Spatial diversification of offshore wind as a flexibility option

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Contents

Background - floating turbines

Methodology - electricity system modelling, scenario comparison

Results - impact of floating turbines on the rest of the system

Floating turbines

Early stage of commercialisation

Conventional offshore wind is restricted to very few sites globally

Several designs are under consideration, with varying stability and cost

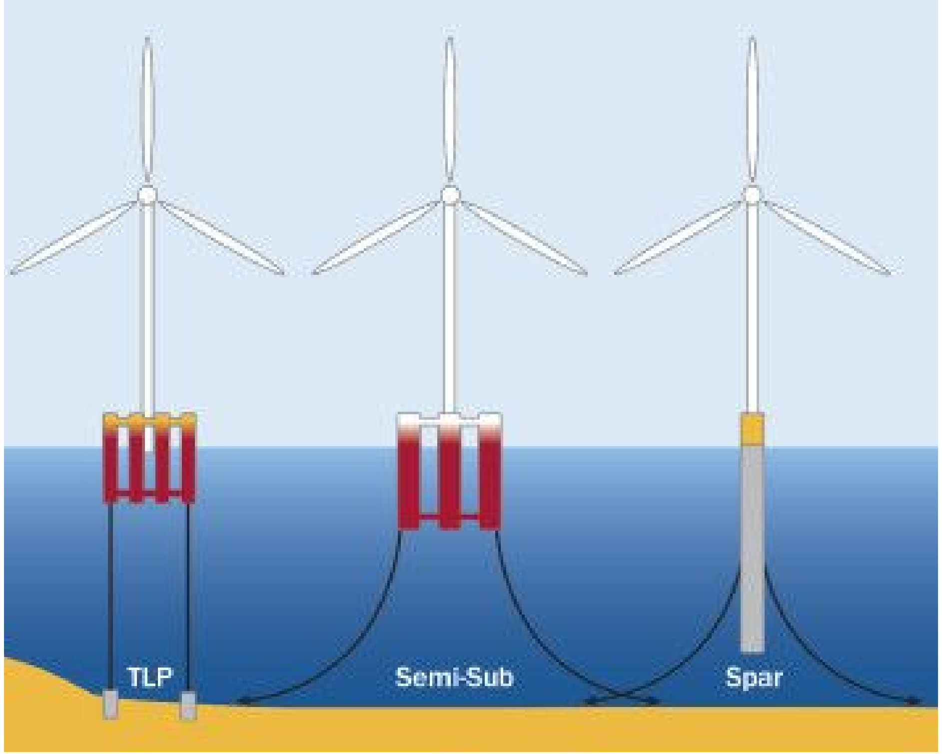


Image: Bailey, H., Brookes, K. L., & Thompson, P. M. (2014). Assessing environmental impacts of offshore wind farms : lessons learned and recommendations for the future, 1–13.

Research Questions

Is there any system benefit afforded by floating offshore wind?

Is it worth paying a premium for floating turbines?

What impacts does the deployment of floating offshore wind have on other parts of the system?

2 models used in this project

UKTM to give the boundaries of the electricity system, and highRES to design spatially explicit high renewable share electricity systems

UKTM

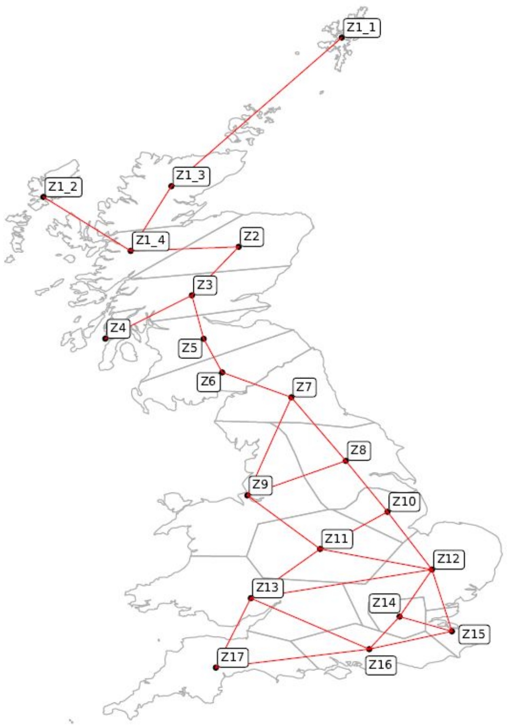
TIMES framework. Long term transition pathways from 2010 to 2050 for whole of UK energy system

http://www.ucl.ac.uk/energy-models/models/uktm-ucl

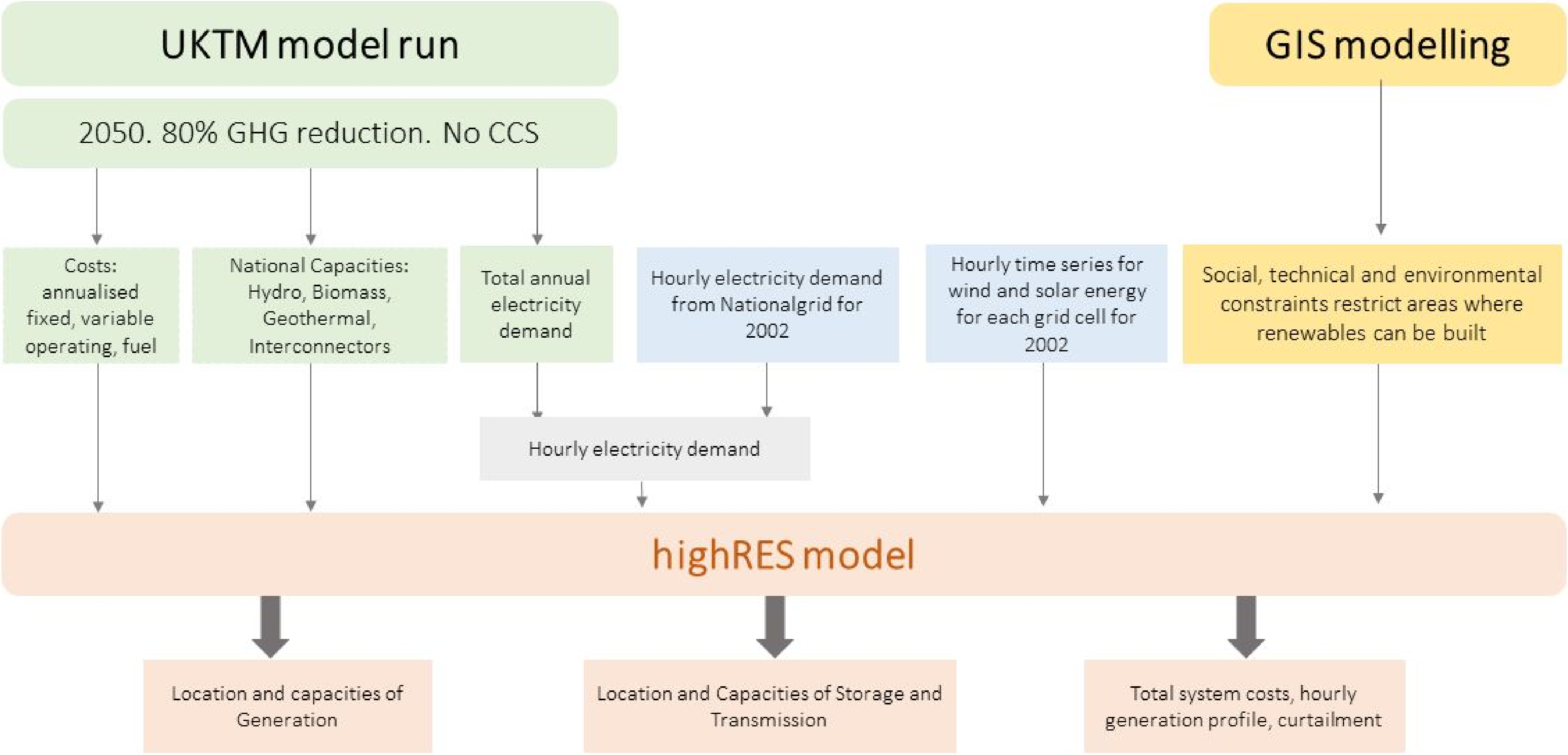
highRES

Single year 1-hourly time steps with 0.5 lat/lon resolution weather data. Used for analysing the behaviour of high renewable share systems

http://www.ucl.ac.uk/energy-models/models/highres

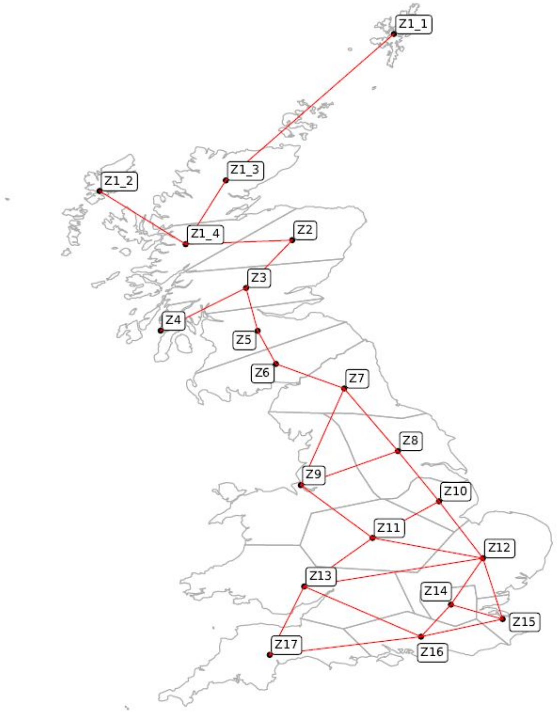


Modelling Approach

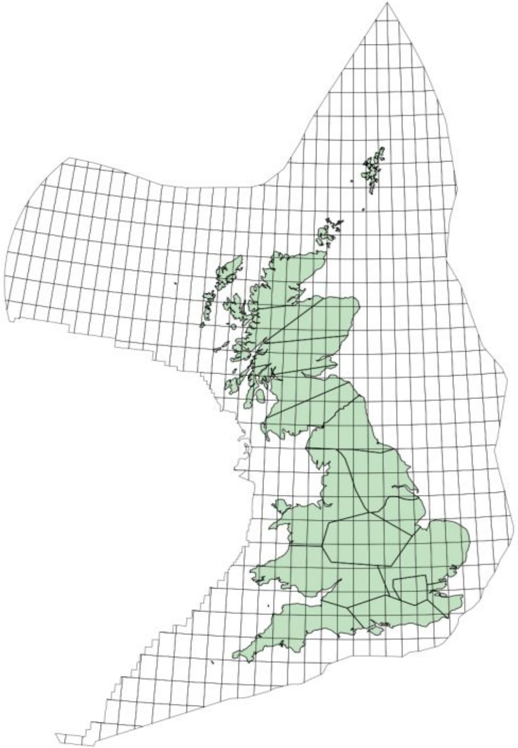


highRES spatial inputs

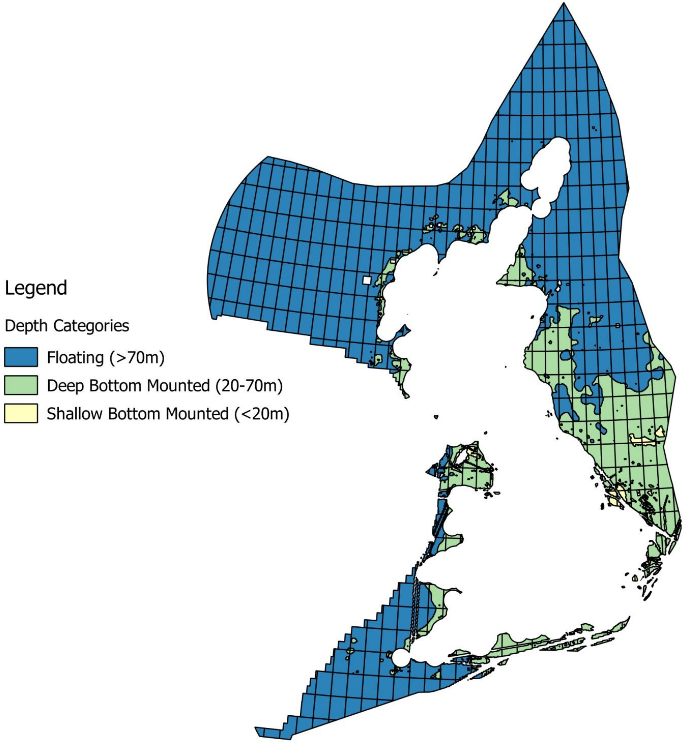
Demand Zones and transmission links



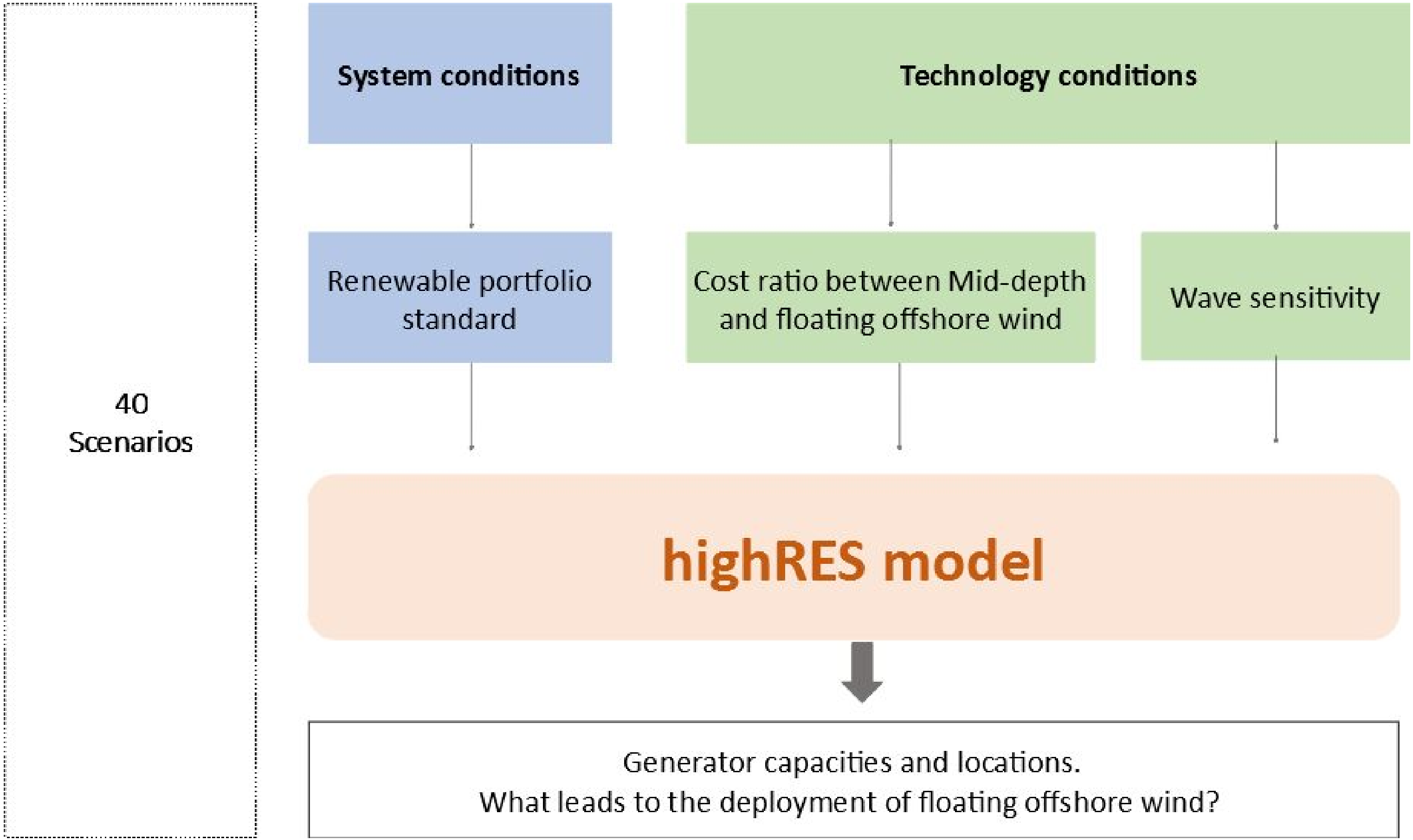
Weather data on grid cell resolution



GIS social and environmental constraints



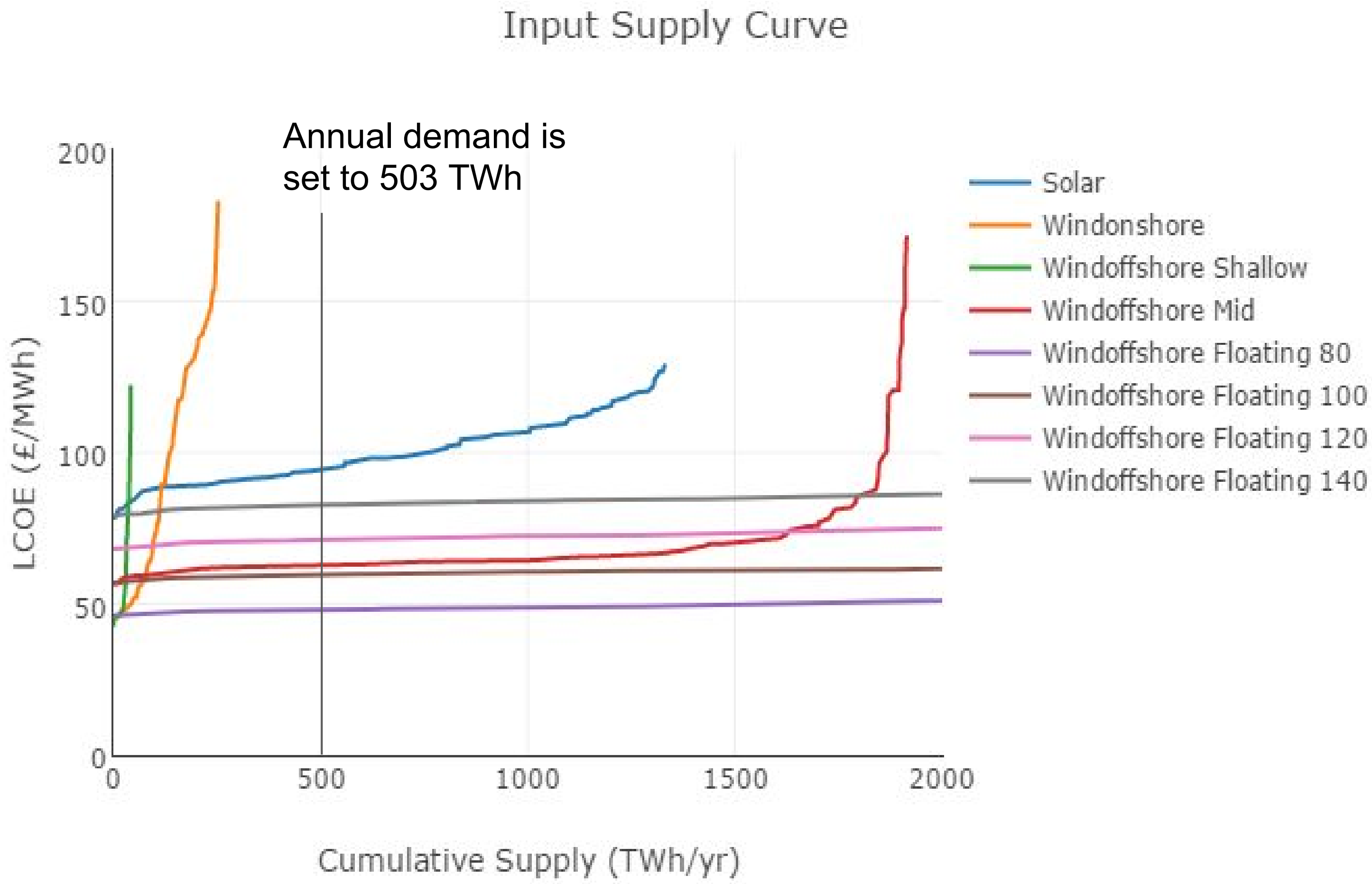
Scenario Definition



Results - LCOE supply curves

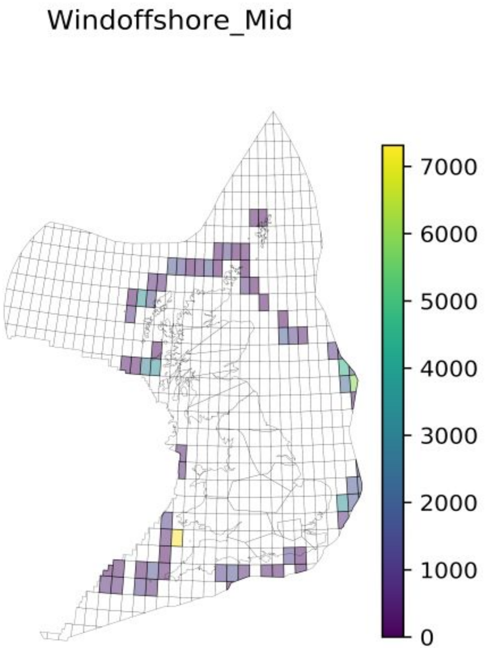
Cumulative annual supply from different sites is plotted for each technology

Departure from the supply curve order implies relative ‘system benefit’ over other VRE choices

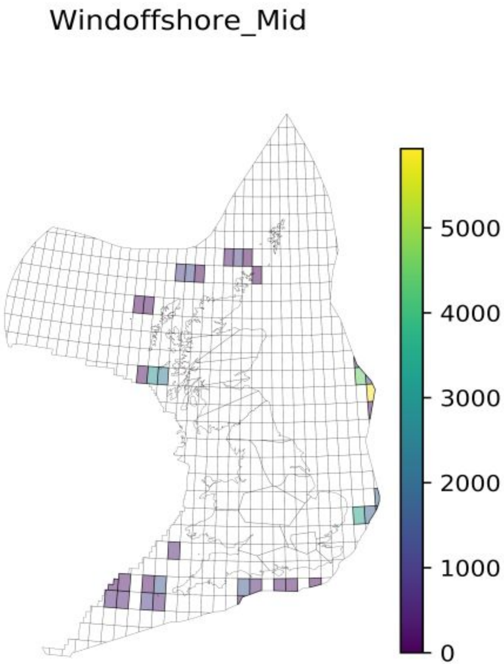


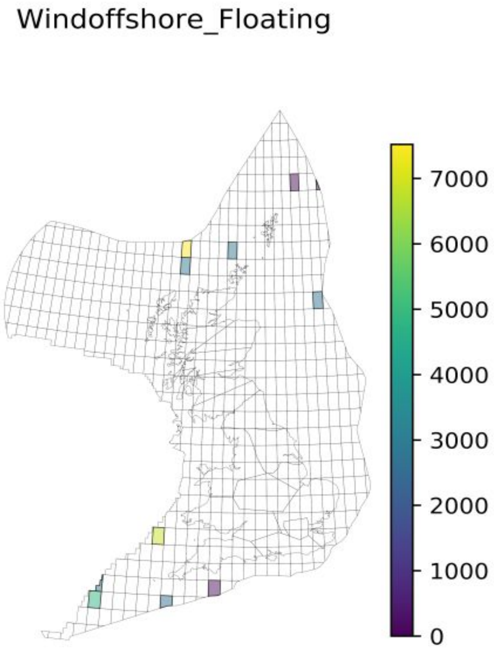
Results - Spatial distribution - 90% Renewable Share

Zero floating wind
(140% cost)

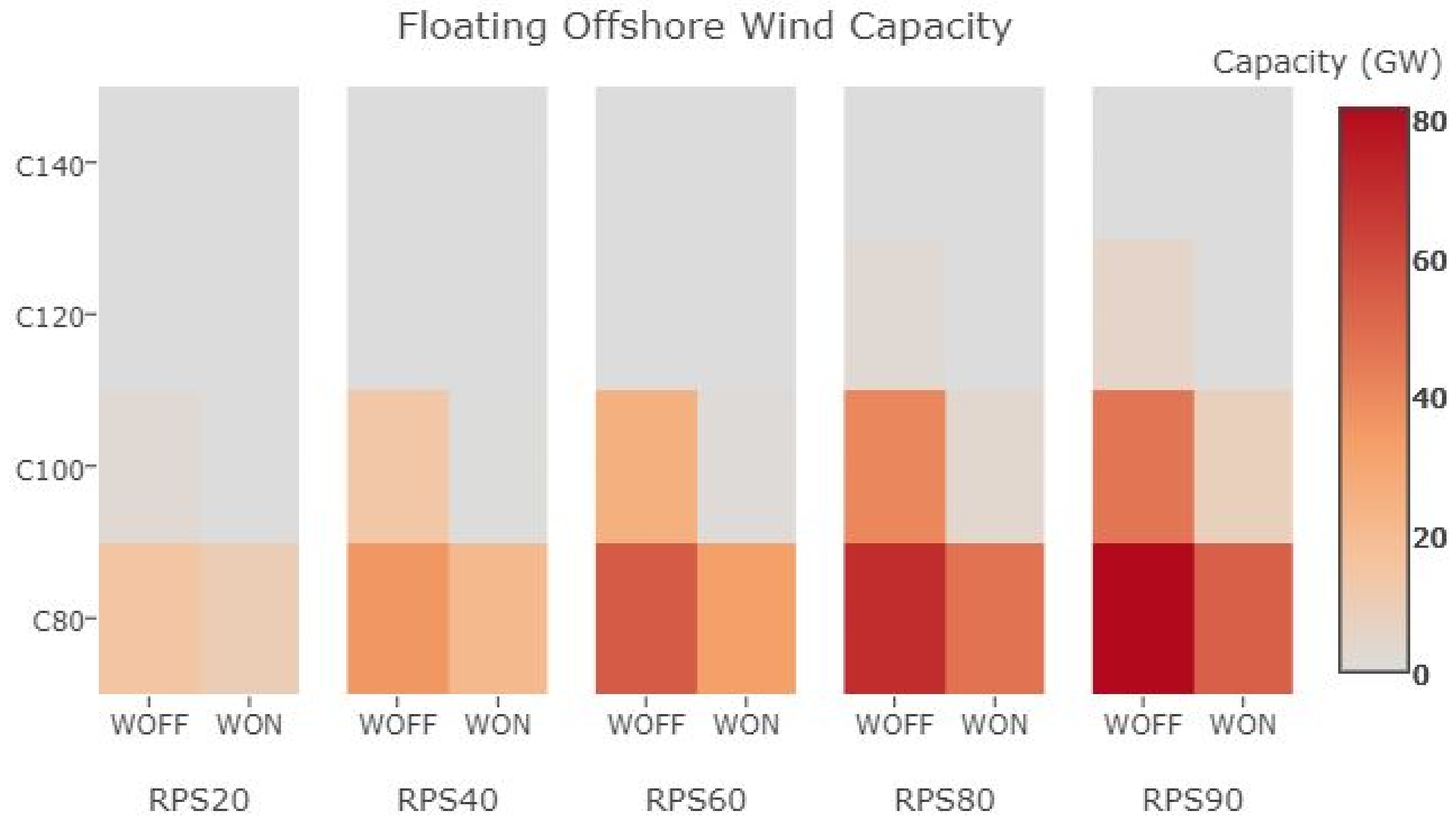


Equal capacities
(105% cost)





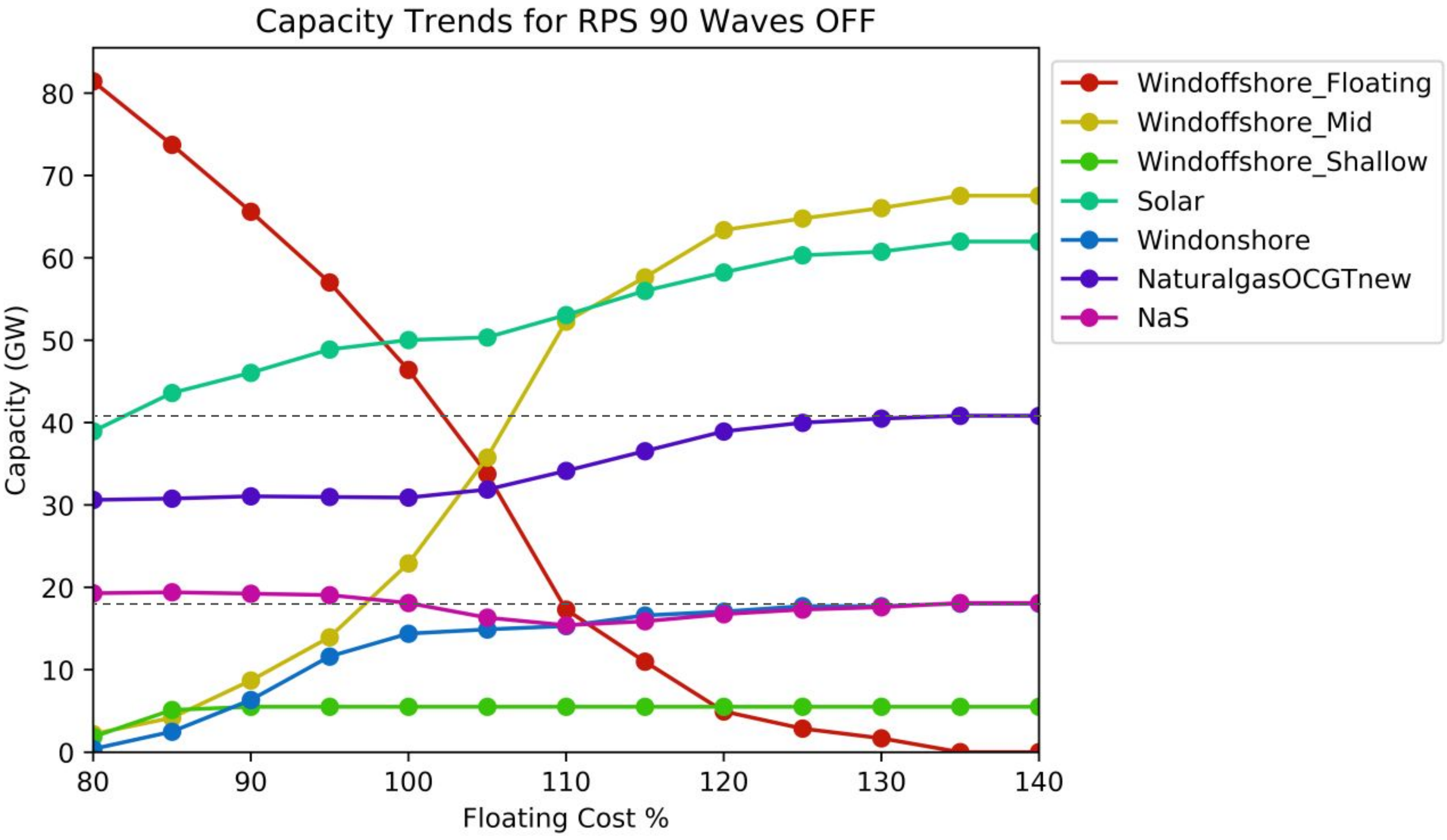
Results - Floating Wind Installations



Results - Capacities - 90% Renewable share

Storage capacity changes very little

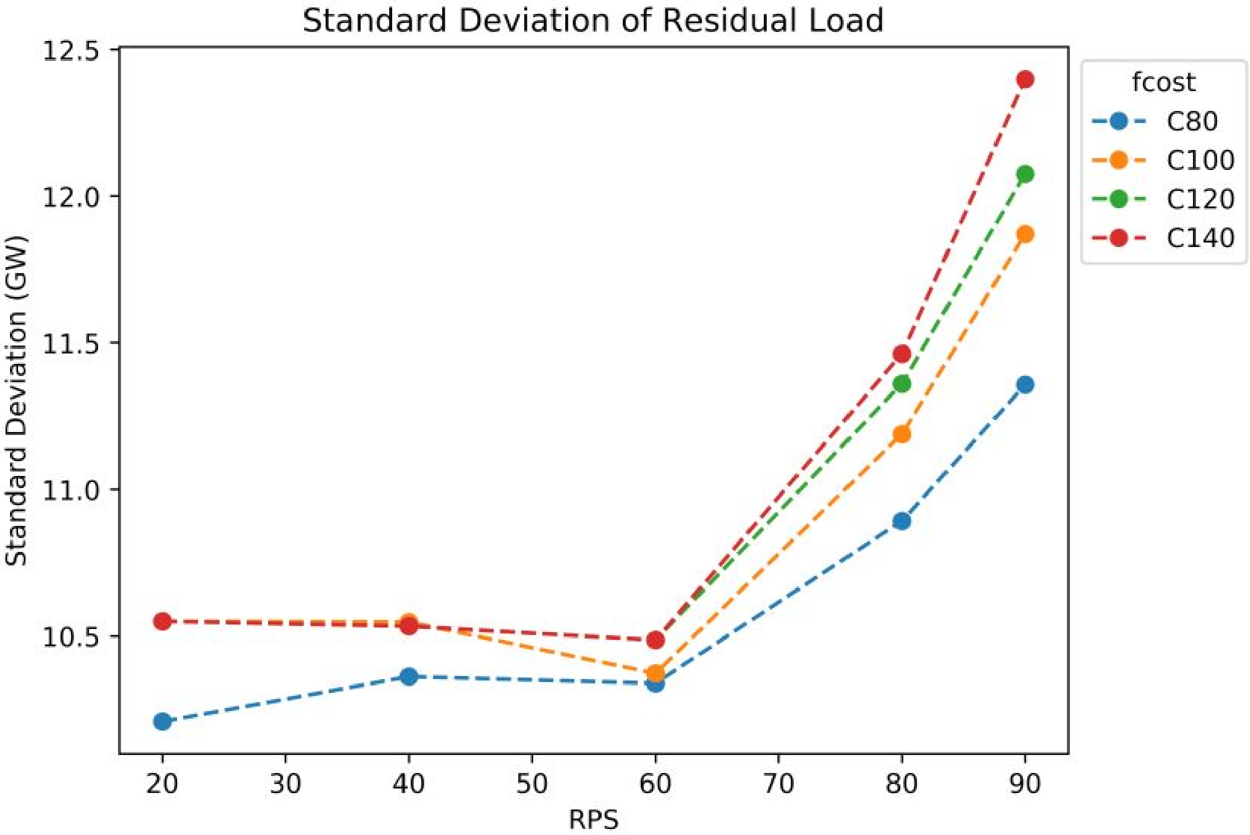
Natural Gas capacity reduces as floating turbines are introduced



Results - Residual load

As floating turbine cost is decreased, residual load variance reduces

The effect is most pronounced at high shares of renewables



Conclusion

High renewable share systems rely on spatial diversification to be cost optimal

Floating wind can provide that, with a 5% cost premium leading to equal capacities of floating and conventional offshore wind

Increased capacity of floating wind leads to a reduced need for natural gas capacity

Remaining questions

How can we quantify spatial diversification?

To ensure more appropriate policy, how can it be incentivised?

If revenues are exposed to the market, how can we model prices?

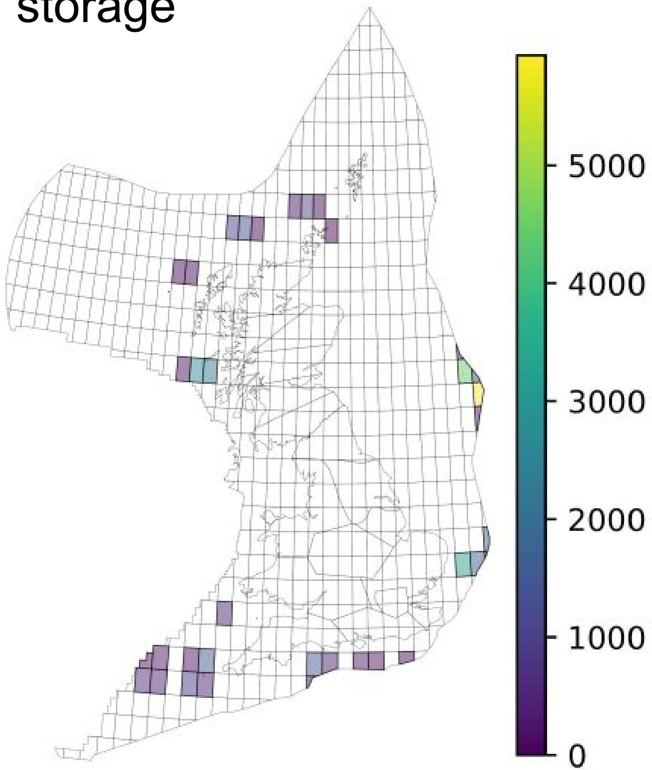
Questions

For anyone reading the presentation online please feel free to email me

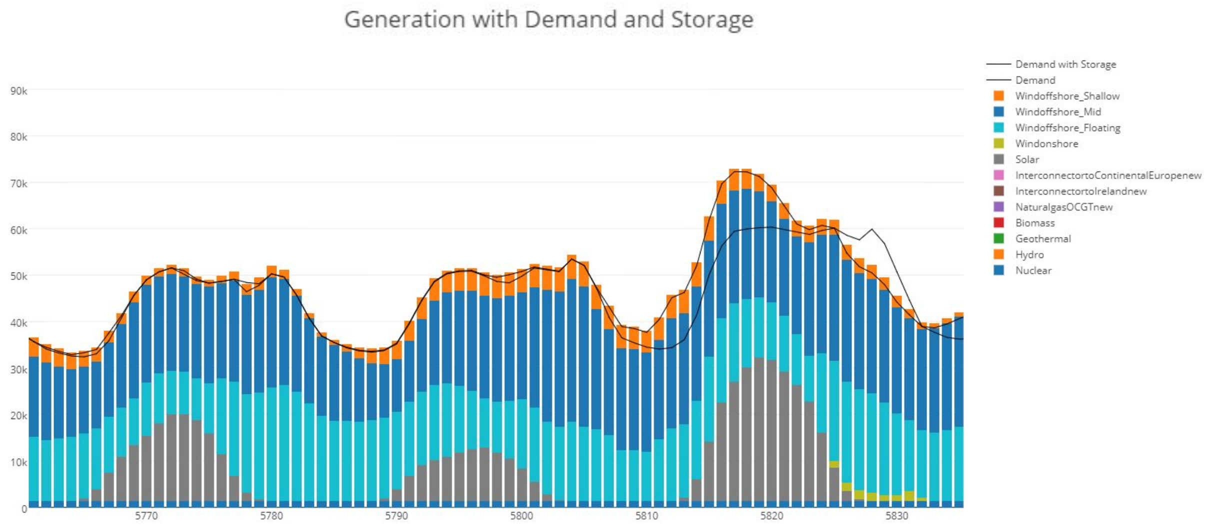
Appendices

highRES example outputs

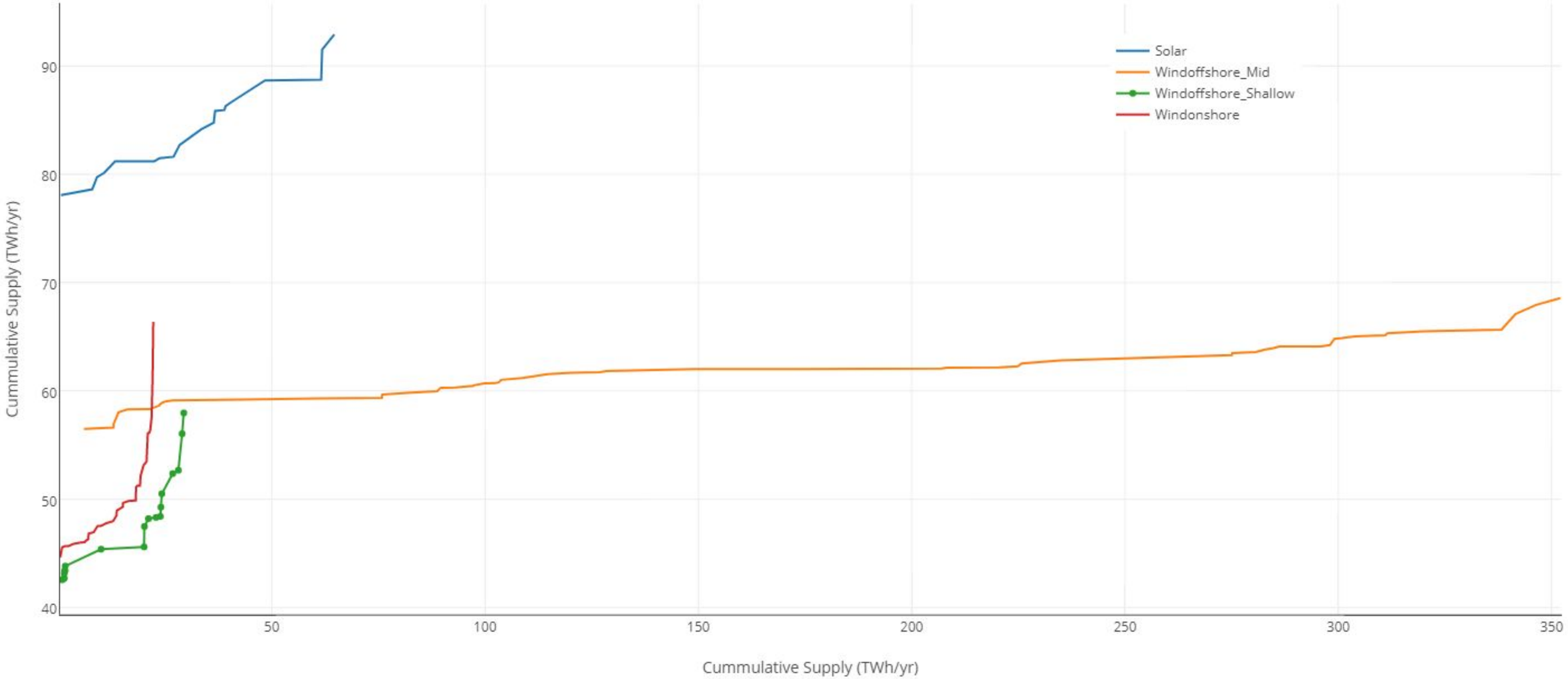
Locations and capacities of generators, transmission and storage



Hourly production profile



Resultant ‘Utilised LCOE Supply Curve’
90% Renewable Share, 140% Floating Cost



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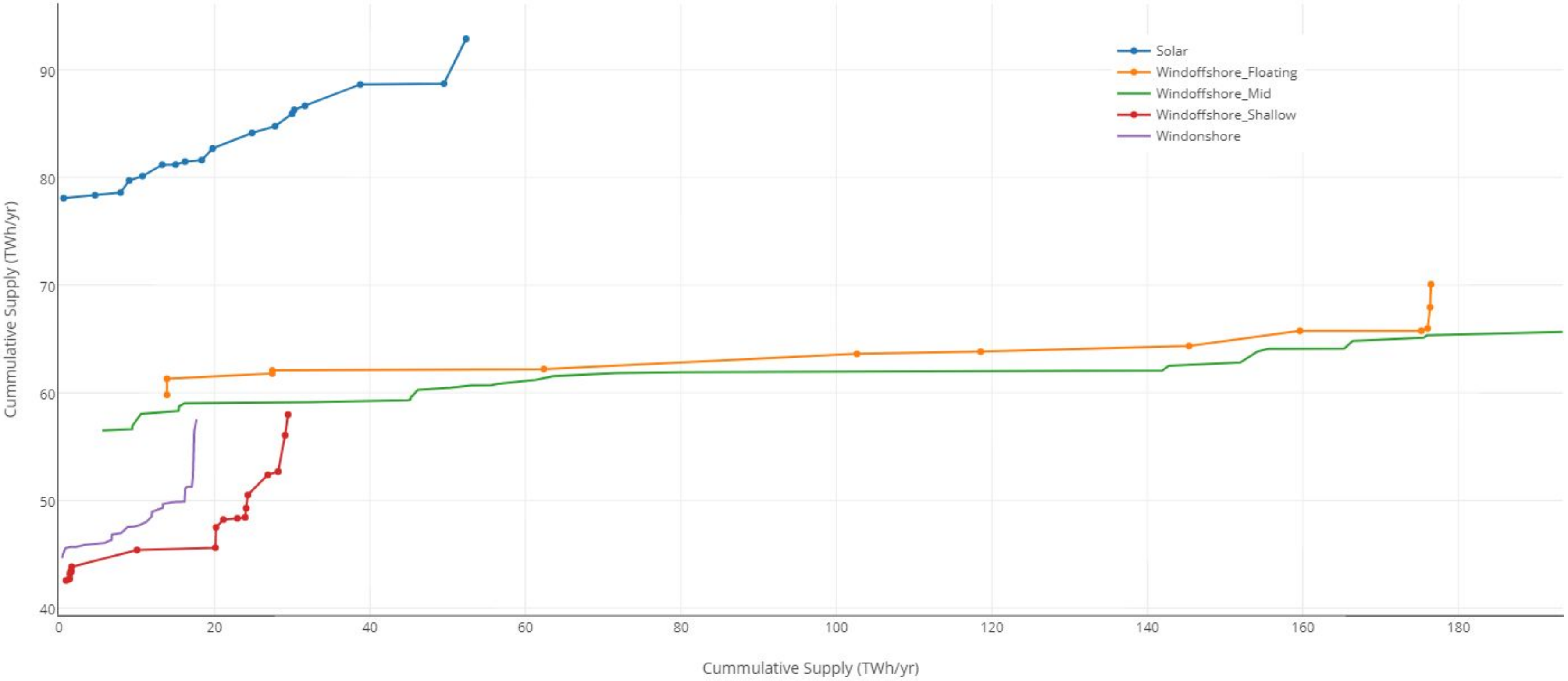

Results - Correlation Matrix

90% Renewable Share, 105% Floating Cost