21 December 2022

Energy Security Board
By Email: info.esb.org.au

**Response to Transmission Access Reform Directions Paper**

Dear Energy Security Board,

The Battery Storage and Grid Integration Program (BSGIP) welcomes the opportunity to provide input on the Energy Security Board (ESB)'s Transmission Access Reform Directions Paper.

The Battery Storage and Grid Integration Program undertakes research across the development, integration, operation and optimisation of energy storage in electricity grids and electricity markets globally. The program places a strong focus on transdisciplinary research, development and demonstration (RD&D) and is involved in a number of key national projects worth over $119M and incorporating more than 30 partners. BSGIP research activities are categorised into the following four themes; 1) Materials, battery technologies and characterisation, 2) Energy system modelling and analysis, 3) Energy system control and coordination and 4) Social science, economics and policy. Established in 2018, BSGIP is hosted within The Australian National University by the School of Engineering and the Research School of Chemistry. The program is funded by the ACT Government, as part of the Renewable Energy Innovation Fund, and the Australian National University.

Having monitored the discourse on Transmission Access Reform (TAR) throughout the year, we have observed that the stakeholder consultation process has been largely supported by modelling of long-term future scenarios, however makes limited quantitative reference to the current state and trends of congestion in the National Electricity Market (NEM). This seems a necessary prerequisite to appreciate the magnitude of the problem that TAR seeks to resolve, and to identify the most heavily impacted parties under the status quo. Therefore, as an independent research institution we thought it valuable to contribute the findings of our quantitative analysis of the issue.

Using publicly available market data published by the Australian Energy Market Operator (AEMO), we have analysed the curtailments due to congestion for each individual utility-scale generator that has been impacted by a binding constraint between January 2019 and June 2022. Our findings reveal and act to affirm several of the key claims made qualitatively throughout this consultation process:

- Curtailments due to congestion currently amount to less than 0.6% of annual demand, although are slowly rising.
- Renewables are disproportionately impacted by congestion.
- Congestion already represents a significant financial risk for a number of existing renewable generators.
- The current market design often fails to incentivise storage and flexible loads to relieve congestion.

## 1. Curtailments due to Congestion currently amount to less than 0.6% of annual demand, although are slowly rising.

Much of the discourse on this issue has avoided a quantitative description of the current scale of congestion in NEM, instead referencing projections from the long-term Integrated System Plan (ISP) modelling. Our analysis places the total curtailment due to congestion in the NEM at 1.34 TWh for FY22, representing just under 0.6% of annual demand and 3% of utility-scale VRE generation. We anticipate that this is lower than many stakeholders may have expected.

The figure below plots quarterly congestion over the recent years, and does appear to show a small trend of trend of growth in total curtailments. However, a much more distinct trend is the shift towards renewable curtailment. 29.6% of curtailed energy came from utility-scale VRE generators in 2019, and this share increased significantly to 79.4% in 2021 while the total volume of curtailment has remained relatively stable.

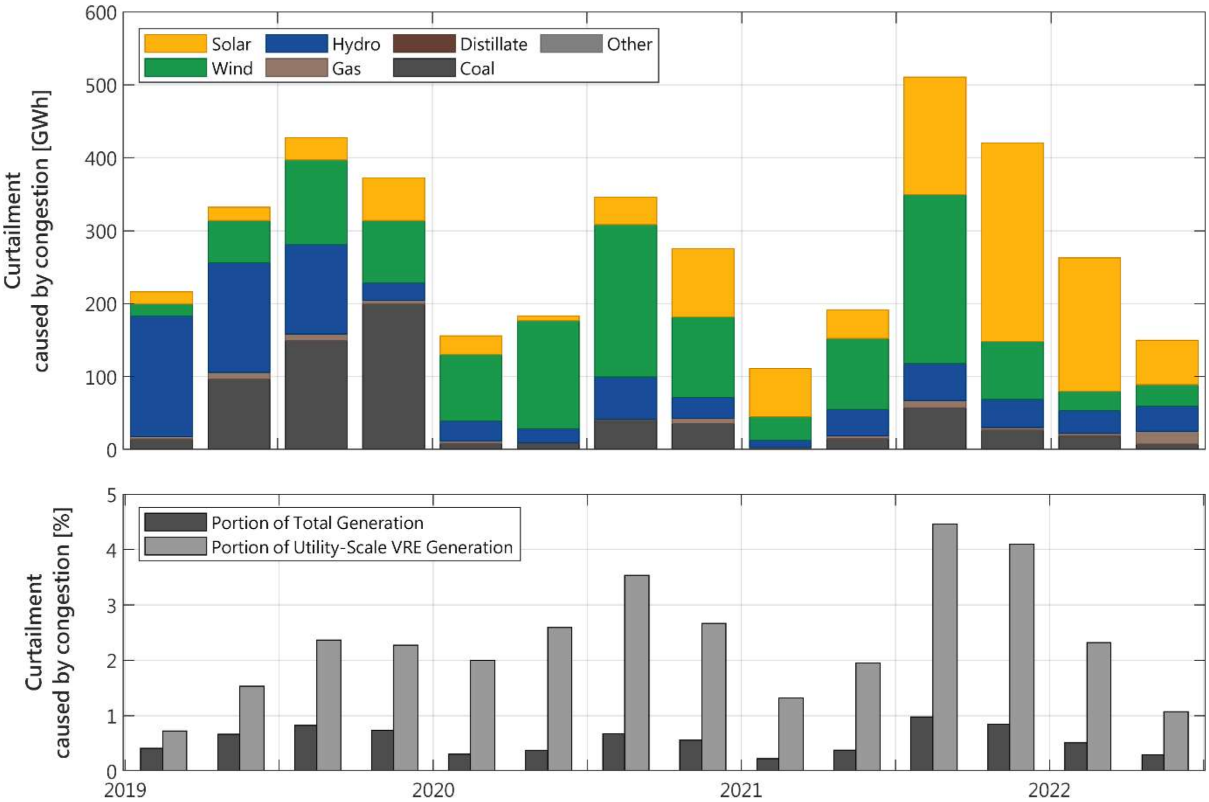


***Figure 1:*** *NEM-wide quarterly curtailments due to congestion categorised by primary technology (top), and placed in reference to total generation (bottom). Both plots show that curtailment caused by congestion is increasingly impacting VRE.*

In addition to these trends, there is clear intra-annual variability with congestion often peaking in the early spring months as a likely product of reduced heating and cooling loads, alongside abundant sunshine and wind.

## 2. Renewables are disproportionately impacted by congestion.

Despite representing 39.6% of the NEM's installed generating capacity in June 2022[1], utility-scale VRE and hydro together contributed 89.2% of curtailments due to congestion in FY22. This disproportionate curtailment of VRE generation is consistent across each of the five NEM market regions as shown in the figure below. In NSW, VIC, SA, and TAS renewables represented almost the entirety of curtailments due to congestion, although QLD continued to show a significant contribution from fossil fuels.

Solar is by far the worst impacted, with curtailments almost double that of the next closest in wind despite having a smaller installed capacity. We can observe that the majority of solar curtailment occurs in NSW, while the majority of wind curtailment occurs in SA. Notably, the curtailment of solar energy alone in the NSW market region (418 GWh) is greater than the total curtailment of any other region.

The figure below also compares these generating technologies by the weighted average price of curtailed energy throughout FY22, calculated using historical Regional Reference Prices. It is shown that energy curtailed from solar (58.74 $/MWh) and wind (46.34 $/MWh) is on average much cheaper than both that curtailed from gas (716.69 $/MWh) and coal (169.42 $/MWh), as well as the average unit price of energy over this period (140.75 $/MWh)[2]. Together these findings affirm the claims made throughout this stakeholder consultation, that congestion is causing large volumes of cheap renewable energy to be curtailed.

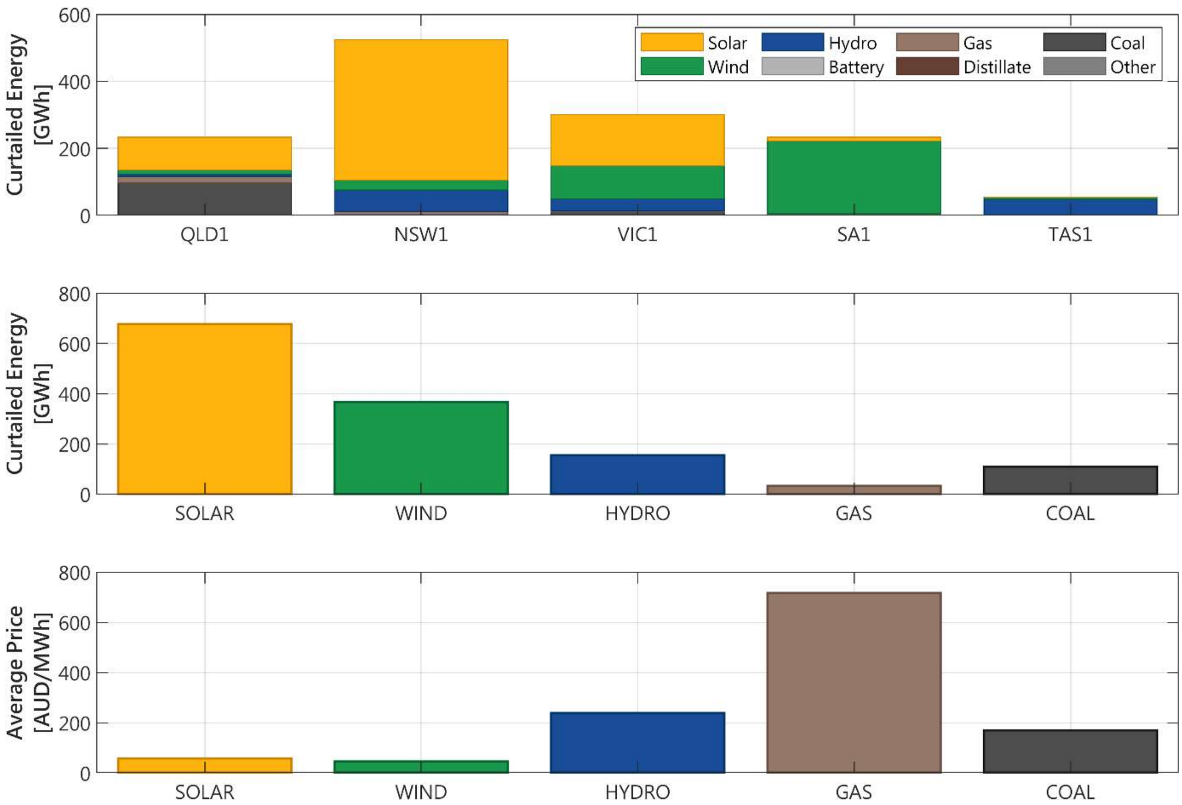


***Figure 2:*** *Aggregated curtailments due to congestion by (top) market region and primary technology, and (middle) primary technology only throughout FY22. In addition to (bottom) weighted average price of curtailed energy categorised by primary technology.*

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[1] https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/generation_information/2022/nem-generation-information-june-2022.xlsx?la=en

[2] https://opennem.org.au/energy/nem/?range=all&interval=fin-year

## 3. Congestion already represents a significant financial risk for a number of existing renewable generators.

Our analysis examined the 342 registered energy market participants that have been impacted by a binding transmission constraint in recent years, and ranked them across a number of metrics for congestion impact. The results show that a large number of predominately renewable generators are already facing significant impacts and losses due to congestion.

In order to manage congestion, AEMO issues negative Mis-Pricing Adjustments (MPA) to generators that are at risk of having their power curtailed. This is just one part of a package that the directions paper describes as “blunt heuristics”, and often acts to reduce any competitive advantage a generator may have had in bidding. Negative MPAs represent a significant barrier to market participation, and we consider the cumulative duration for which they are applied to an individual generator to be a useful measure of congestion impact. As shown in figure 3, individual generators spent as much as 118 days of FY22 under a negative MPA and subject to the associated arbitrary dispatch conditions. This is increasingly significant considering the already intermittent availability of solar and wind generators.

Given that all generators have their revenue coupled to production in some way, curtailment is ultimately the most informative measure of congestion impact. Figure 4 ranks generators based on the portion of their annual production that was curtailed due to congestion, and shows that several of the worst affected solar farms face annual curtailments of more than 10%. The worst impacted generators are the neighbouring Molong (47.2%) and Manildra (39.0%) solar farms in central west NSW, followed by several others in the area and across southern NSW and VIC. These clusters of heavily congested generators can be visualised alongside the ISP Renewable Energy Zones on the map in Figure 5.

Curtailments of this scale denote significant financial losses for these generators, and contribute to investment uncertainty and risk for future projects. Across both rankings we observe that almost the entire top 40 consists of renewable generators, primarily solar and wind. Earlier it was shown that the aggregated NEM-wide curtailment is less than only 0.6%, however here we are showing that many individual renewable generators carry a disproportionate amount of that burden.

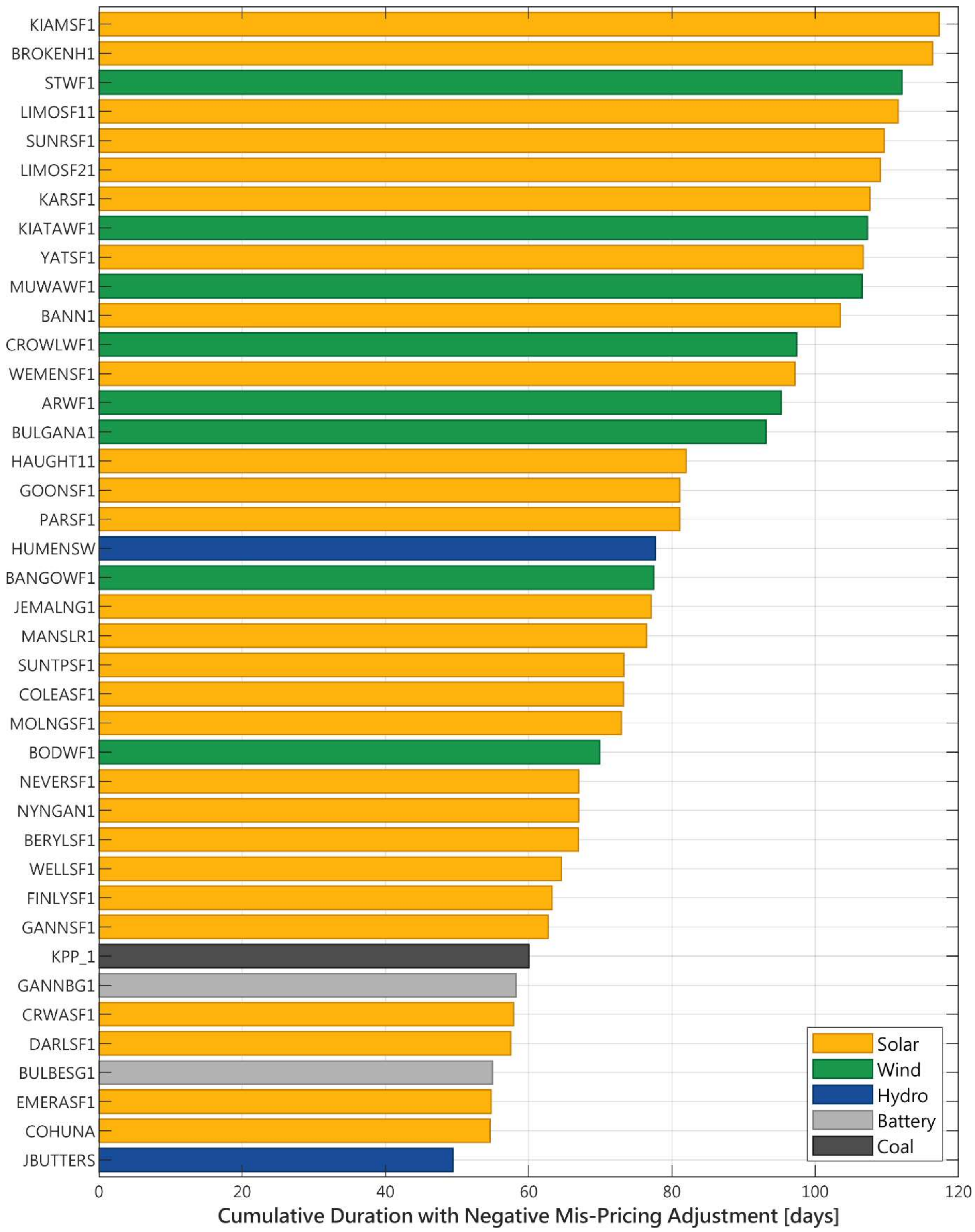


***Figure 3:*** *Top 40 generators in the NEM ranked by cumulative duration under a Negative Mis-Pricing Adjustment in FY22.*

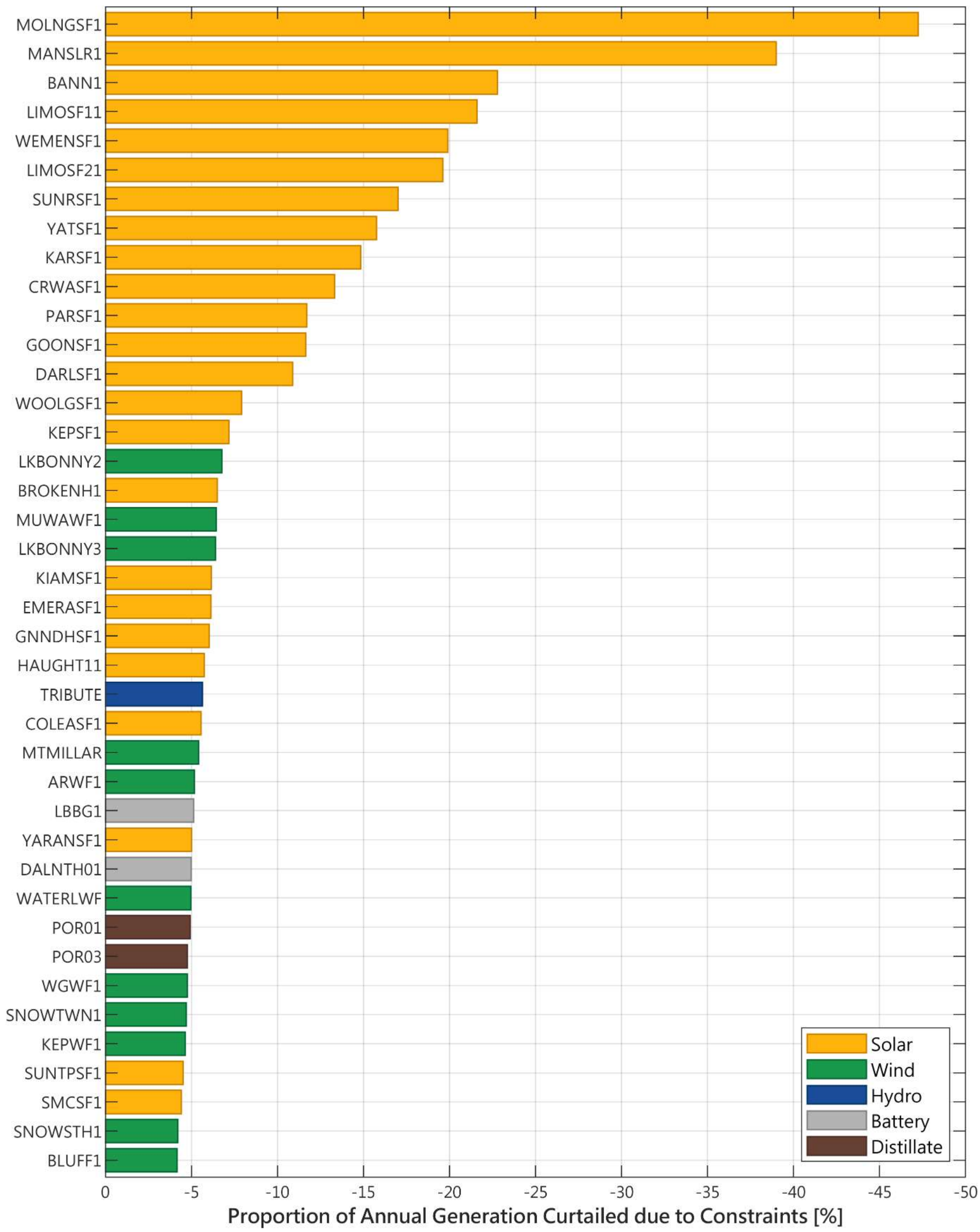


***Figure 4:*** *Top 40 generators in the NEM ranked by proportion of annual production curtailed due to congestion in FY22.*

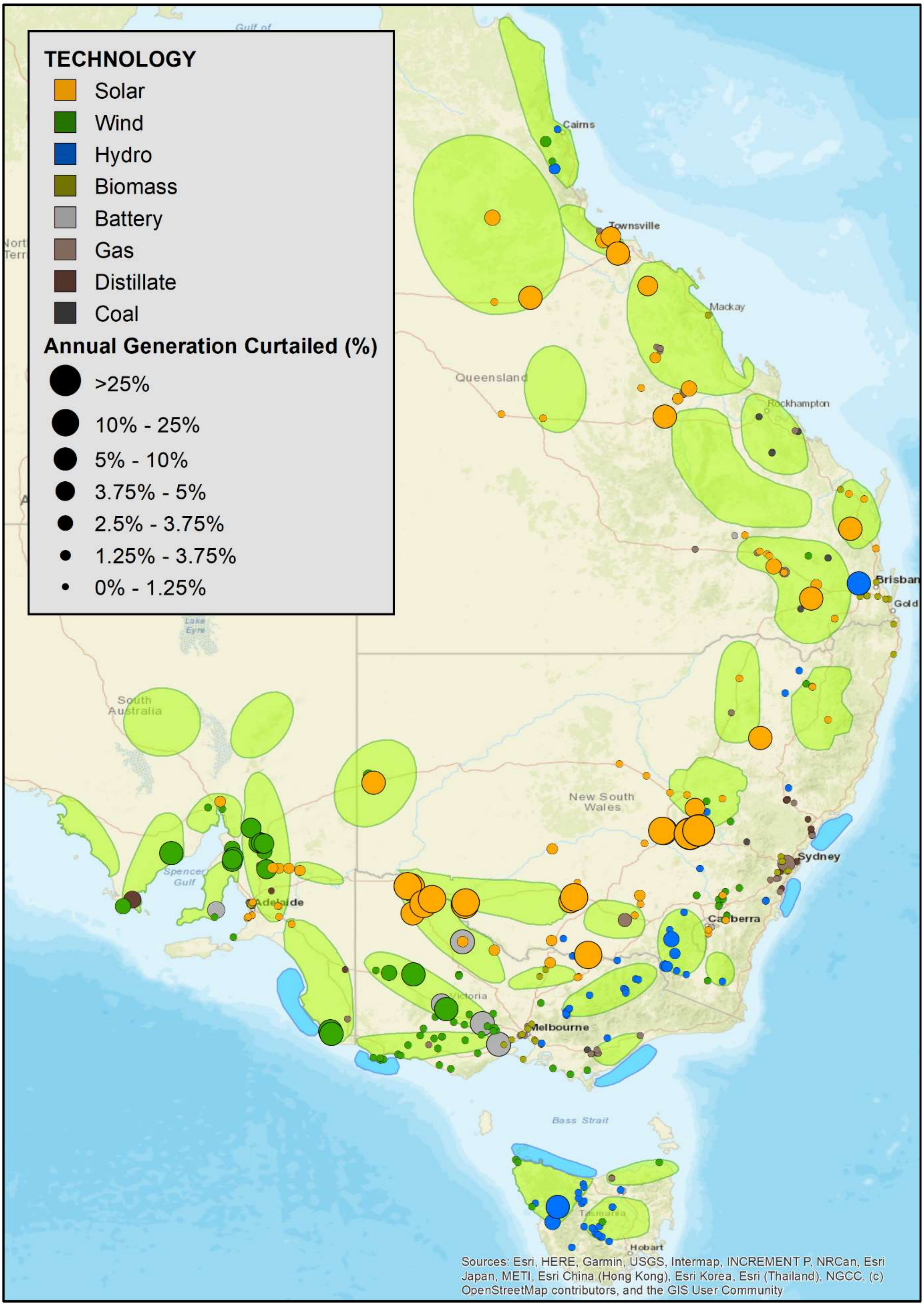


***Figure 5:*** *Map of NEM generators sized according to congestion related curtailment during FY22 and superimposed with ISP Renewable Energy Zones in green.*

## 4. The current market design often fails to incentivise storage and flexible loads to relieve congestion.

Storage and flexible loads have great potential to provide congestion relief, and reduce the wasteful curtailment of cheap renewable energy. While some level of spillage and curtailment is widely acknowledged to be part of an efficient high VRE grid, it is also clear to see how the congestion relief capability of existing storage assets is potentially being under-utilised in the current market structure.

To illustrate this, the figure below analyses behaviour of the 8 grid scale batteries that were subject to a binding constraint in FY22 and compares their utilisation for congestion relief. The cumulative duration for which they were impacted by congestion is plotted along the x-axis and partitioned based on bidding behaviour during that time. The blue segments show the duration for which the batteries bid in such a way as to charge and relieve local congestion, whereas the red represents the duration that the batteries bid to discharge and exacerbate it. This bidding behaviour is indicative of incentives presented to the batteries, although notably is not representative of real dispatch behaviour due to number of operational considerations.

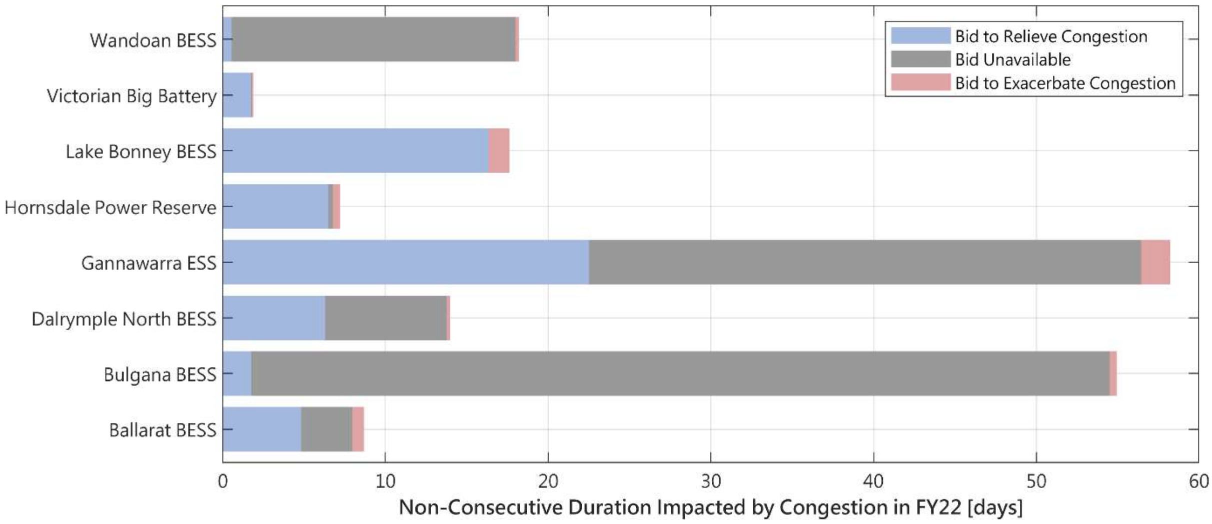


***Figure 6:*** *Utilisation of 8 grid-scale batteries in the NEM for congestion relief during FY22.*

Much of the conversation surrounding the need for a Congestion Relief Market suggests that the current market design does not incentivise storage to alleviate congestion, however the findings above seem to indicate that it often actually does. It is clear to see that several of the batteries do overwhelmingly bid to relieve congestion, even in the absence of an explicit incentive. This is likely because the low spot prices that incentivise charging can often occur alongside congestion as a result of a region-wide oversupply of VRE. Further, the large durations bid unavailable for certain batteries are likely to be related to the battery sizing. For example, the Gannawarra battery only has two hours of storage, meaning that on a heavily congested day it can only relieve congestion for 2 hours and would have to sit idle for the remainder.

Despite this, it is also clear that there are also occasionally times where each battery bids to exacerbate congestion by discharging. This represents the scenario referred to so frequently in much of the discourse, wherein the lack of explicit incentive allows batteries to make congestion worse. While we have not sought to quantify the impact of these periods at this time, it is anticipated that they are relatively minor given the sizes of these batteries.

Even considering that existing batteries largely tend to relieve congestion under the status quo, there remain occasions where misaligned incentives direct batteries to instead make it worse. While these scenarios persist, the market may yet benefit from a more explicit congestion relief incentive.

BSGIP thanks the ESB for the opportunity to contribute our research to this process. We will soon be releasing a more detailed report on the state of congestion in the NEM over the past four years. If you wish to further discuss any of our comments in this submission, please contact Jack Sorensen by email at Jack.Sorensen@anu.edu.au.

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