Assessing The Role of Offshore Wind Energy in A Future Least Cost 100% Renewable NEM

Jonathan Rispler[1], Ben Elliston[1,2], Mike Roberts[1,2] and Anna Bruce[1,2]

[1]School of Photovoltaic and Renewable Energy Engineering, University of New South Wales, Sydney, Australia
[2]Collaboration on Energy and Environmental Markets, UNSW Sydney

It is widely acknowledged that climate change is occurring because of anthropogenic emissions. To avoid the worst impacts of climate change, many countries are aiming to achieve net zero emissions by 2050. Reaching net zero emissions by 2050 will likely require a net zero electricity grid somewhat earlier than 2050 as other sectors of the economy will be slow to decarbonise. According to current literature, decarbonisation of the national electricity market [NEM] will need to occur by 2037 for Australia to achieve net zero emissions by 2050 (WWF, 2014). Furthermore, it is feasible to decarbonise the NEM by using 100% renewable electricity [RE] (Elliston et al. 2014). Although previous studies on a 100% RE NEM have explored a wide array of generation technologies, offshore wind has not been included in their final modelling. To address this gap, this paper presents an assessment of the potential role for fixed foundation offshore wind in a 100% RE NEM in 2037. To achieve this, the National Electricity Market Optimiser [NEMO] tool was used to perform a least cost grid solution search for a range of scenarios and offshore wind costings.

Fixed foundation offshore wind technology refers to traditional turbines which are directly attached into the seabed via a foundation to prevent movement relative to the seabed. This differs from emerging floating offshore wind technology, which relies on anchor systems to prevent floating turbines from being displaced. A review of the literature provided a lower bound estimate for offshore wind capital costs for 2037 of 2,300 AUD/kW[1] (IRENA 2019), which was used for a ‘rapid scenario’ representing rapid decrease of offshore wind costs. This was compared to a ‘control scenario’ which did not include offshore wind as a potential generation technology. Each scenario was modelled twice for the following NEM conditions: 85% non-synchronous penetration [NSP] limit, 95% NSP limit enabled via battery storage. The lowest cost grid solution (including transmission network costs) was taken as the final result for each of the four modelling parameter combinations.

Table 1. Results Summary

	No Battery (NSP Limit: 85%)		With Battery (NSP Limit: 95%)	
Scenario	Offshore Wind Capacity (GW)	Annualised Cost ($/MWh)	Offshore Wind Capacity (GW)	Annualised Cost ($/MWh)
Control No Offshore Wind	N/A	94.26	N/A	83.94
Rapid	17.3	93.31	17.3	81.38

[1] Note that all costs are in 2020 AUD

As show in Table 1, if offshore wind capital costs fall in line with the favourable 2037 cost projection of 2,300 $/kW, then fixed foundation offshore wind should play a significant role in the NEM. This can be stated as 17.3GW of offshore wind capacity was installed in the least cost solution [LCS] 100% RE NEM for the rapid scenarios. This finding is independent of whether installation of battery storage enables greater levels of non-synchronous penetration in the NEM. Any cost reduction caused by the inclusion of cheap offshore wind is insignificant compared to the cost reductions caused by the relaxation of the NSP limit by 10%. The annualised system cost results of all eight simulations undertaken are shown below in figure 1.

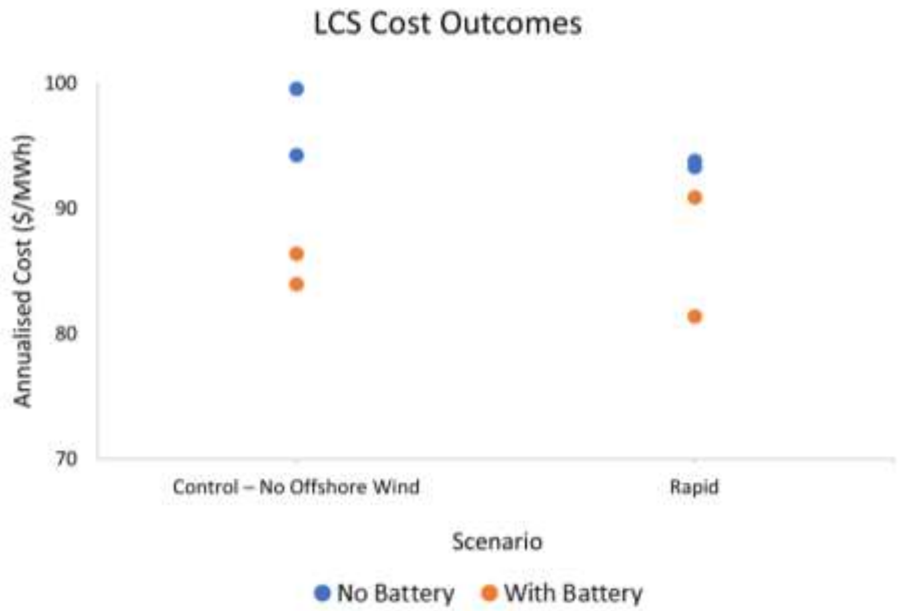

Figure 1. Annualised cost results from each modelled scenario

A broader engineering perspective was used to assess the role of offshore wind energy. This was achieved through the use of additional metrics, including levleised cost of electricity [LCOE], total LCS generation capacity, and total amount of surplus generation. These metrics remained stable or improved when offshore wind was included in the LCS. This indicates the inclusion of offshore wind can occur without causing negative techno-economic impacts to the LCS 100% RE NEM. The lowest LCOE achieved by the most prominent variable generation sources are outlined in Table 2. Note that calculations of LCOE for generators excludes generation in excess of the electrical demand that is used for refilling pumped hydro [PHES], recharging battery storage, or is spilled.

Table 2. Lowest LCOE summary for solar, onshore wind, and offshore wind

	Effective LCOE for: Non-Battery Scenarios ($/MWh)			Effective LCOE for: Battery Scenarios ($/MWh)		
Scenario	Solar	Onshore Wind	Offshore Wind	Solar	Onshore Wind	Offshore Wind
Control No Offshore Wind	24	55	N/A	25	65	N/A
Rapid	25	56	80	26	58	73

Figure 2 depicts the generation capacity installed in each modelling scenario. The scenarios which include offshore wind with the rapid costing have less total capacity. This is driven by the fact that the inclusion of offshore wind in the LCS reduces the need for onshore wind capacity, with each GW of offshore wind displacing more than a GW of onshore capacity in the LCS. This holds with and without battery storage. This result helps to explain the reduced annualised system costs in the rapid offshore wind scenarios.

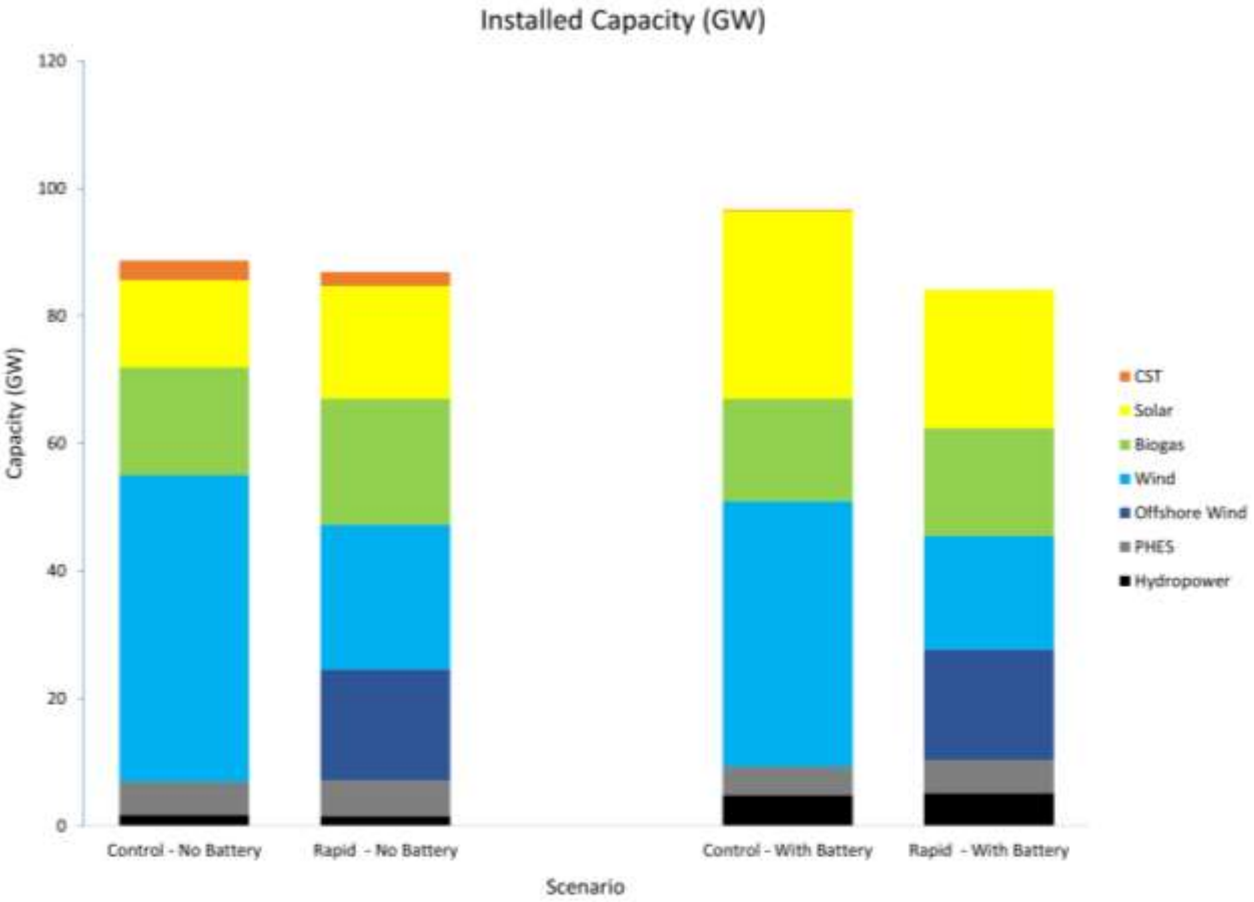

Figure 2. Installed capacity breakdown for modelled scenarios

The breakdown of annual generation for each LCS is plotted in Figure 3, as well as the amount of unused surplus generation spilled throughout the year. This unused surplus is the generated energy in excess of electrical demand which was not stored.

Figure 3 shows that the rapid costing scenario for offshore wind, in conjunction with a NSP limit of 95%, is able to achieve the lowest amount of unused surplus generation. This scenario enables a substantial level of generation from utility solar & offshore wind and avoids overbuilding of wind capacity in the LCS. These are the main factors which enable this LCS to achieve the lowest values for both unused surplus generation and annualised system costs.

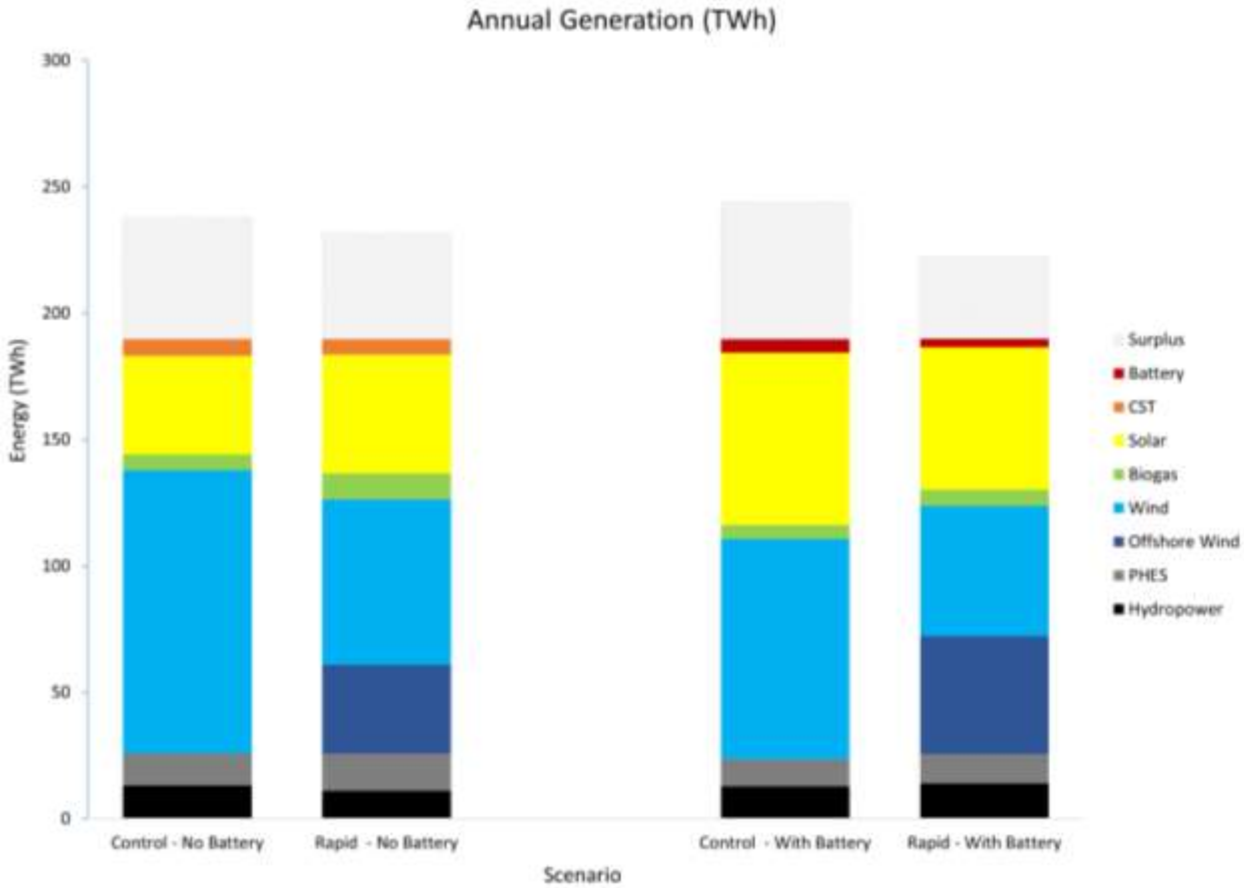

Figure 3. Annual generation breakdown for modelled scenarios

The results of this study are significant as previous studies on a 100% RE NEM excluded offshore wind on the assumption that it would not play a role in a future least cost NEM. This research was able to demonstrate that, given rapid cost reductions, there is a strong case for installing substantial amounts of offshore wind in the NEM. This is supported by the positive role offshore wind could play in reducing the annualised costs of the LCS. Further studies are required to understand the cost-effectiveness of offshore wind under more moderate cost reduction scenarios.

References

Elliston, B., MacGill, I. and Diesendorf, M, 2014, ‘Comparing least cost scenarios for 100% renewable electricity with low emission fossil fuel scenarios in the Australian National Electricity Market’, Renewable Energy, vol. 66, p. 196-204.

IRENA 2019, ‘Future of wind: Deployment, investment, technology, grid integration and socio-economic aspects (A Global Energy Transformation paper)‘, International Renewable Energy Agency, <https://www.irena.org/publications/2019/Oct/Future-of-wind>.

Pascoe, O. and Caught, K. 2014, ‘Expert Panel Review Of The Renewable Energy Target’, World Wildlife Fund – Australia.