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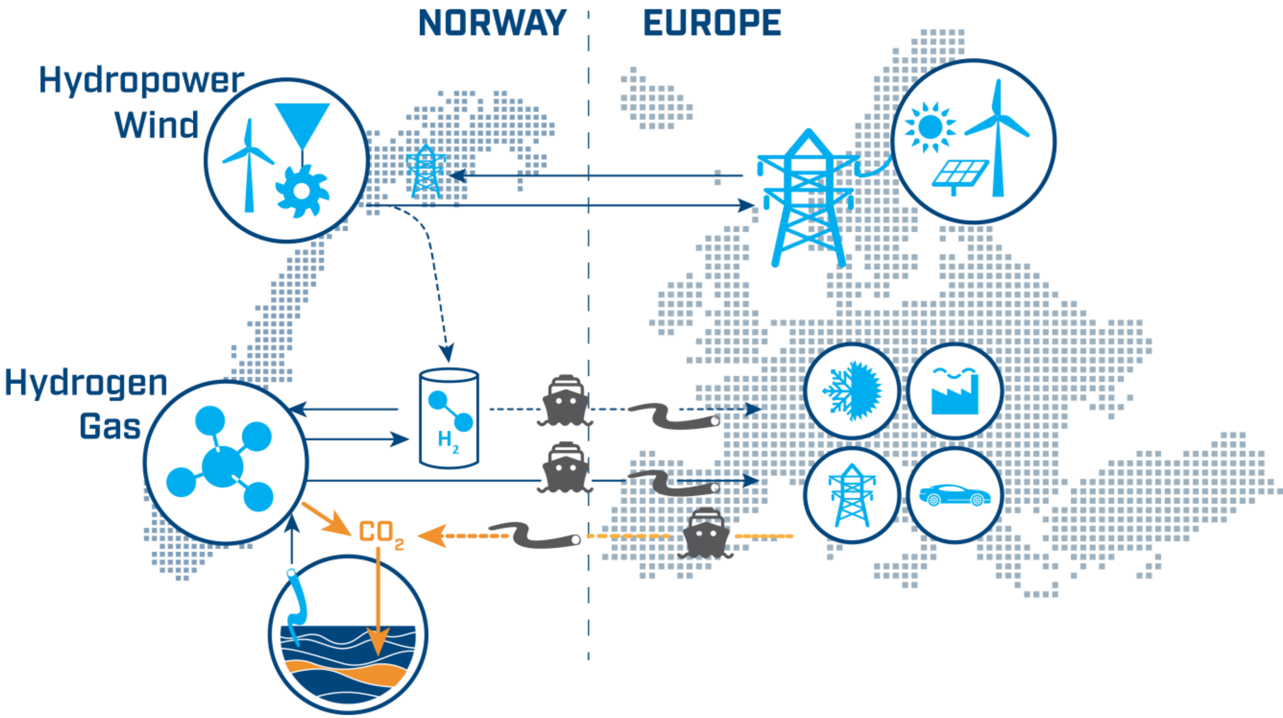
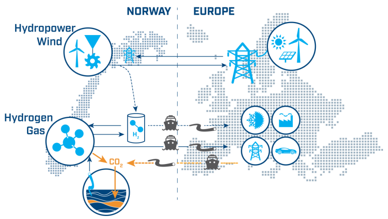


Integrated optimization of power and hydrogen infrastructure for offshore wind

Espen Flo Bødal, Julian Straus, Sigmund Eggen Holm, Lars Hellemo, Brage Rugstad Knudsen, and Dimitri Pinel

Acknowledgement:
This study has received funding by the CleanExport project - Planning Clean Energy Export from Norway to Europe, (knowledge building project 308811). The authors gratefully acknowledge the financial support from the Research Council of Norway and the user partners.



Motivation

- Offshore wind power plays crucial role for decarbonization of the economy
- Similarly, hydrogen identified as important energy vector for decarbonization of hard-to-abate sectors like industry or transport
- Coupled offshore wind power with direct linked hydrogen production *via* electrolysers can result in reduced cost through smaller costs for hydrogen pipelines compared to power lines at large capacities
- Offshore electrolysis installation is still in its infancy and accurate cost and efficiency data is difficult to obtain

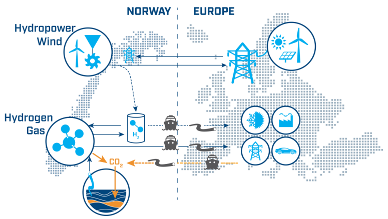
Objective

- Integrated optimization of hydrogen and electricity infrastructure for offshore wind development in the North Sea for satisfying a given hydrogen and electricity demand in neighboring countries
- Analyze the impact of the premium to be paid for offshore electrolysis on the distribution of onshore and offshore hydrogen production
- Illustrate the usage of a novel, multi energy carrier models for coupled analyses with potential for a higher geographical resolution and improved description of individual energy conversion processes compared to stands energy models

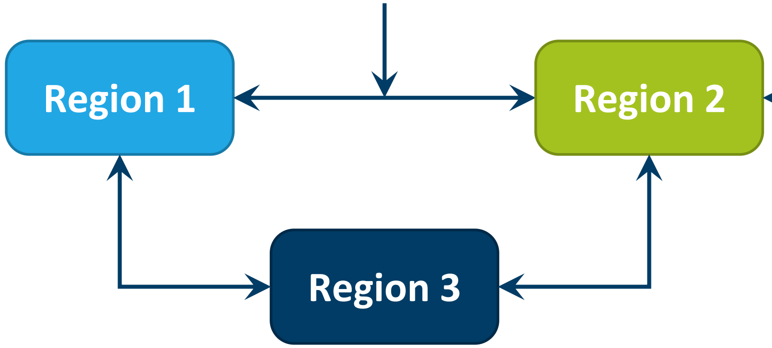
Model description

- Modular multi energy carrier model developed in Julia using the package JuMP
- Model developed as multi energy carrier model from beginning, so that
- Modularity allows for:
  - Different technology descriptions for the different technologies, like wind power, electrolysis, and regulated hydroelectricity
  - Inclusion or exclusions of a geographical representation
  - Different costing approaches (discrete, continuous, semicontinuous, and other) for the individual technologies and transmission options

  without changes to the core model
- General description as (MI)LP, but can also be extended to (MI)QP or even (MI)NLP without changes to base structure

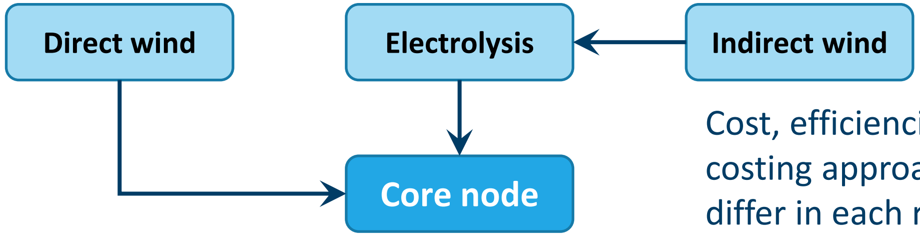


Transmission CORRIDOR for exchange of energy between areas, can include several transmission MODES with different mathematical descriptions



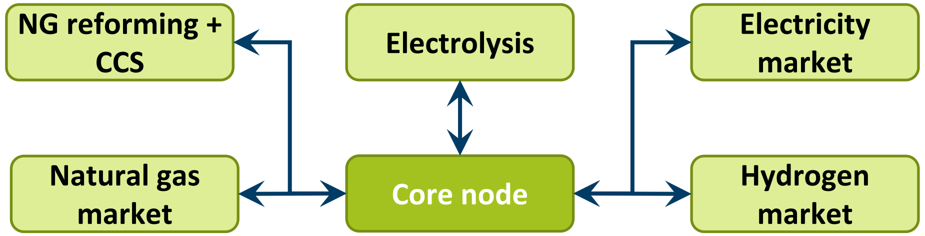
Geographic AREA with own, local energy system

Region 1 (offshore region):



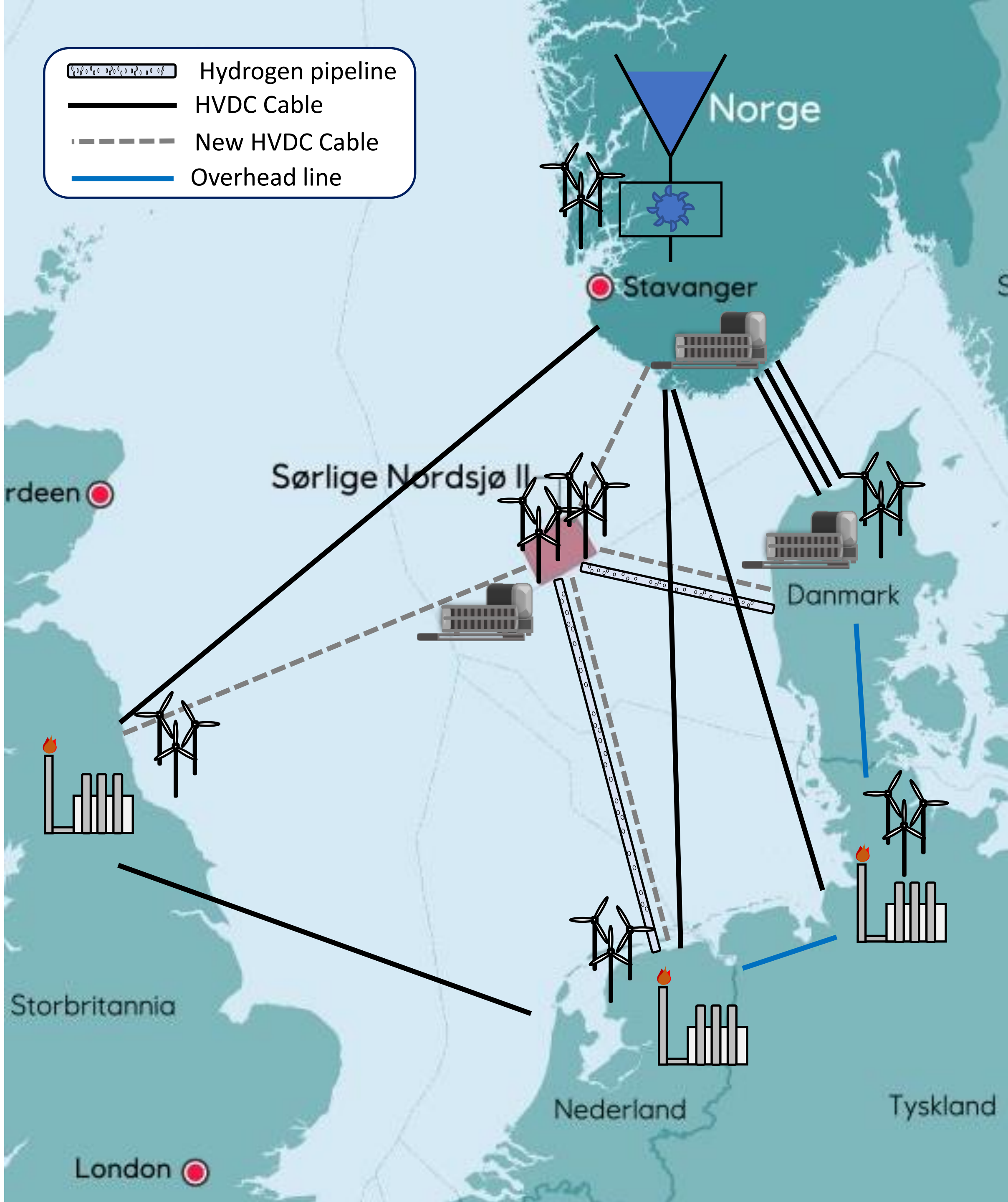
Cost, efficiencies, and costing approaches may differ in each region for the same technologies, *e.g.*, for electrolysis

Region 2 (onshore region):



Working case study

- Co-development of offshore wind power and electrolysis in the North Sea
- Onshore electrolysis is also an investment option
- Energy transmission through DC cables or hydrogen pipelines
- The onshore electricity and hydrogen markets are represented by price profiles
- Four investment periods are modelled – 2025, 2030, 2040 and 2050
- Operation is modelled by 6 representative weeks with 3-hour resolution



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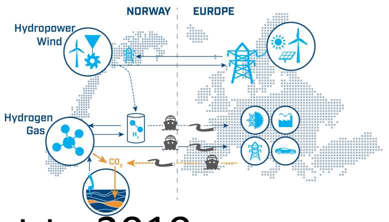
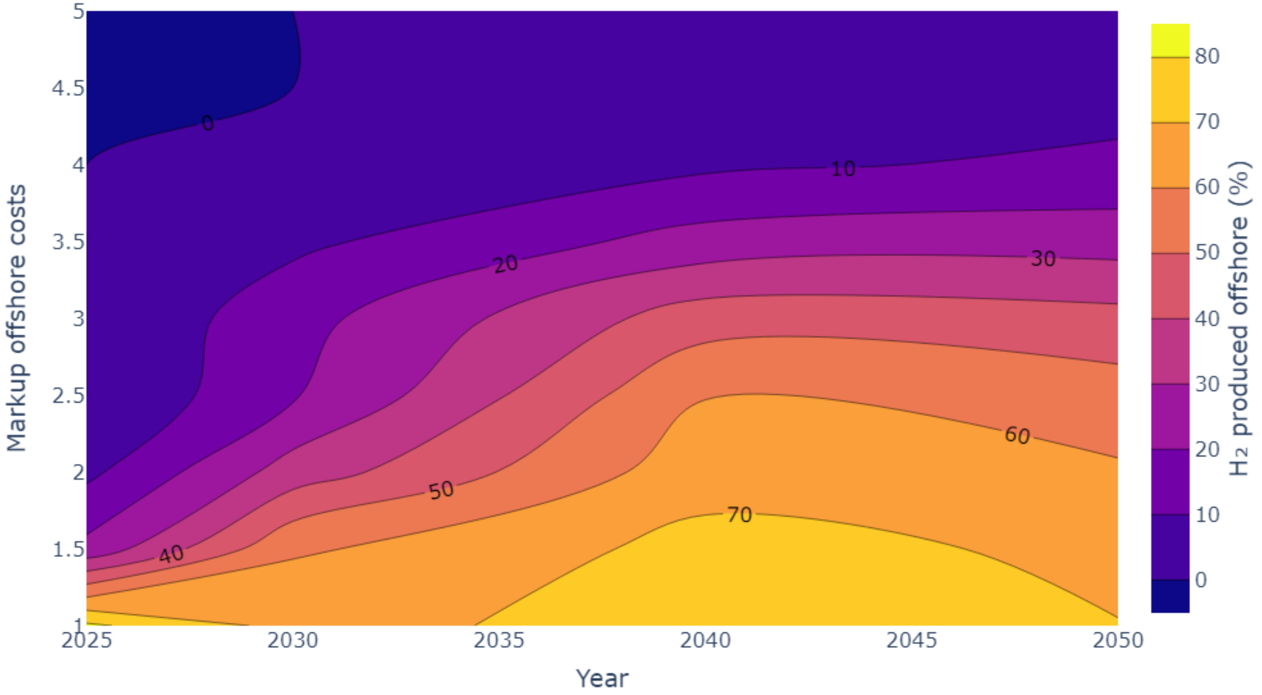
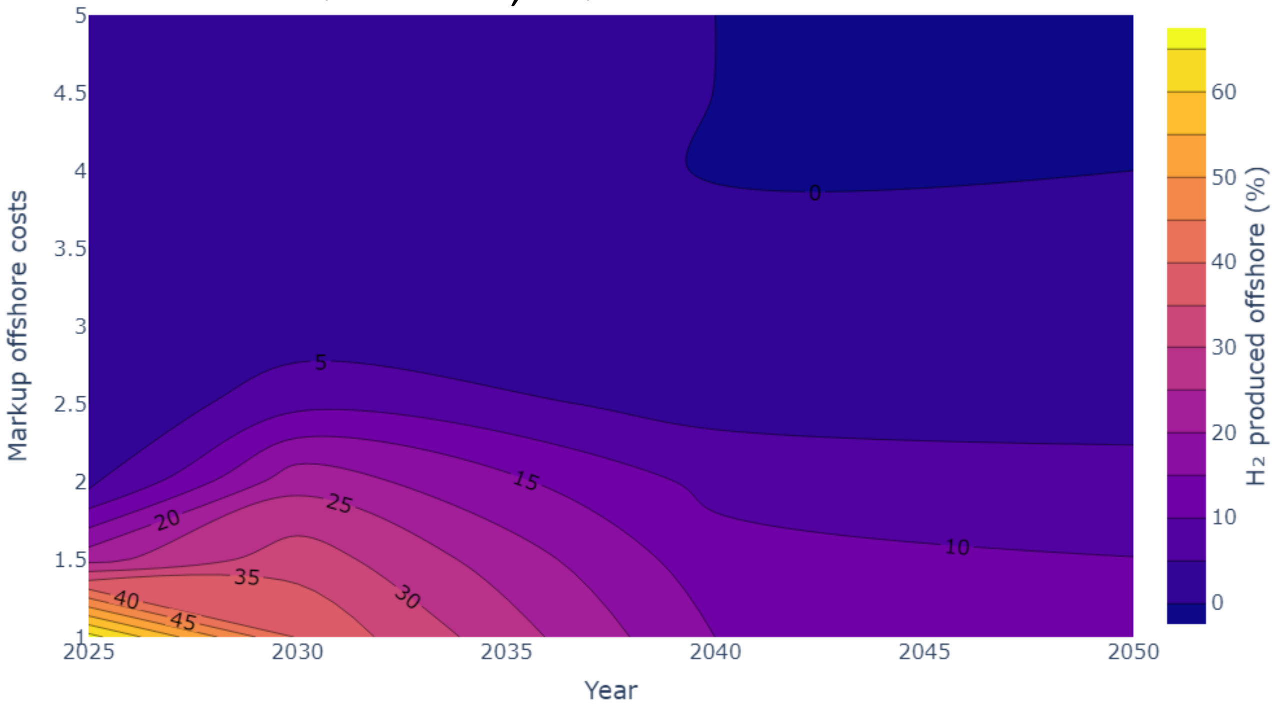
Share of H_2 produced offshore



Electricity price stays on 2019 levels



Electricity price is reduced with respect to 2019
90% in 2030, 50% in 2040 and 2050



- Sensitivity analysis of the electrolysis (Elec) CAPEX markup related to offshore installations
- Up to 70-80 % hydrogen can be produced offshore with 2019 onshore electricity prices and low offshore Elec CAPEX markup (>1.5 times onshore Elec CAPEX)

- High electricity price:
  - 50 % offshore H2 production with markup of 2.5 times
  - Peak offshore H2 production around 2040-2050
- Low electricity price
  - Less than 5 % H2 production offshore with markup of 2.5 times
  - Peak offshore H2 production around 2030