Transmission investment and the system benefits of offshore wind

EERA DeepWind 2024

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Context: system planning challenges in Great Britain

In 1962 a study into the requirements of a high voltage transmission network made use of the concept of MW-miles (today MWkm) to decide on which transmission design to use when planning the first England and Wales 400kV network. Much of the network they designed is still in use today.

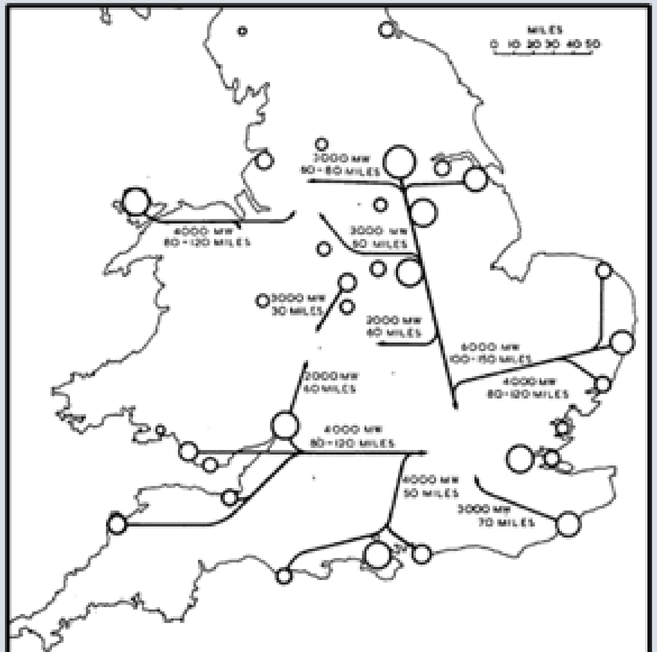


Fig. 2.—Principal power flows.

Britain has ambitious targets …

National targets

- Connect at least 50 GW of offshore wind by 2030
- Fully decarbonise the electricity system by 2035
- Deliver net zero across the economy by 2050

Targets set by Scottish Government

- 20 GW of onshore wind by 2030
- Reduce greenhouse gas emissions by 75% by 2030
- Reach net zero by 2045

… but delivering them will be challenging

- There is currently 15 GW of offshore wind connected, a further 4 GW in construction, and a further 18 GW consented
- The 2023 Contract for Difference Auction did not attract any offshore wind bids due to the administrative strike price (the maximum the UK Government was willing to pay) being set too low
- There are significant headwinds including cost inflation and slow grid connection

Context: how the GB transmission network is planned today

Future energy scenarios (FES)

Electricity ten year statement (ETYS)

Network options assessment (NOA)

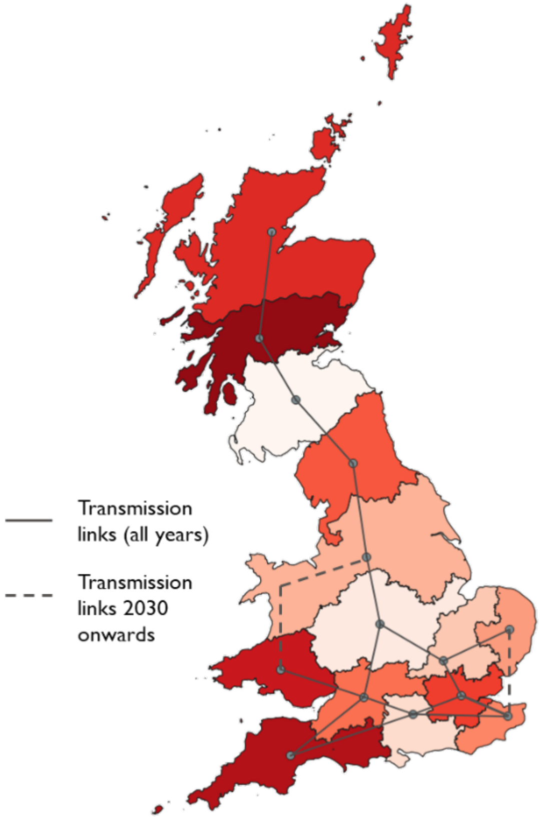
Output: Four ways in which the electricity market might evolve out to 2050, including geographically

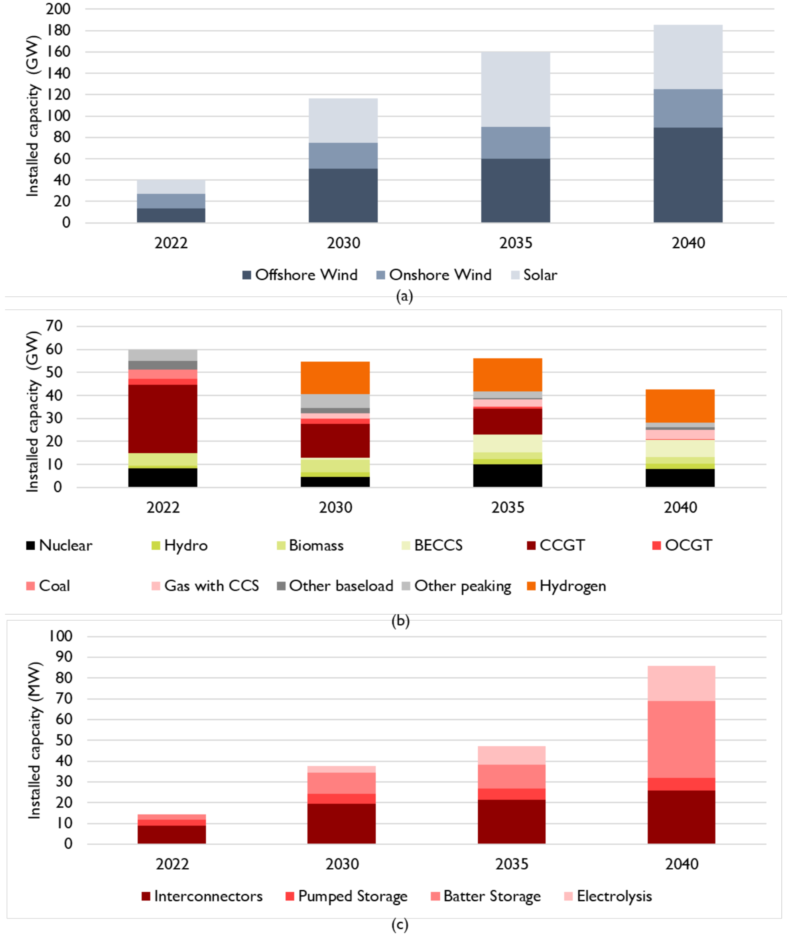
Output: How much transmission network capability do we need in each year for each scenario?

Output: A CBA for specific transmission investments to deliver the capability identified and recommendation on which to take forward

- For the past decade NGESO – the GB system planner – has used an annual 'market led' cycle to make transmission network planning decisions
- Today the system is going through a transition to a more 'targets led' approach. The cycle above will be integrated into a Centralised Strategic Network Plan (CSNP) over the next couple of years

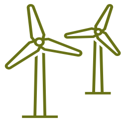
Modelling: balancing transmission costs against operational savings from renewables





Demand $_{Peak}$ = 74 GW

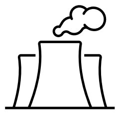
Demand $_{annual}$ = 388 TWh



Installed = 117 GW

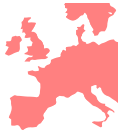
Of which offshore wind = 50 GW

Available generation = 343 TWh

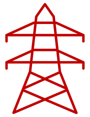


Installed $_{inflexible}$ = 4.6 GW

Installed $_{flexible}$ = 61 GW



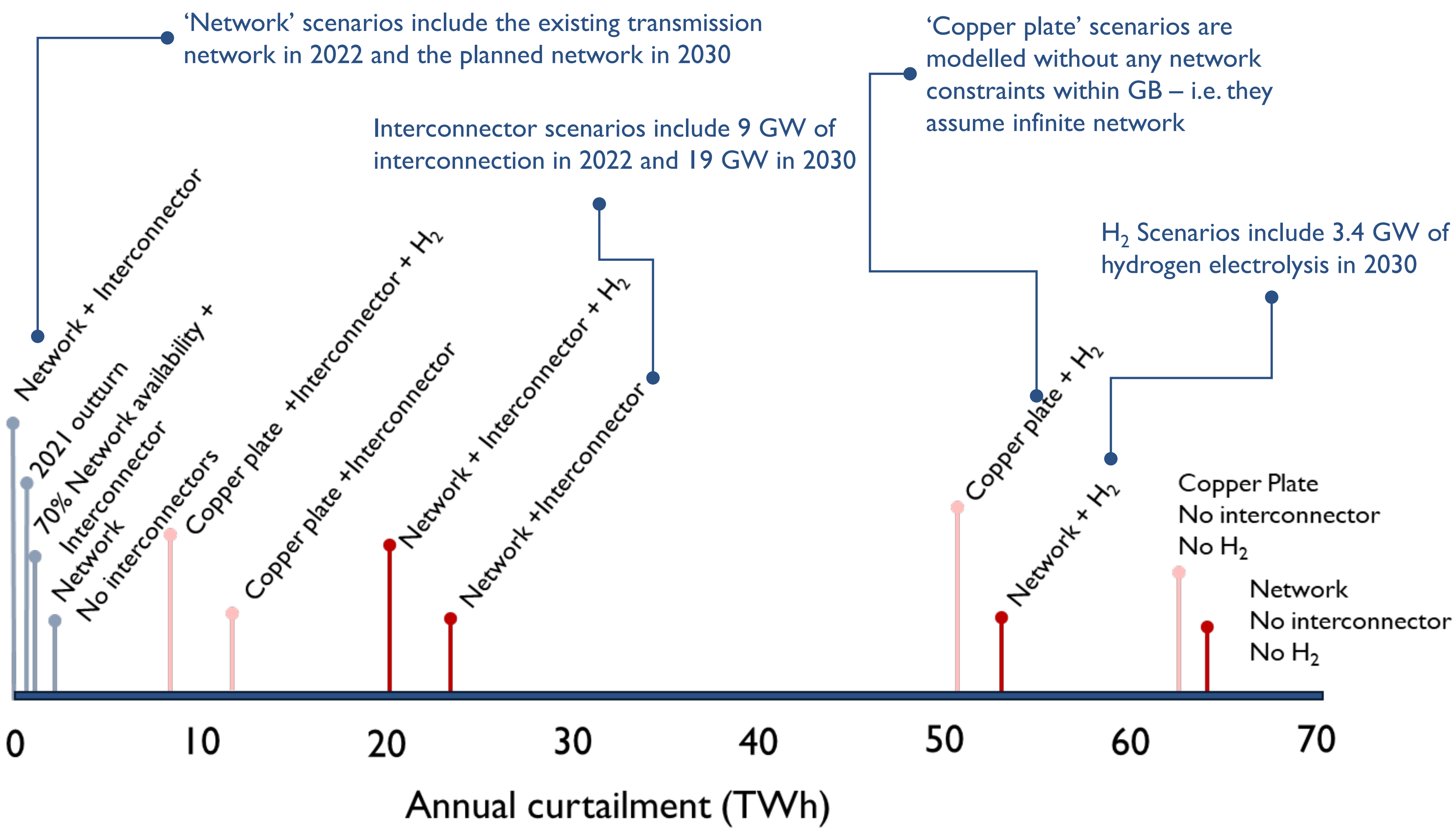
Installed interconnector capacity = 19.5 GW



Transmission capacity planned to grow by 73% between 2022 and 2030 from 9.0 million MWkm to 15.6 million MWkm.

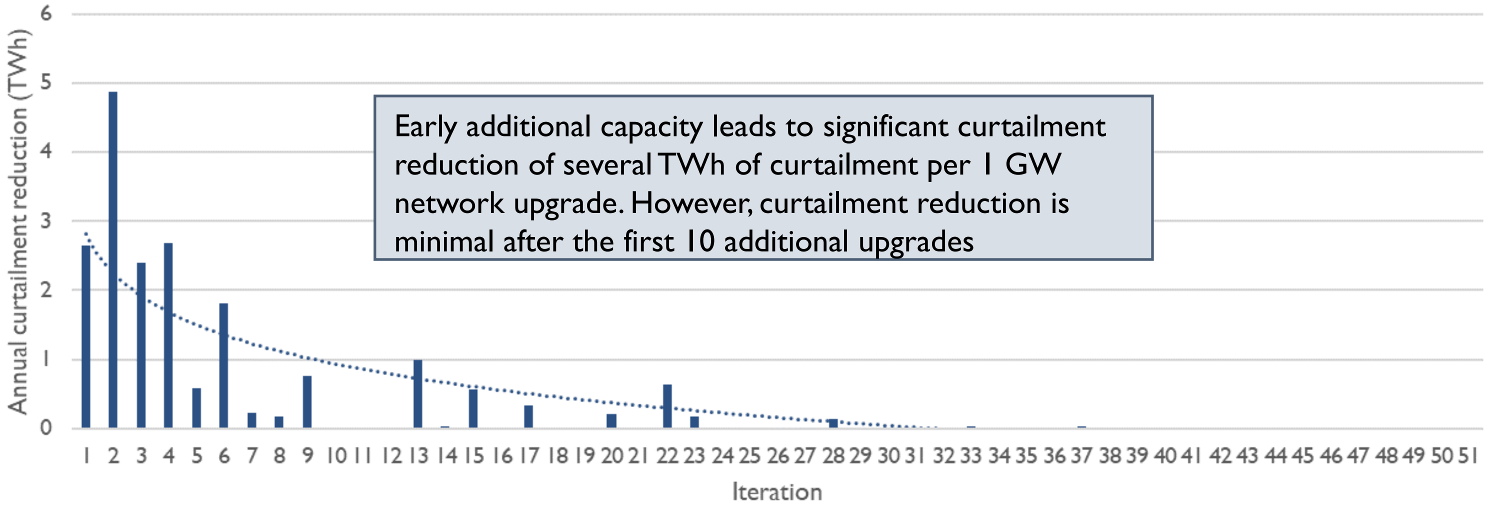
- Modelling uses a 14-zone simplified representation of the GB transmission system to run a DC Optimal Power Flow for conditions during each hour of a representative year
- Scenarios have been run for 2022, 2030, 2035 and 2040
- Outputs include operational cost, renewable curtailment, MWkm flows and can be run in a ‘build out mode’ which adds additional network capacity and identifies operational cost and curtailment impacts

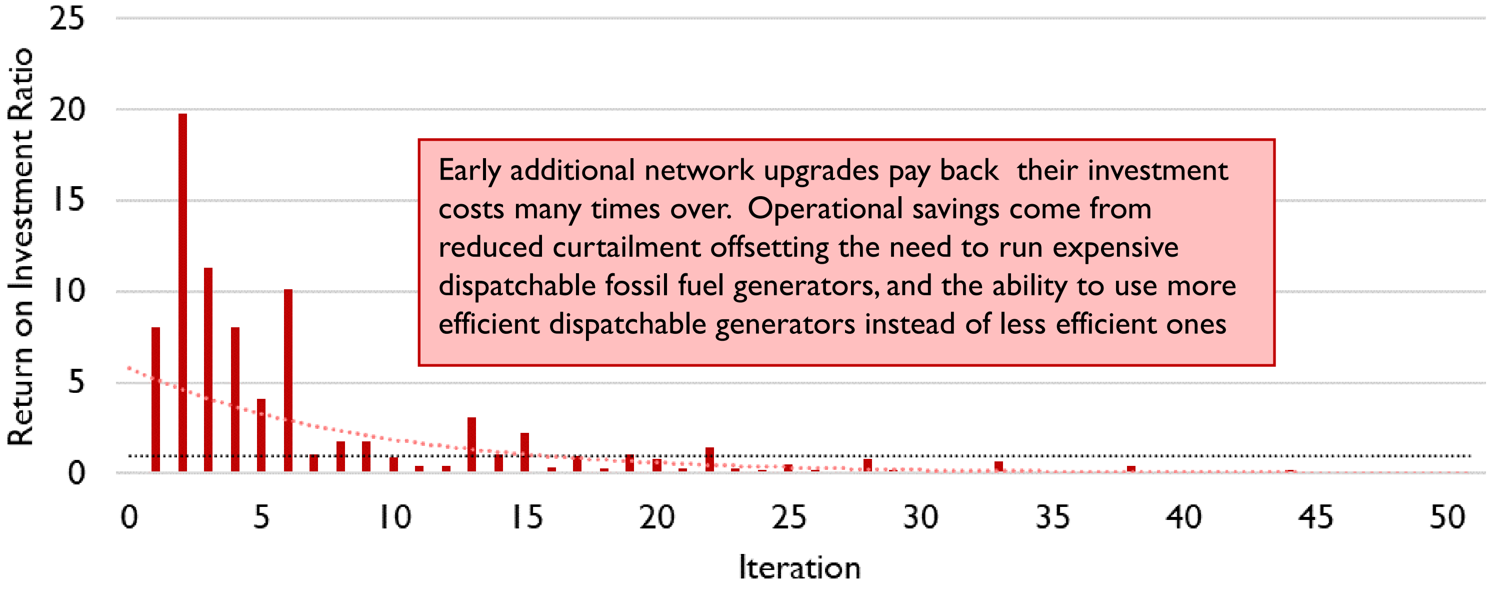
Results: curtailment on the rise



- Modelling shows at least an order of magnitude increase in curtailment volumes between 2022 and 2030
- Because renewable capacity is increasing the percentage increase in curtailment is smaller but there is still at least a doubling between 2022 and 2030
- In 2030 there is substantial energy-related curtailment – i.e. curtailment that isn't caused by network constraints but by an excess of renewables over demand and flexibility
- Interconnectors make a substantial impact in reducing constraints, but the results shown here assume (a) an optimistic build out of interconnectors and (b) those interconnectors operate perfectly from a GB perspective, regardless

Should we build even more network?





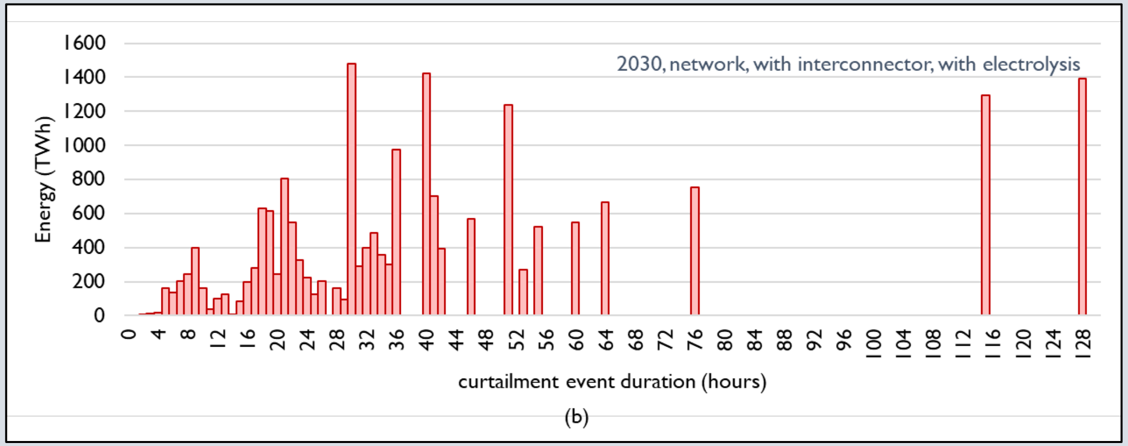
- The model allows additional network capacity to be added to the most constraint branch
- Results show the curtailment reduction and return on investment ratio for additional network capacity in 2030 *beyond the planned network*
- Suggests that significant additional network capacity beyond the planned network would provide significant reduction in curtailment and significant return on investment
- Should we aim to completely remove network related curtailment? No, it should be reduced to the level at which further network investment does not pay back its costs through operational savings

Return on investment ratio:

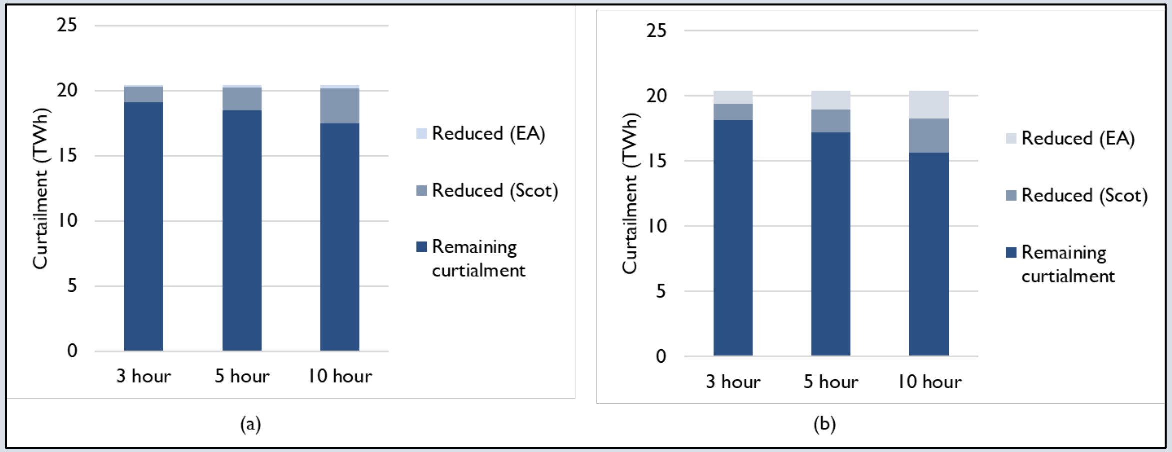
$$\frac{\text{Annual Operational cost savings}}{\text{Annuitised transmission investment cost}} < 1$$

Energy storage

Duration of curtailment events



Impact of typical battery storage durations on curtailment



Hydrogen "seasonal" energy storage

- By 2030, curtailment events are likely to last typically tens of hours, measured in terms of energy contained in curtailment events, the median duration is 34 hours
- Short duration energy storage, typical of today's battery installations, makes only a relatively small impact on network related curtailment (although it may be more useful for *energy* related curtailment)
- Maximising the value of offshore wind is likely to require us to think about very large scale (TWh), very long duration storage

Conclusions

- We believe that high level, agile modelling, such as used here and in the spirit of the 1962 CEGB pioneers has a place into today's power system despite the availability of highly complex, data heavy, computationally expensive complex modelling
- The level of future curtailment is an order of magnitude higher than what we see today
- The level of planned transmission network capacity is almost certainly lower than the economically efficient level
- We need to get interconnector development and operation right; this will make the biggest difference to curtailment levels. We also need to make sure we are applying similar modelling approaches at an international level to ensure that the European system as a whole works
- The big wins from energy storage will come from large scale long duration energy storage on the scale of TWh not, short duration storage on the scale of GWh or MWh

Thank you

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