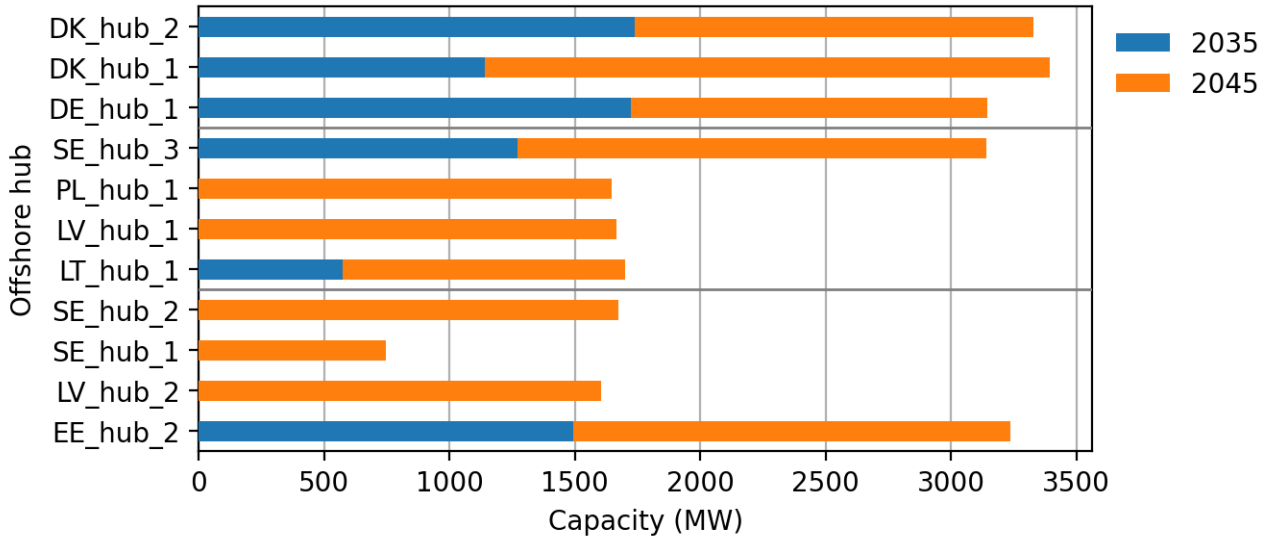
PowerIGM RESULTS –Capacities
(scenario 1)

HVDC connections

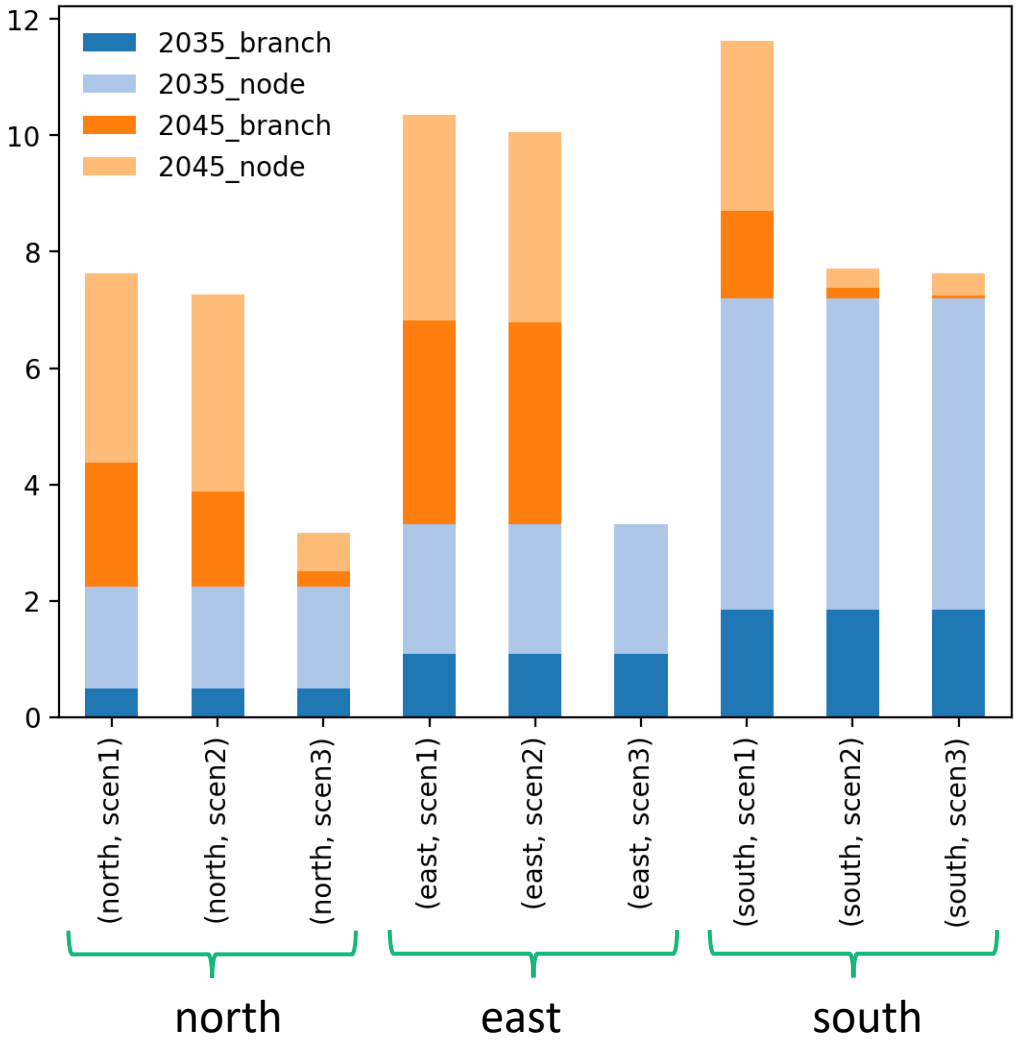


Offshore hubs:





PowerIGM RESULTS –Investments (bn EUR)



Investment costs
Split per region and per scenario

(2035 investments are independent of scenario)

Thank you for the attention