

Integration of renewable energy, hydrogen and natural gas in Europe

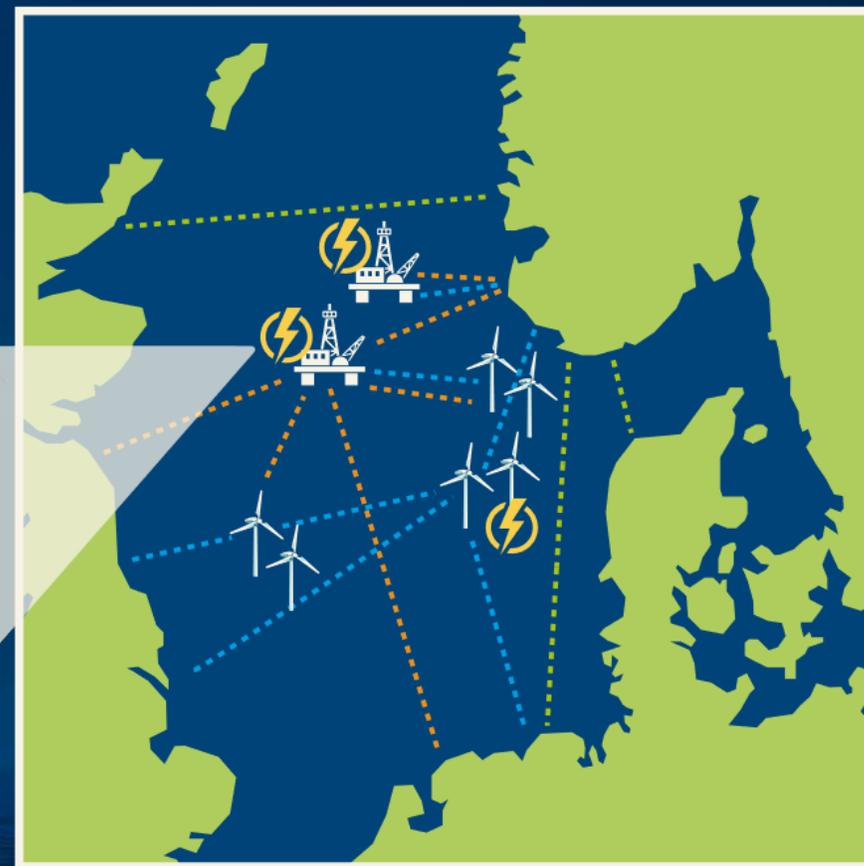


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North Sea network

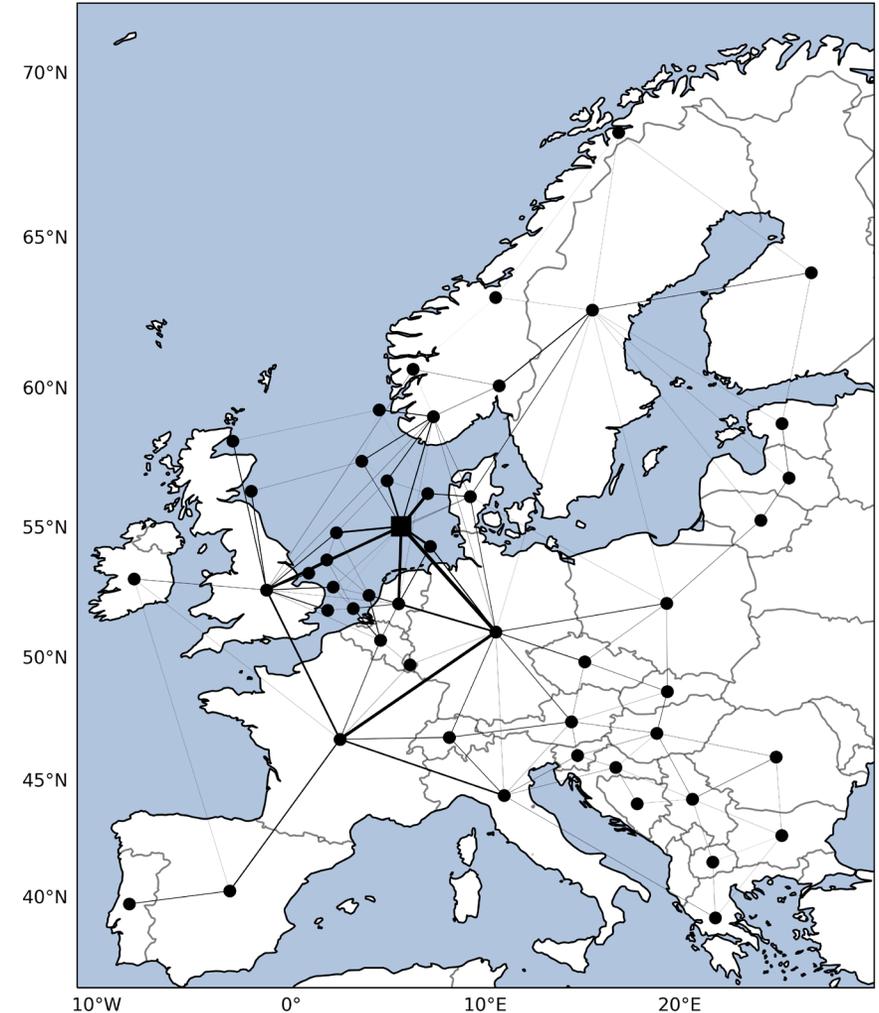


Integration of renewable energy, hydrogen and natural gas

Over the next years Europe faces an energy trilemma. In short

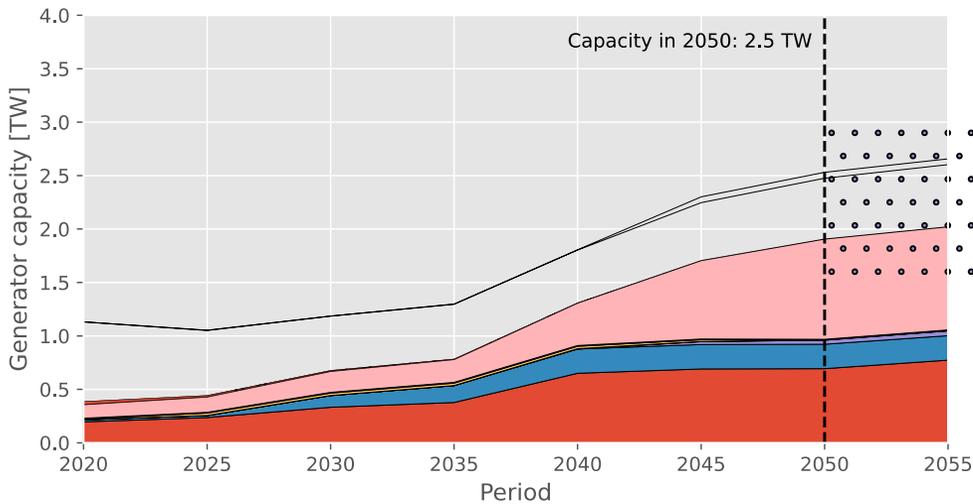
- Security of supply with an increasing renewable volume
- Affordable energy
- Clean energy

Hydrogen may play a role, but does not change the fact that there is energy shortage in the European system (clean, secure and affordable)

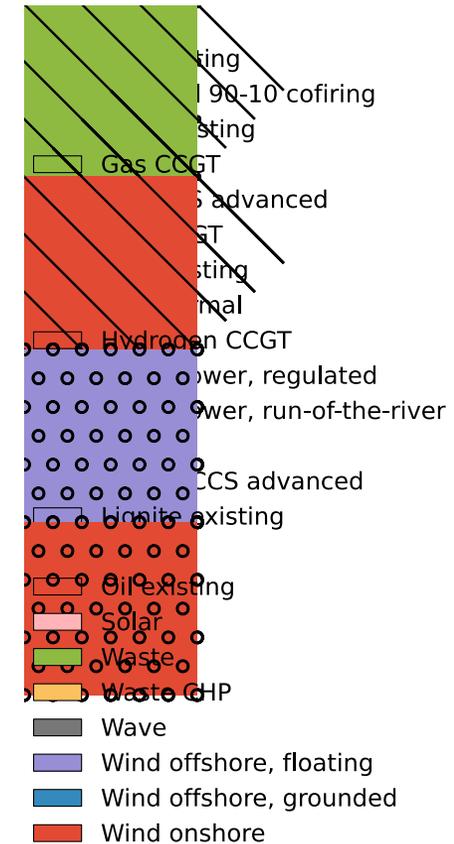
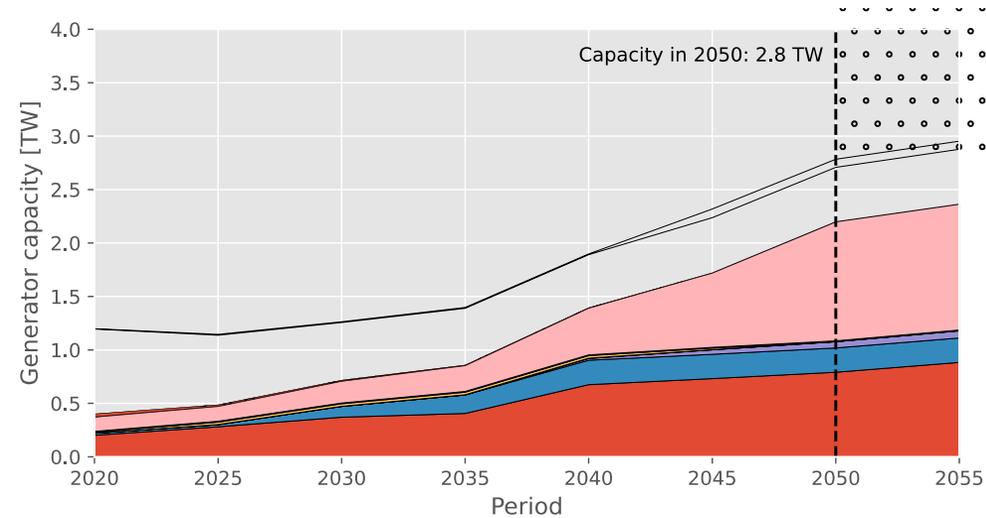


Lower availability of natural gas increases power generation from coal and renewables

With Russian gas

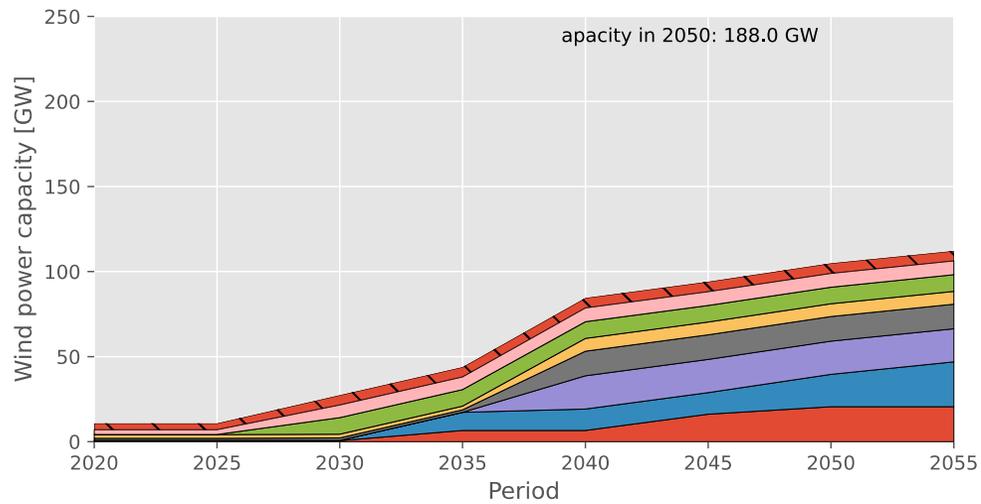


Without Russian gas

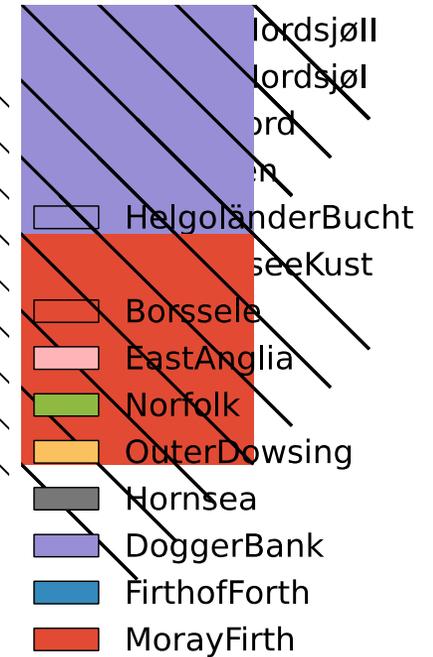
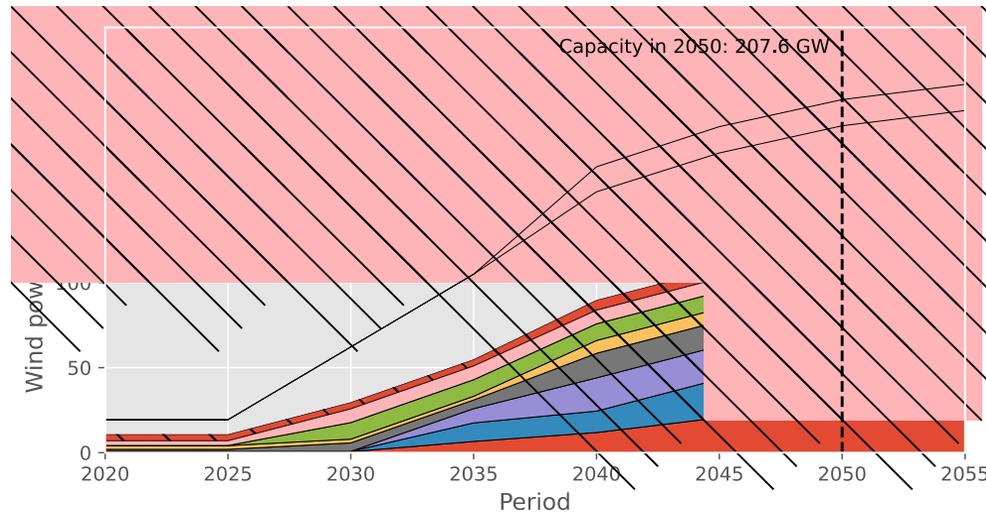


Offshore wind is instrumental for decarbonization

With Russian gas

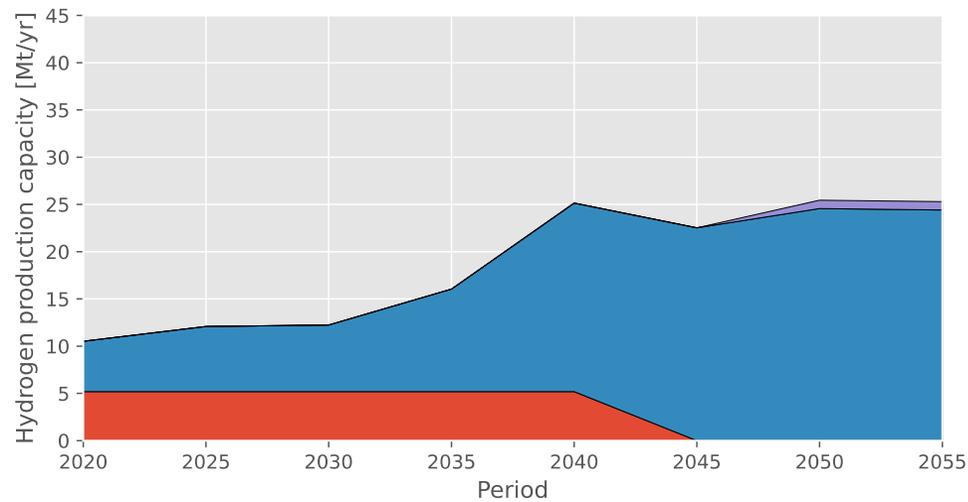


Without Russian gas

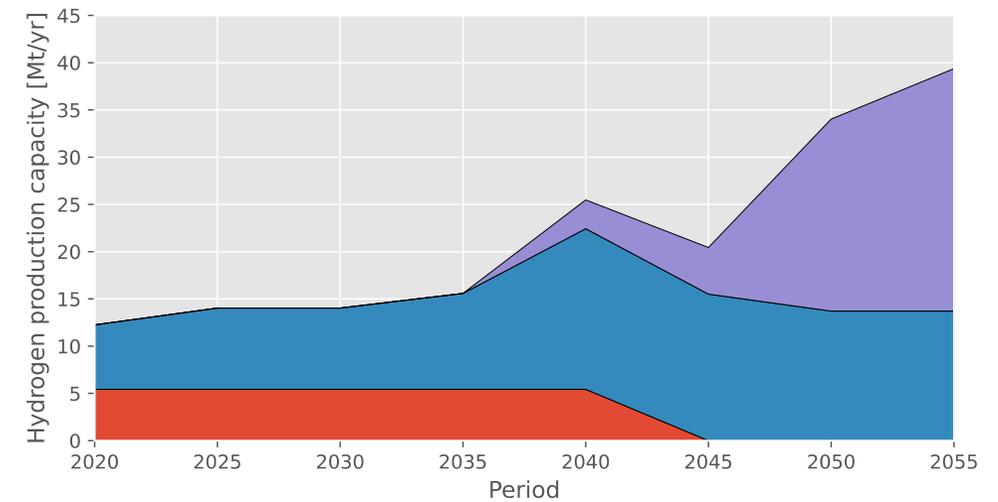


Natural gas remains an important source of hydrogen, but green hydrogen has tremendous future potential

With Russian gas



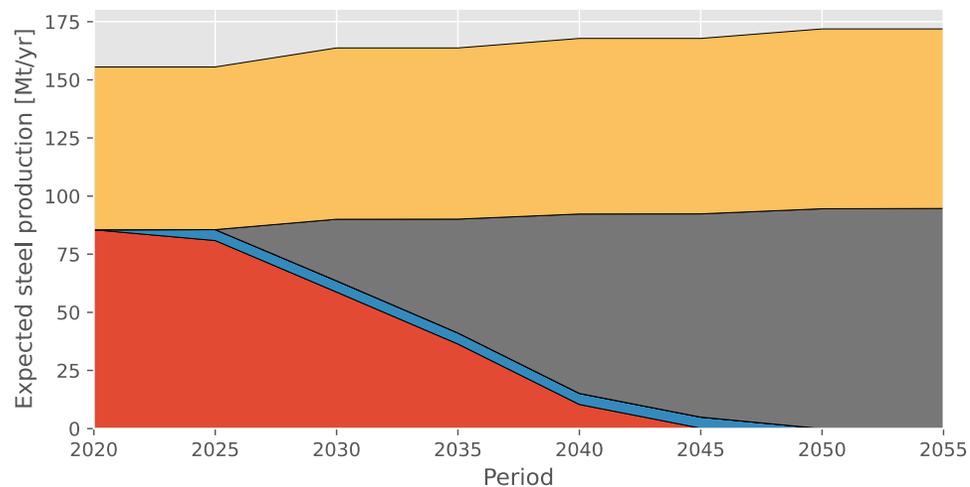
Without Russian gas



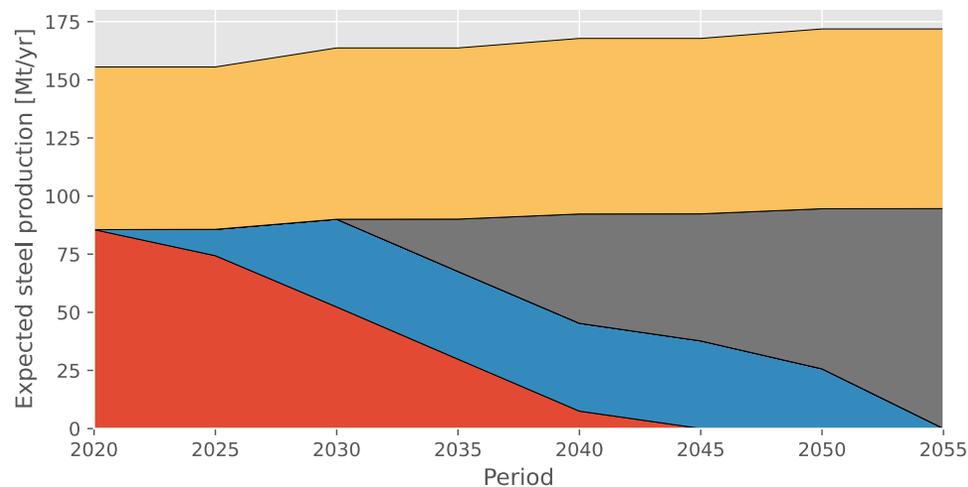
PEM Electrolyzer
 Autothermal reforming, gas heated reformer, CCS
 Steam methane reforming

Hydrogen uptake in steel sector is sensitive to availability of affordable hydrogen

With Russian gas



Without Russian gas



- EAF, Scrap
- EAF, H2 DRI
- BF-BOF, biocarbon
- BF-BOF, CCS
- BF-BOF

Cement production

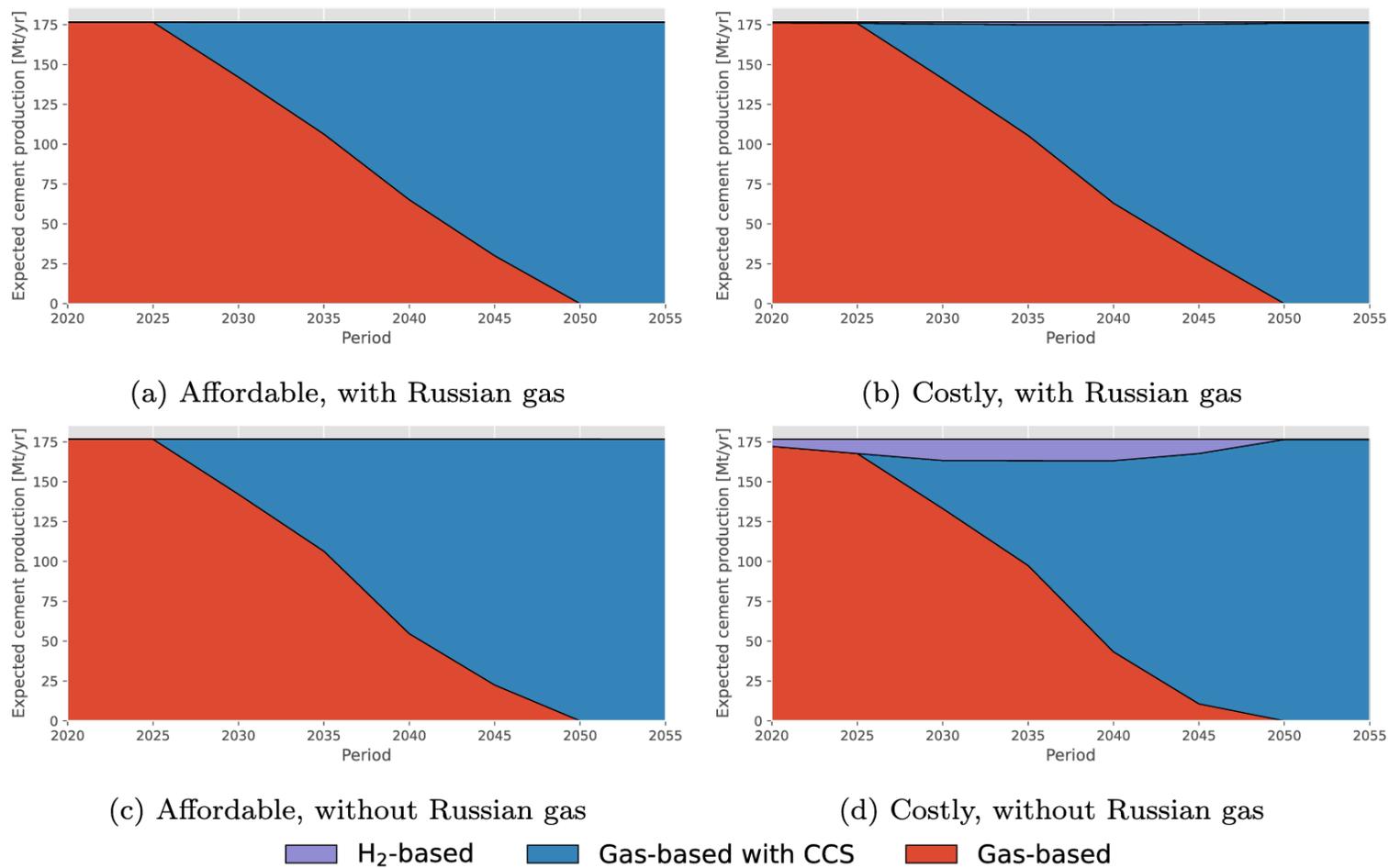
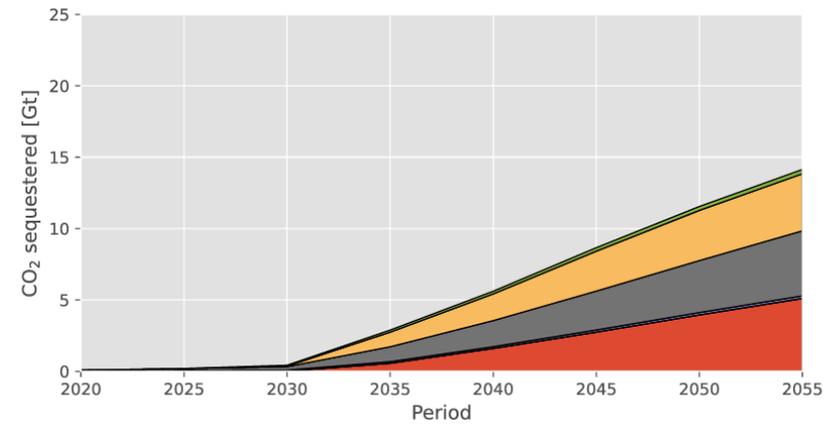
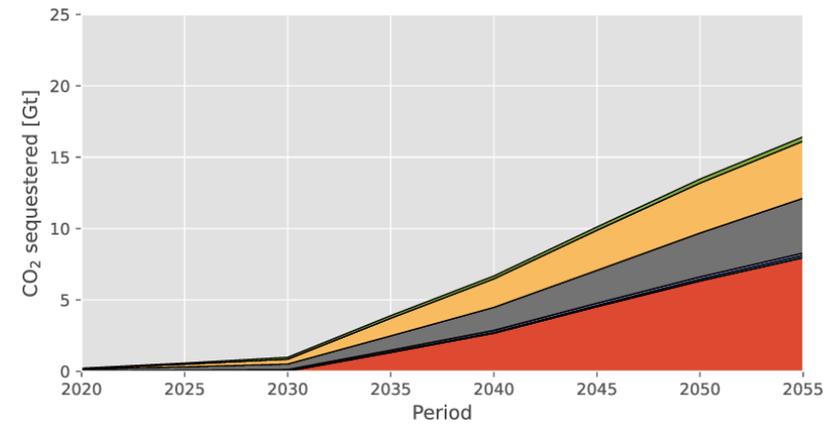


Fig. 5. Evolution of European cement clinker production.

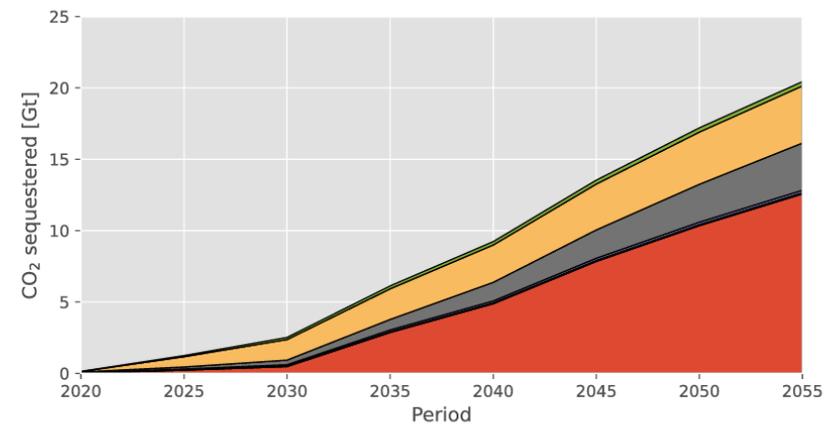
CO₂ - sequestration



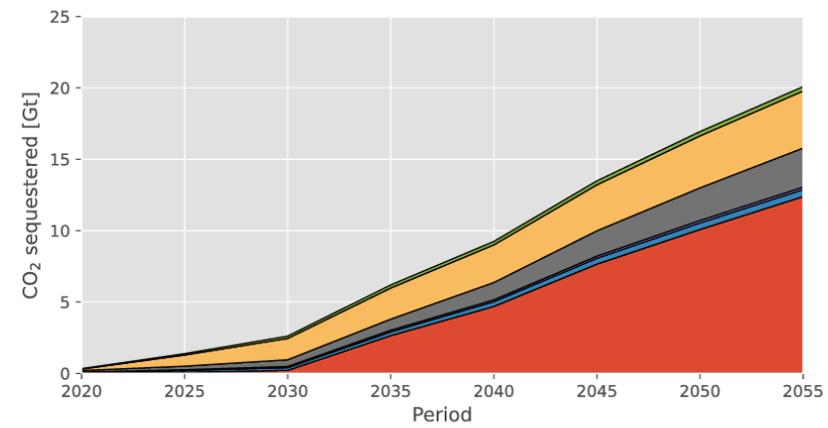
(a) Affordable, with Russian gas



(b) Costly, with Russian gas



(c) Affordable, without Russian gas



(d) Costly, without Russian gas

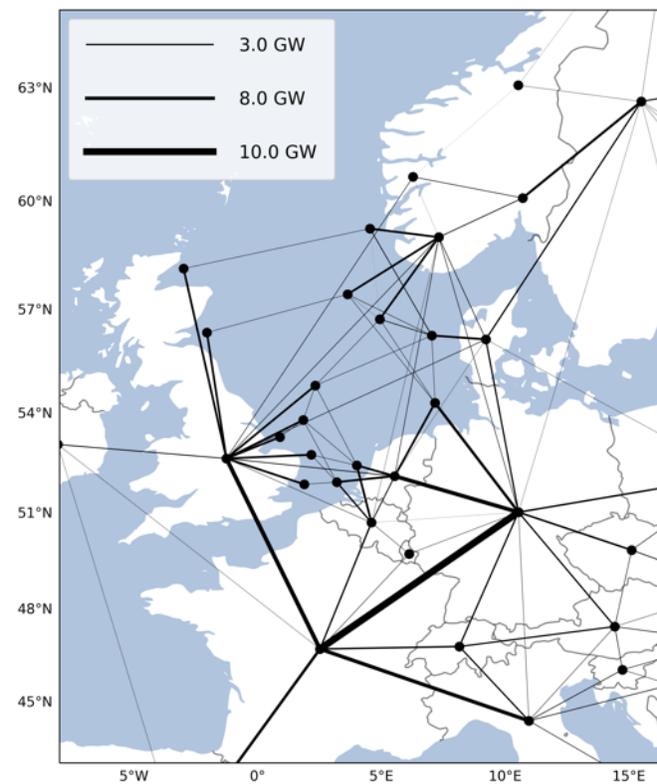
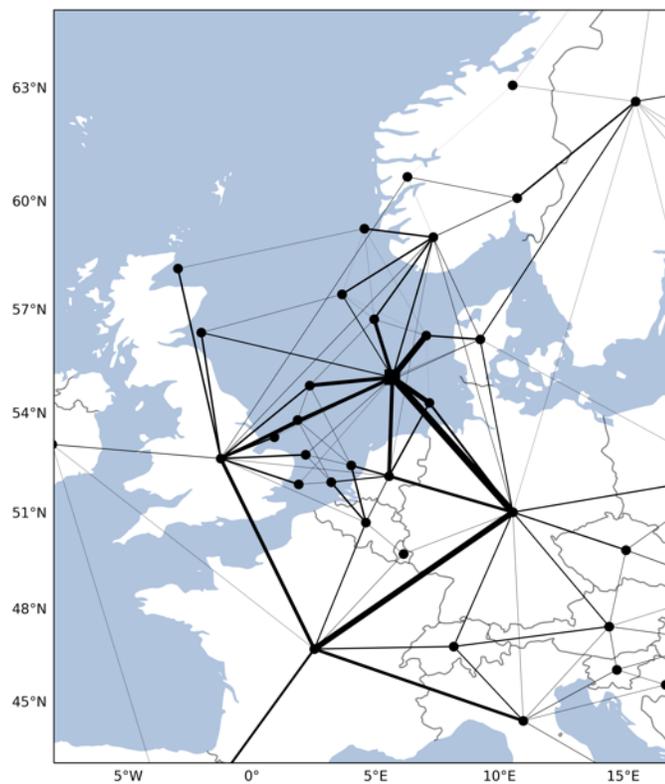


Fig. 6. Expected cumulative amounts of CO₂ sequestered in the North Sea.

Interconnection capacity

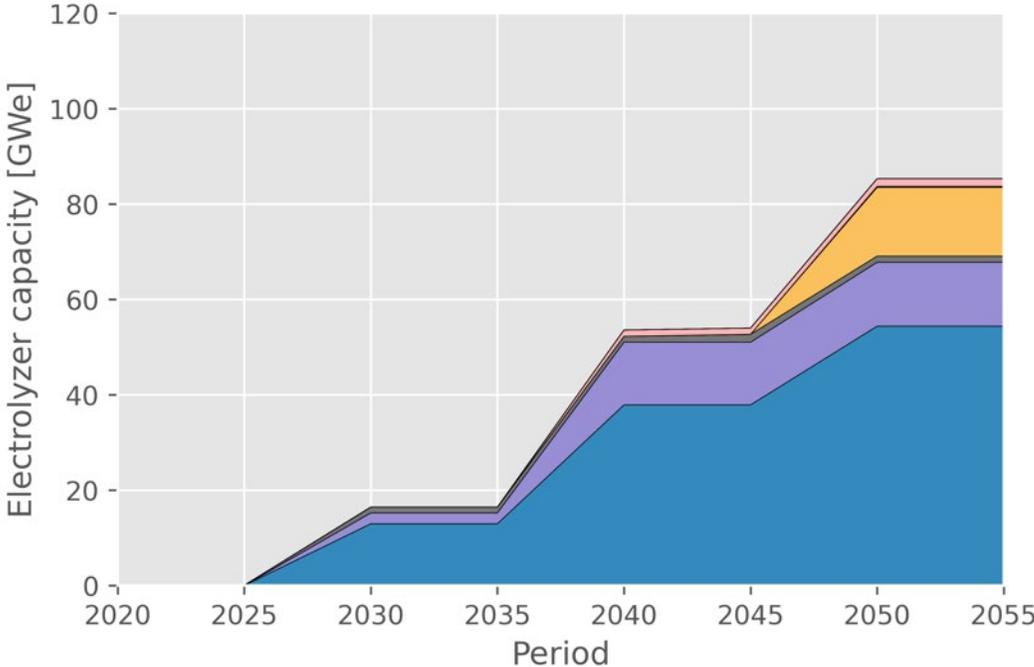
	Without hydrogen	With hydrogen
With offshore energy hub	248.7	264.8
Without offshore energy hub	154.0	165.0

North Sea grid transmission capacity (GW)

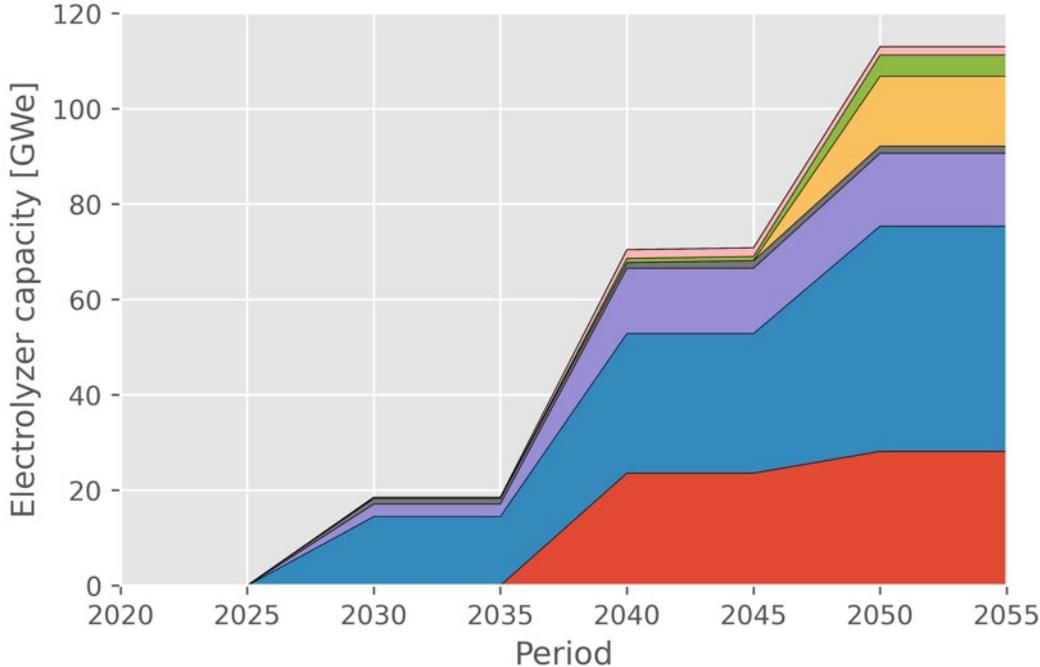


Placement of electrolyzer capacity in North Sea

Without hub



With hub



-  Belgium
-  Netherlands
-  NO5
-  France
-  GreatBrit.
-  Germany
-  NO2
-  EnergyhubEU
-  Denmark

Summary



- Restrictions on gas lead to a significant increase in total power generation capacity in Europe
- This increase is primarily in coal & renewables
- North Sea plays key role in all cases



- Natural gas reforming is a highly competitive source of hydrogen
- Green hydrogen much more attractive as natural gas supply is restricted



- Steel is primarily decarbonized through hydrogen
- The uptake of hydrogen depends heavily on the availability of cheap hydrogen

We need more renewable energy and CCS, and North Sea is central in both