

# Supplementary Information for “Spatial optimality and temporal variability in Australia’s wind resource”

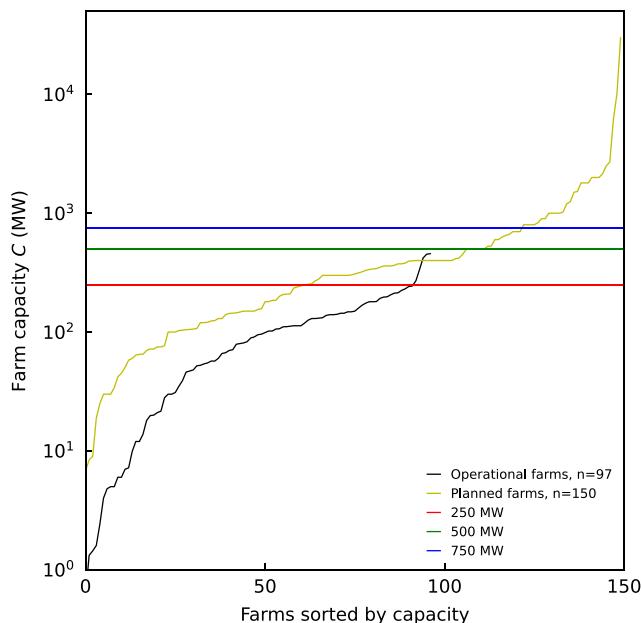
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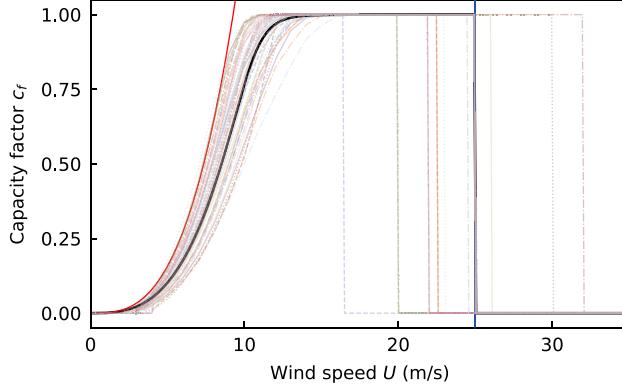
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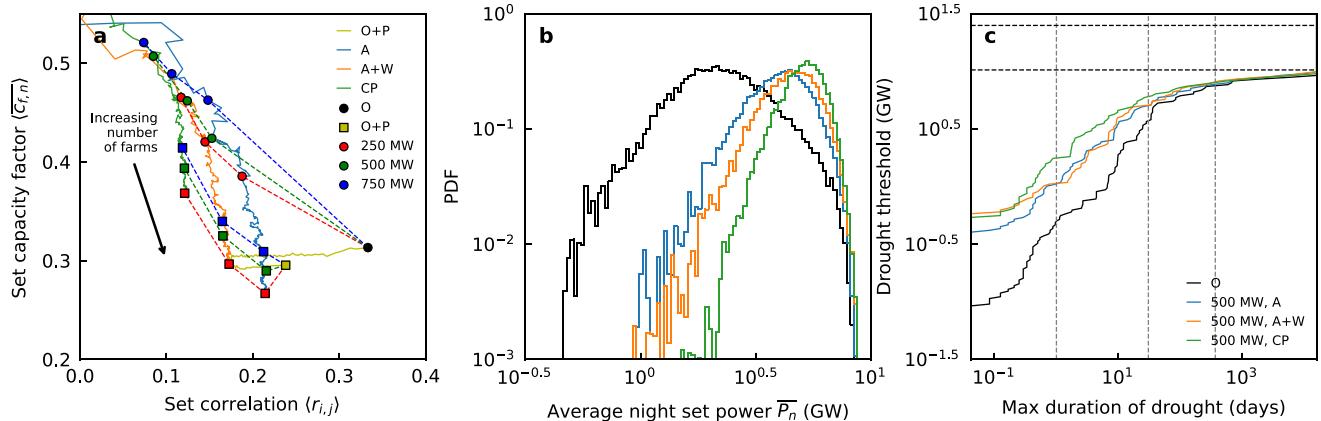
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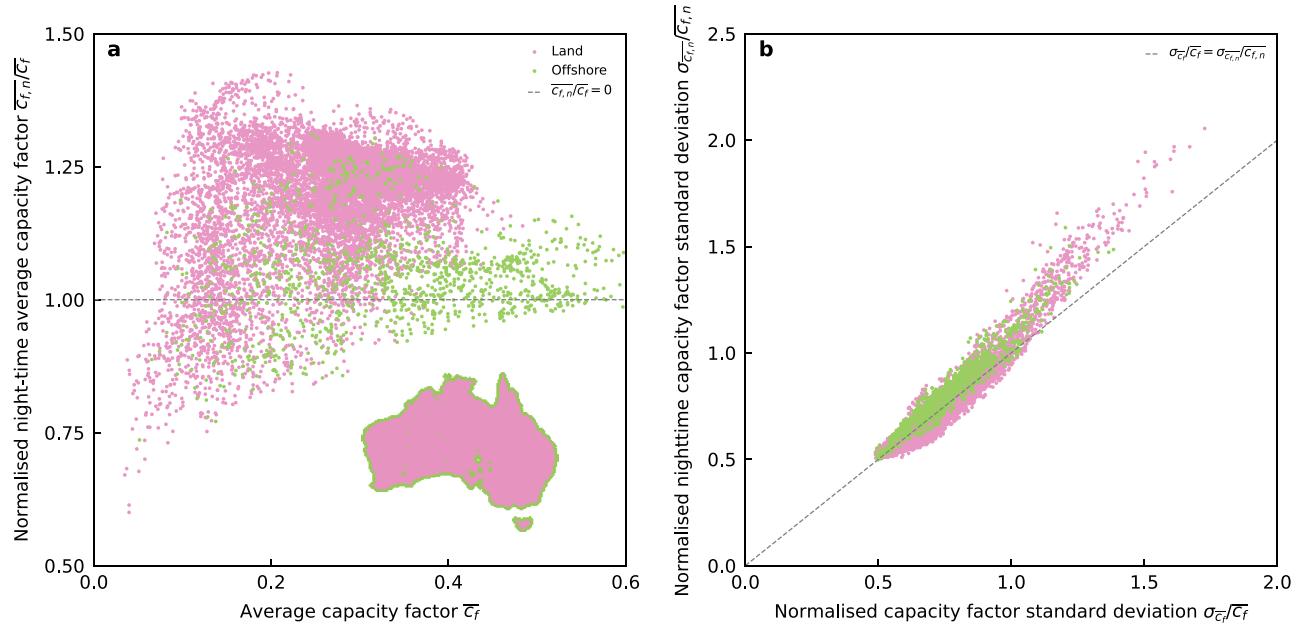
**Figure S1. Wind farm capacity in Australia.** Capacities for presently operational AEMO-connected wind farms (black) and planned grid-connected wind farms (yellow) sorted by capacity. 250 GW (red), 500 GW (green) and 750 GW (blue) hypothetical wind farm capacities also shown.



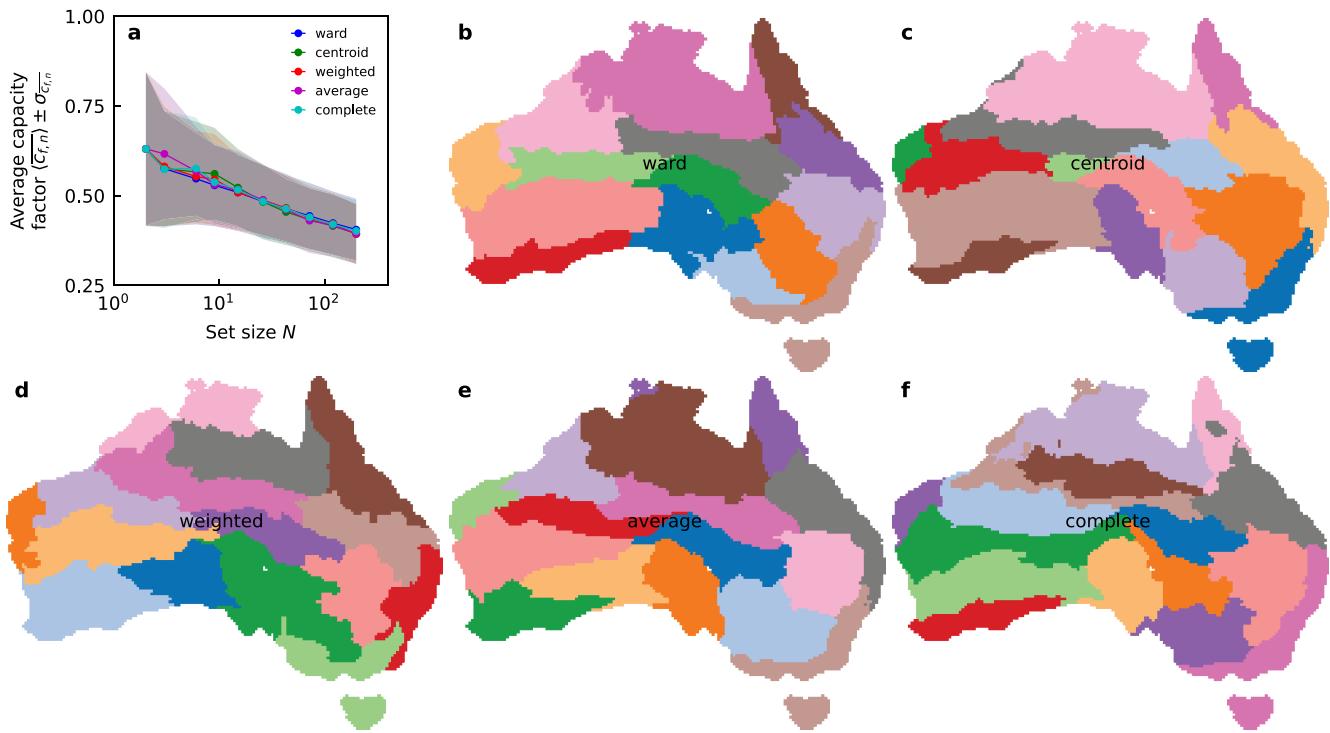
**Figure S2. Turbine capacity curves.** Capacity factor power curves for a range of various existing turbines (translucent lines, legend shows manufacturers and models) and the theoretical one used in this study (black). Also shown are the Betz limit (red) and cut-off speed (blue) for the theoretical curve.



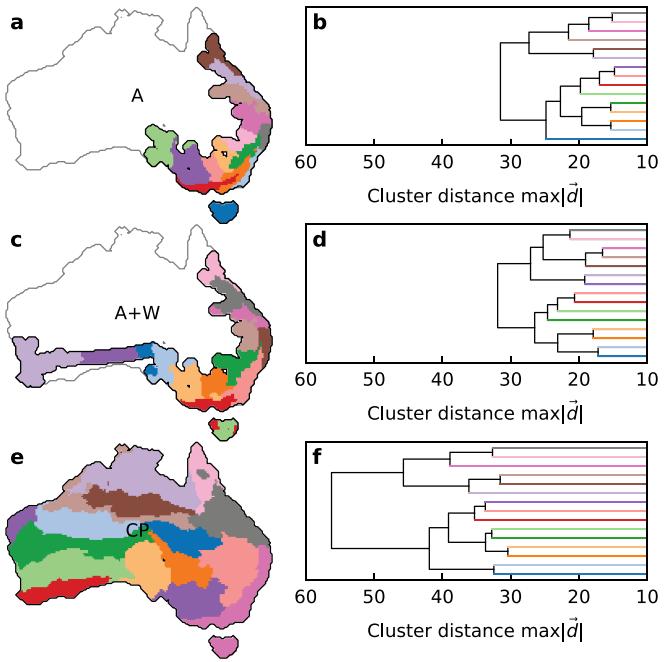
**Figure S3. Total set performance.** (a) The average set correlation  $\langle r_{i,j} \rangle$  and capacity factor  $\langle \bar{c}_f \rangle$  from 1979-2021 for an increasing number of farms; within 100 km of the AEMO grid (pale blue solid line) or connected AEMO and southern WA grid (orange solid line), copper plate scenario (pale green solid line), or planned farms in addition to the presently-operational farms chosen to minimise total set correlation (yellow solid line). Markers on these lines match the total set capacity of the operational (circle) or operational and planned (square) wind power. Marker colours indicate the farm capacities for; operational (black) and planned (yellow) farms, or hypothetical 250 MW (red), 500 MW (green), and 750 GW (blue) farms. Dashed lines connect sets with equivalent total capacity. (b) Probability density functions of average night set power produced by equivalent-capacity sets; operational (black), 500-MW farms within 100 km of the AEMO grid (pale blue), 500-MW farms within 100 km of the connected AEMO and southern WA grid (orange), and 500-MW farms in the copper plate scenario (pale green). (c) Maximum ‘drought’ duration (days) within the 1979-2021 period where the sets in (b) do not produce power above some ‘drought’ threshold (GW). Grey dashed lines indicate a day, month and year, and black dashed lines indicate  $\sim 25$  GW AEMO baseload and total set capacity.



**Figure S4. Offshore site comparison.** **(a)** A scatter plot of the average capacity factor against the average nighttime capacity factor normalised by the average capacity factor of sites on land (pink) and offshore (green). Offshore sites can have higher capacity factors but do not experience strong increases in capacity at night. Map shows the locations defined as land and offshore. **(b)** The standard deviation in daily-average capacity factor normalised by the average capacity factor against the same but for nighttime only. A one-to-one line (grey dashed) is given. Offshore sites tend to have larger variability at night than compared to average, relative to sites on land.



**Figure S5. Influence of clustering algorithm choice.** (a) The average capacity factor (envelope is  $\pm 1$  standard deviation) of farms in hypothetical sets in the copper plate scenario of different sizes obtained using 5 separate clustering algorithm methods. In this study we use the complete method, which performs smoothly at small set size and well, relatively to the other methods, at all set sizes, especially large ones. Maps show the 15 correlated regions chosen using these methods; (b) ward, which splits clusters with the largest intra-cluster deviation (c) centroid, which compares distances between the point-weighted centers of clusters, (d) weighted, where clusters are split where the mean distance between points within the cluster is more than any other, (e) average, which compares the average distance between all points in a cluster to all points in another, and (f) complete, which compares the maximum distance between any point in one cluster with any in another. The consistency of these curves shows the analysis is not especially sensitive to the algorithmic method. Note clusters are not defined spatially, they are defined in the space spanned by the correlation for each location, and distances are defined as the Euclidean between points or clusters in that space.



**Figure S6. Clusters in each scenario.** (a) The scenario ‘A’ for farms within 100 km of the AEMO grid outlined in black (Australia in grey), with the first 15 clustered regions labelled in a unique colour. (b) The dendrogram of the first 15 clustered regions in ‘A’ (colours match the map in (a)), with the leg distance equal to the maximum Euclidean distance between points in each cluster in the space spanned by correlation values. (c) as (a) for the scenario ‘A+W’ for farms within 100 km of the hypothetically linked AEMO and southern Western Australia grids. (d) as (b) for ‘A+W’. (e) as (a) for the copper plate scenario ‘CP’ where farms can exist anywhere (same as Fig. 2e). (e) as (a) for ‘CP’. Note that panels (b), (d) and (f) share the same distance axis: clusters in the ‘CP’ scenario form at greater dissimilarity since there is more variety in the wind climate.

Set Capacity (GW)	Set Name	Farm Size (MW)	Number of Farms	Average Night-time Capacity Factor		Normalised Standard Deviation of Night-time Capacity Factor		Night-time Capacity Factor Correlation
				Value (to 3 D.P.)	Improvement on Baseline (%)	Value (to 3 D.P.)	Improvement on Baseline (%)	
10.28	O	various	97	0.313	-	0.465	-	0.333
	A	250	41	0.385	<b>23</b>	0.300	<b>36</b>	0.188
		500	21	0.424	<b>35</b>	0.285	<b>39</b>	0.153
		750	14	0.462	<b>48</b>	0.299	<b>36</b>	0.148
	A+W	250	41	0.420	<b>34</b>	0.255	<b>45</b>	0.145
		500	21	0.462	<b>47</b>	0.253	<b>46</b>	0.124
		750	14	0.489	<b>56</b>	0.256	<b>45</b>	0.106
	CP	250	41	0.465	<b>49</b>	0.213	<b>54</b>	0.117
		500	21	0.507	<b>62</b>	0.201	<b>57</b>	0.085
		750	14	0.521	<b>66</b>	0.204	<b>56</b>	0.074
123.50	O+P	various	247	<b>0.295</b>	-	<b>0.399</b>	-	<b>0.238</b>
	A	250	494	0.267	<b>-10</b>	0.355	<b>11</b>	0.214
		500	247	0.290	<b>-2</b>	0.347	<b>13</b>	0.216
		750	165	0.309	<b>5</b>	0.337	<b>16</b>	0.212
	A+W	250	494	0.297	<b>0</b>	0.295	<b>26</b>	0.173
		500	247	<b>0.325</b>	<b>10</b>	0.282	<b>29</b>	<b>0.165</b>
		750	165	0.340	<b>15</b>	0.278	<b>30</b>	<b>0.165</b>
	CP	250	494	0.368	<b>25</b>	0.219	<b>45</b>	0.121
		500	247	0.394	<b>33</b>	0.214	<b>46</b>	<b>0.121</b>
		750	165	0.414	<b>40</b>	0.210	<b>47</b>	0.119

**Table S1. Summary of wind farm sets in this study.** Average night-time capacity factors, standard deviation of night-time capacity factors (normalised by the average), and night-time capacity factor correlation, for the different wind farm sets in this study. Farms with equal total capacity to the operational farms are coloured in grey, and those with equal total capacity to the operational and planned farms are coloured in yellow. Hypothetical sets are listed based on their extent (2nd column) and the capacity of individual farms within the set (3rd column). For hypothetical sets, the number of equal-capacity farms required to make a total set capacity equal to the baseline is given in the 4th column. Values are given, as well as the percentage improvement from the baseline (real) set in bold. Italicised rows are the sets focused on in the main text.

**Table S2. Operational and planned wind farms in Australia.** A table collating the names, capacities and coordinates of all farms. Data source is given for the information on each farm, as is the planning stage designated to each planned farm. This table is provided as an auxiliary file with the manuscript named ‘Tables2.csv’.