GE Renewable Energy

Martin Kennedy
Head of Sales – Hydropower
Australia

M : +61 416 642 398
E : martin.kennedy@ge.com

www.ge.com
www.gerenewableenergy.com

Audrey Zibelman
Managing Director & CEO
Australian Energy Market Operator

www.aemo.com.au

Date: 28 January 2021
Subject: Request for Feedback on Draft Inputs, Assumptions & Scenarios Report (IASR)

Dear Audrey,

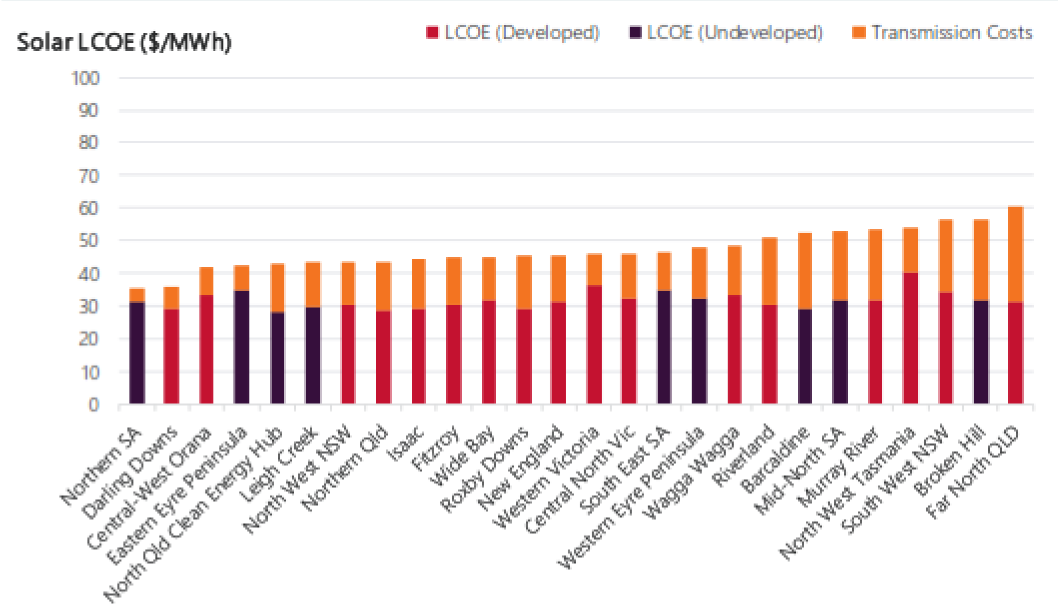
We would firstly like to thank you and your team for the considerable effort expended on activities such as the IASR, which play a vital role in the ongoing development of the NEM by ensuring a consistent, agreed fact base lies at the heart of the analysis and recommendations put forward.

As such, we are pleased to share our feedback on the Draft 2021 IASR, released 17 December 2020. We have focused our attention on the topics of greatest relevance to us and endeavoured to provide supporting information and references, as outlined below.

Section 4.6.5: As Entura pumped hydro cost estimates are location- and resource limit-specific, should AEMO modelling consider an expansion of PHES limits at higher cost?

Pumped hydro costs are highly site-specific. In an ideal world, this would be treated by estimating a cost curve of the various projects registered with AEMO, ranking them from cheapest to most expensive using the modelling done by Entura. AEMO modelling could then run off the marginal cost of additional pumped hydro capacity rather than working off state-level averages as shown in the current IASR document.

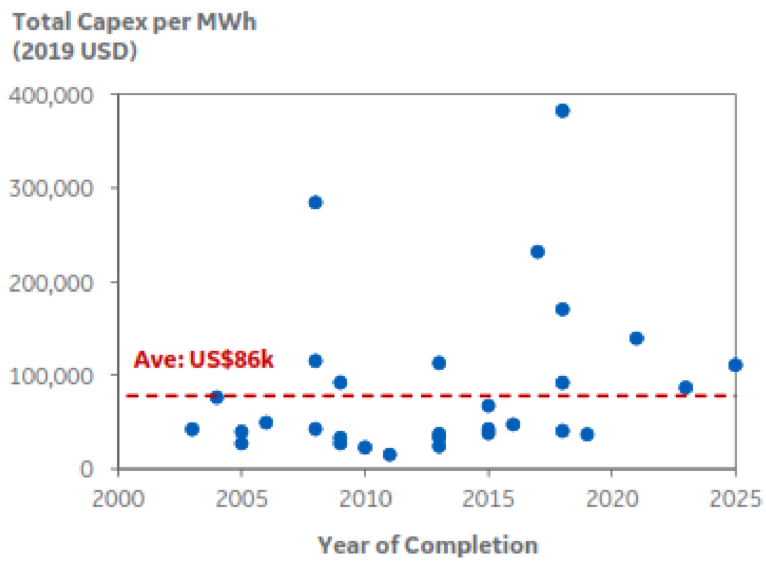
In the absence of this level of granularity, a compromise could be to model the known developments in each REZ and then develop a chart similar to the one for solar PV below, showing the estimated average $/MWh of pumped hydro in each REZ.



Source: 2020 ISP, p46

Section 4.6.5: Are the cost assumptions for pumped hydro reasonable?

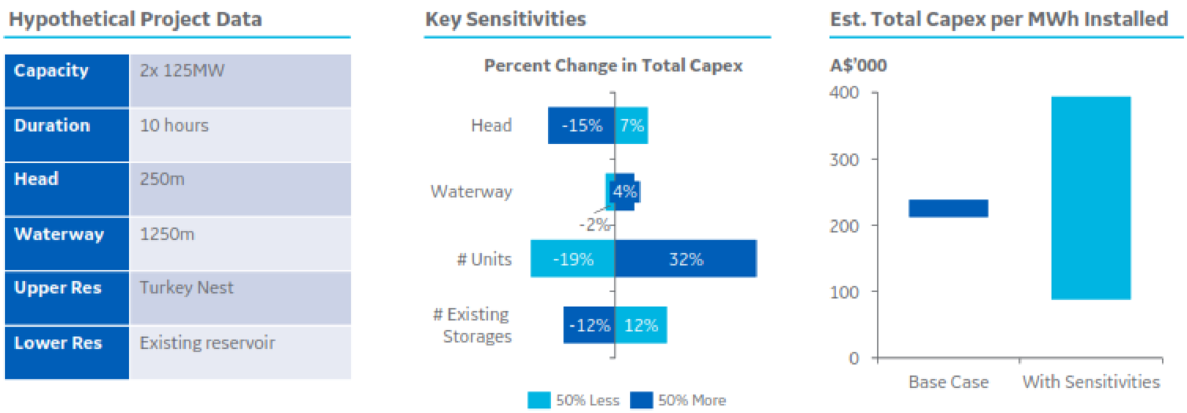
Pumped hydro capital costs vary widely from site to site. Refer below GE's analysis of total capex for pumped hydro projects around the world since 2003. While this data shows no significant downwards trend (or 'cost curve effect'), it doesn't show a clear upwards trend either. The notion that pumped hydro is becoming more expensive over time is simply not supported by the data.



Source: GE Marketing, GlobalData
Notes: Includes data on 31 Active, Completed or Under Construction projects globally, adjusted at CPI in country of location

In this regard, we would be interested to better understand the basis of the 50% upwards adjustment to pumped hydro costs mentioned in the 2020 ISP and the 2021 IASR. While a number of developments (often with sub-optimal site conditions) have experienced increases in estimated capex since they were first announced, Entura's analysis appears to allow for this (refer the table on p11 of their report), so to apply a further 50% uplift on top of this appears to be double counting.

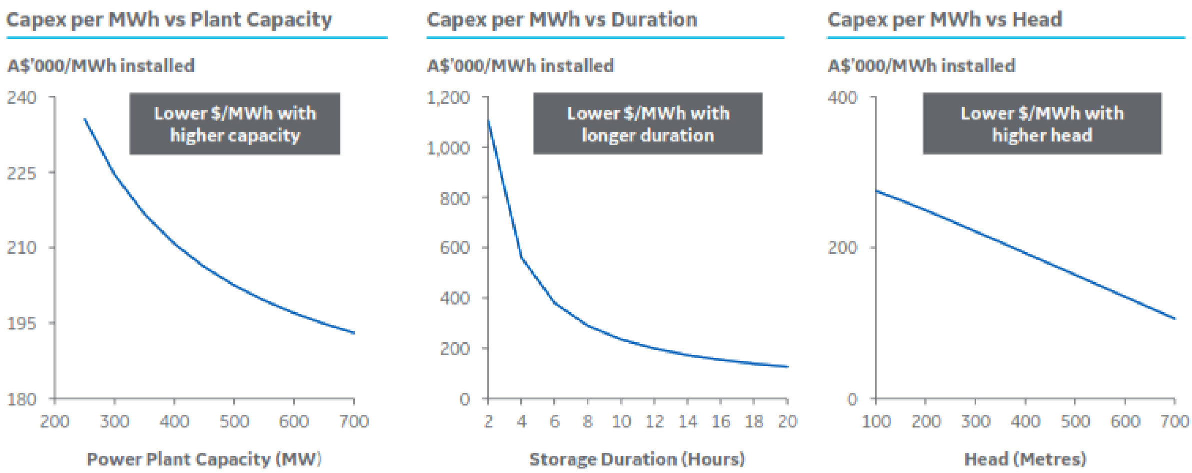
While there is no significant change in pumped hydro capex over time (in real terms), there is significant variation from one project to the next, evidenced by the wide dispersion of values around the mean in the chart above. Our modelling shows that this is primarily due to differences in project parameters. Consider the below analysis, showing the capex sensitivity of a hypothetical pumped hydro project to changes in key parameters and the resulting spread of capex values to which this could ultimately give rise.



Source: GE Hydro Webinar Presentation – *Opportunities, Challenges and the Path Forward for Pumped Hydro in Australia*, 3 December 2020

The dark blue bar in the right-hand chart shows the estimated capex range (in A$/MWh) for the base case parameters shown in the table on the left. The light blue line in the right-hand chart shows how significantly the range of capex estimates expands if 'best of the best' sensitivities from the central chart are applied vs 'worst of the worst' sensitivities.

When we focus in on the impact of capacity, duration and head on pumped hydro capex, we can see that while pumped hydro may not benefit from a cost curve effect, it clearly enjoys significant economies of scale, duration and head, as shown below.



Source: GE Hydro Webinar Presentation – *Opportunities, Challenges and the Path Forward for Pumped Hydro in Australia*, 3 December 2020

We understand that any analysis of the scale and complexity undertaken by AEMO will require simplifying assumptions to be made, however we feel that the work undertaken by Entura provides a sufficient basis for a more nuanced approach to pumped hydro. Continuing to approach pumped hydro in the current manner risks overstating its costs and underestimating the optimal amount of pumped hydro that should be developed.

Section 4.6.5: Is the proposed approach to modelling battery storage technologies appropriate, particularly with regards to the end-of-life assumptions?

As noted in Aurecon's *Cost and Technical Parameters Review*, the assumed lifetime of 10-years and the assumed annual degradation of 2.8% are both based on an assumption of one cycle per day.

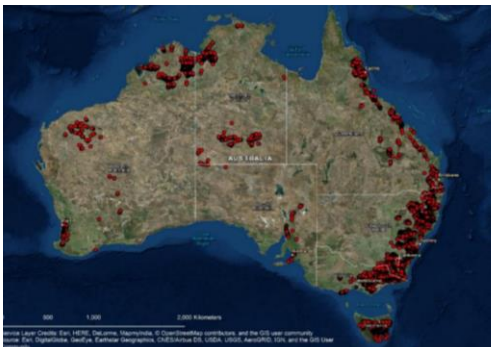
As battery life is ultimately driven by the number of cycles they complete, rather than the passage of time, it is necessary for AEMO modelling to allow for faster degradation and shorter lifetimes should the modelling dispatch the battery fleet more than one cycle per day. It was not clear to us from the IASR that this was the case.

Section 4.6.5: Is the proposed approach to accounting for storage degradation appropriate, or would an alternative approach be more effective in representing battery storage degradation?

As noted above, battery degradation is ultimately driven by the number of cycles, so the AEMO modelling should calculate the degradation as an output of the number of cycles it dispatches the batteries for in the various scenarios and simulations undertaken, rather than assuming a fixed value as an input.

Section 4.9.2: Do you have specific feedback on the proposed REZ resource limits?

The pumped hydro regional limits appear very conservative. We note that a research team from the Australian National University found >22,000 potential pumped hydro sites across Australia, representing 67TWh of energy storage potential nationally and 53.5TWh across the NEM (refer map and table below).



Potential pumped hydro storage sites

State/territory	Number of sites	Storage capacity (GWh)	Minimum height difference (metres)
NSW/ACT	8,600	29,000	300
Vic	4,400	11,000	300
Tas	2,050	6,000	300
Qld	1,770	7,000	300
SA	185	500	300
WA	3,800	9,000	200
NT	1,550	5,000	200
Total	22,000	67,000	N/A

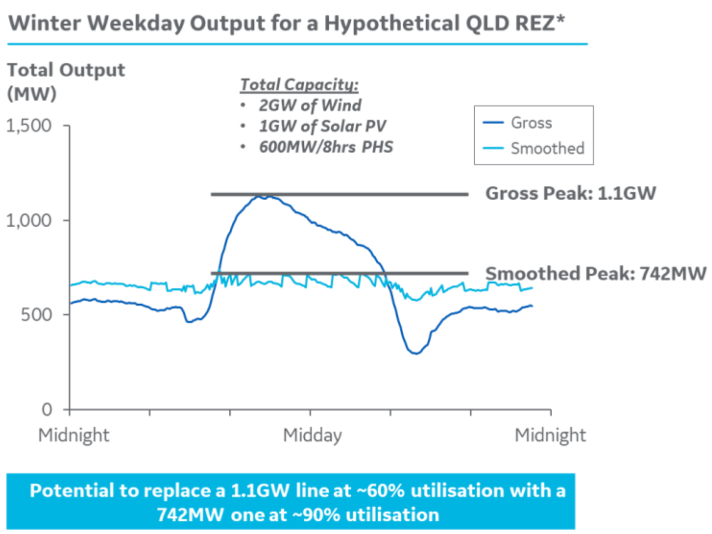
Source: https://arena.gov.au/assets/2019/05/an-atlas-of-pumped-hydro-energy-storage-public-report.pdf;
https://theconversation.com/want-energy-storage-here-are-22-000-sites-for-pumped-hydro-across-australia-84275

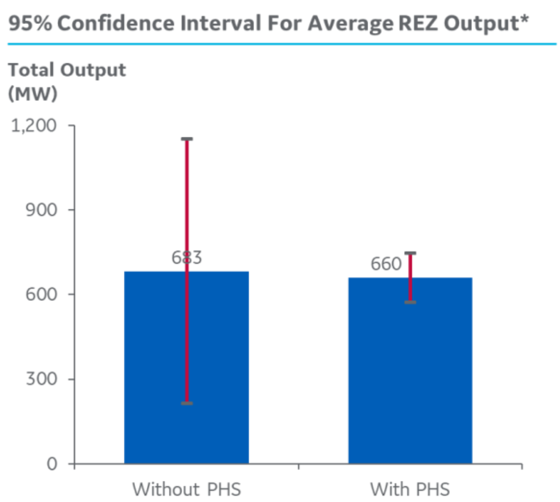
If we compare the above with p113 of the IASR, we see the IASR assumes resource limits representing – on average – less than 1% of the possible capacity identified by the ANU, which seems conservative. Refer below table for details.

	6-Hr	12-Hr	24-Hr	48-Hr	Total GWh	ANU GWh	IASR as % of ANU
NSW	7,000				158	29,000	0.54%
QLD	1,800	1,500	1,100	500	79	7,000	1.13%
SA	1,130	452	452	0	23	500	4.61%
TAS	966	600	1,200	371	60	6,000	0.99%
VIC	1,200	1,200	700	500	62	11,000	0.57%
NEM TOTAL					**382**	**53,500**	**0.71%**

Section 4.9.3: AEMO seeks stakeholders' views on the approach to REZ transmission limits for future build of REZs

We wish to bring to AEMO's attention the ability of pumped hydro to 'smooth' output within a given REZ, enabling a smaller, cheaper, better utilised transmission network. Refer below an indicative analysis of a hypothetical REZ in QLD with 2GW of wind and 1GW of solar PV, complemented by 600MW of pumped hydro at 8-hour duration.





In addition to reducing transmission cost, fixed speed pumped hydro is also synchronous, meaning it would provide system strength and inertia in both pump and generation modes, reducing the grid remediation cost of the REZ as well.

In order to achieve the optimal system design, it is necessary to consider these substantial benefits in addition to the 'pure storage function' that pumped hydro can serve. Failure to do so would lead to under-deployment of pumped hydro and a more expensive network overall. It would also understate the transmission limits of REZs whose wind and solar potential is complemented by pumped hydro resources.

Section 4.11.1: Do you have any specific feedback on the existing inter-zonal transfer capabilities?

As outlined above, pumped hydro has significant capacity to 'smooth' wind and solar output within zones, enabling greater amounts of energy to be transferred between them for a given network capacity.

We are happy to further discuss any element of the above as useful and look forward to working together in future on this and other projects.

With best regards,

Martin Kennedy
Head of Sales – Hydropower
Australia
GE Renewable Energy