AEMO's Integrated System Plan:
Does it leave Snowy 2.0 high and dry?

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The Australian Energy Market Operator (AEMO) recently published its 2020 Integrated System Plan (ISP) for the National Electricity Market (NEM). The ISP is the culmination of a great deal of honest effort and is a trove of useful data and insight. It has provided further valuable information on pumped hydro generation and specifically on the proposed massive Snowy 2.0 which will be, in dollar terms, by far the biggest government intervention in the NEM in its 22-year life.

AEMO included Snowy 2.0 in the ISP because it is a committed project. It did not evaluate the financial or economic merit of Snowy 2.0, but AEMO did predict how much electricity Snowy 2.0 will produce and consume in each year to 2042, although the production from the 2,040 MW Snowy 2.0 is not disaggregated from the total pumped hydro production from Tumut 3, the existing 1,800 MW pumped hydro plant downstream from Snowy 2.0[1].

Figure 1 below compares Snowy Hydro's claim of how much Snowy 2.0 will produce, compared to how much AEMO says Snowy 2.0 plus Tumut 3 will produce.

[1] For the avoidance of doubt, in their estimate of Tumut 3's "pumped hydro" electricity generation which is included in the "deep storage" estimate, AEMO have grossed up Tumut 3's pumping loading taking account of the round-trip efficiency. This means that AEMO's "deep storage" estimate represents the production from pumped hydro from Tumut 3 and Snowy 2.0 and does not include any amount of the "hydro" production from Tumut 3 (i.e. production from water that was not originally pumped from Tumut 3's lower reservoir).

Figure 1. Snowy Hydro / AEMO projections of electricity production (GWh/year)

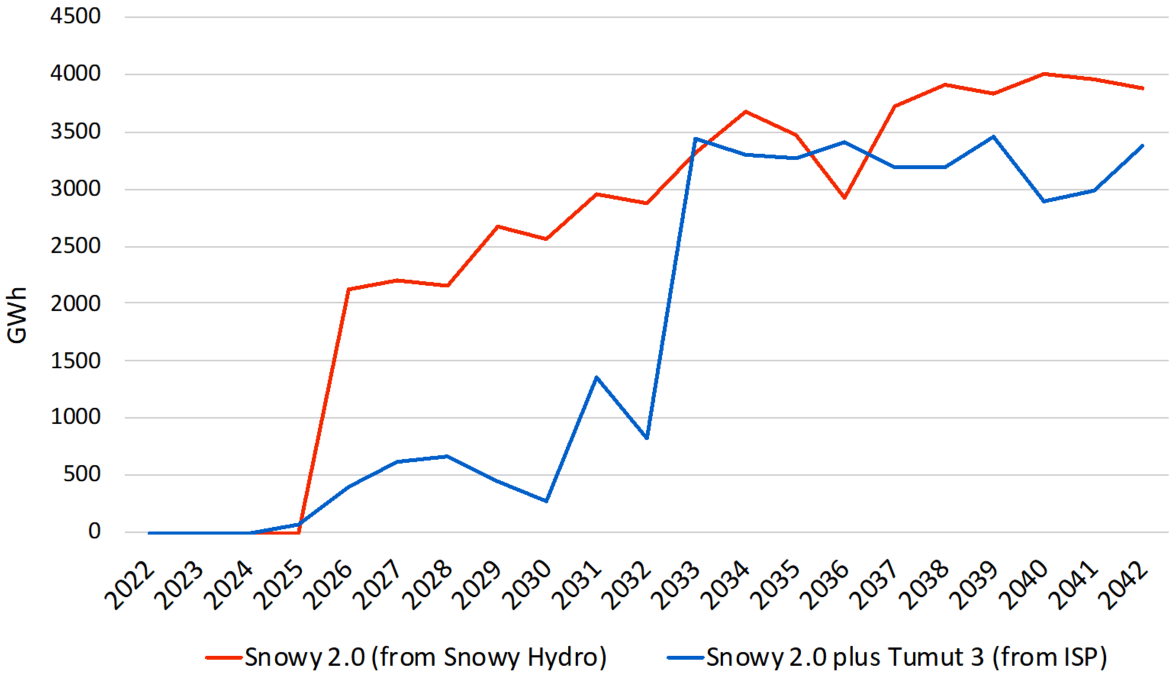


Figure 1 shows that Snowy 2.0 plus Tumut 3 produce an inconsequential amount of electricity even after the massive 2,000 MW "Humelink" transmission expansion from Snowy 2.0 to Sydney, until 2033. It is only from 2033 when the equally massive 2,000 MW transmission expansion to Melbourne (the VNI West project) is commissioned, that Snowy 2.0+Tumut 3 makes a contribution (averaging about 1.7% of the NEM's annual electricity production). In this article, we examine whether Snowy 2.0 is financially viable with the considerably lower usage predicted by AEMO[2].

Is Snowy 2.0 viable?

What does AEMO's projections of Snowy 2.0+Tumut 3 production mean for the financial viability of Snowy 2.0? To answer this, we first establish the relationship between the capacity factor and the "arbitrage margin" that Snowy 2.0 will need to achieve if it is to collect revenues that can come close to recovering its capital outlay[3]. The arbitrage margin is the difference between the average price that Snowy 2.0 pays for electricity to pump water to the upper

[2] As noted in Footnote 1, in the ISP AEMO includes Tumut 3 and Snowy 2.0 in its measure of "deep storage". Unfortunately, the production of each of these is not separately identified. For arguments sake in the analysis in this paper, we assume Tumut 3 production is zero. If Tumut 3 production in future is non-trivial, the conclusions on Snowy 2.0's viability are even worse than assessed here. We return to this in the concluding section.
[3] We say "come close" because to keep it simple we ignore the costs that Snowy will incur in operating Snowy 2.0.

reservoir, and the average price that it will receive when it produces electricity by releasing the same amount of water through the reversible pump/generators when the water runs back down to the lower reservoir.

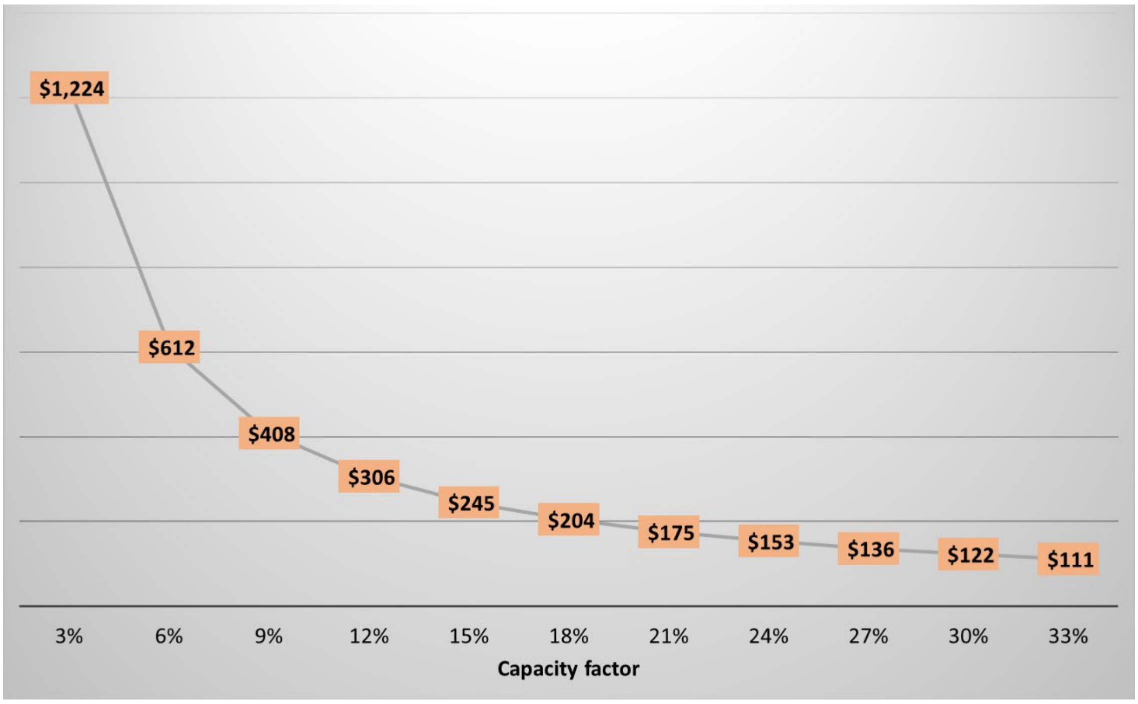
The calculation involves turning a capital sum into an annuity and then averaging that annuity over the annual production as calculated from the capacity factor. A few assumptions are needed: discount factor (we use Snowy Hydro's 8%); economic life (we use AEMO's 30 years); fixed operations and maintenance (we use AEMO's $18/kW/year); capital outlay - we use Snowy Hydro's $5.1bn[4] – i.e. $2.55m/MW; and pumping efficiency (we use AEMO's 76% to take account of the fact that more energy is required to pump water to the upper reservoir than is generated when the same amount of water is run back down through the reversible pump/generators to the lower reservoir).

The resulting relationship between capacity factor[5] and arbitrage margin is shown in Figure 2 below. We see in this figure that if Snowy 2.0 has a capacity factor of 3%, for example, then it needs a margin of $1,224 on each MWh it sells, if it is to come close to covering its capital outlay. By contrast, if it achieves a capacity factor of 33% then it needs to make $111 per MWh sold to cover its outlay. Using AEMO's projection of a 12% average annual capacity factor to 2042 delivers a required arbitrage margin of $306/MWh for Snowy 2.0.

[4] The $5.1bn excludes unknown "contingency", exploratory works, financing cost, Snowy Hydro's project management, transmission connection.

[5] The annual capacity factor is the ratio of the energy produced over a year to the maximum possible energy that can be produced in a year. For the purposes of comparability to other generating plant, the definition we use here assumes that the pumped hydro plant can produce for the whole year at its installed nameplate capacity. Another way of defining the capacity factor would be to only count those hours that a pumped hydro plant could produce for, after accounting for the time that is needed to charge it. This would give a higher capacity factor. But this is simply an issue of convention and adopting this alternative convention would not affect the analysis here or its conclusions. The theoretical maximum capacity factor of Snowy 2.0 (using our convention) is 33% (remember Snowy 2.0 needs to pump for 31.5% more of the time than it generates in order to overcome the losses in its system, and it is necessary to allow for planned and forced outages in estimates of the theoretical maximum).

Figure 2. Snowy 2.0 arbitrage margin needed to recover capital outlay ($/MWh)



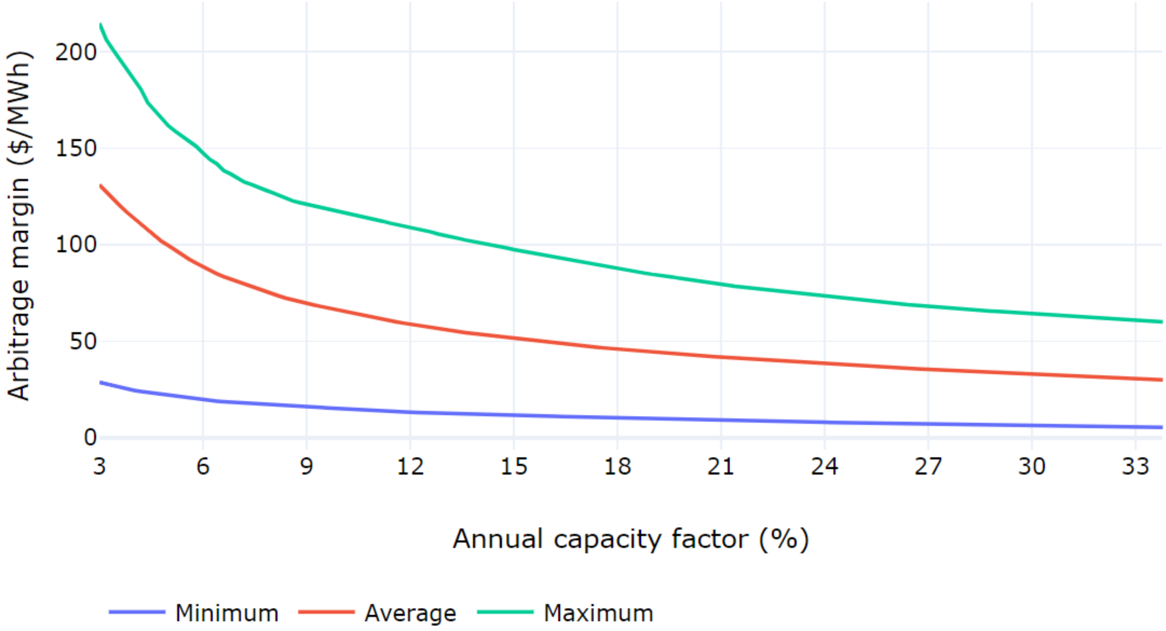
Snowy 2.0 claims that it will operate at a 17% average annual capacity factor (3 GWh per year on average to 2042). From Figure 2 we see that this means it will need to sell electricity for $216/MWh more than it buys, if it is to come close to recovering its capital outlay.

Having established the arbitrage margins that Snowy 2.0 needs to achieve to recover its outlay, we can ask whether it is likely to achieve those arbitrage margins. One way to answer this is to examine the history of prices in the NEM. Does this suggest that the necessary arbitrage margin can be achieved?

Figure 3 presents an analysis of the arbitrage margin using the NSW spot price, from 2012 to now. Again, the calculation is done for discrete capacity factors. So, for example, for a 3% capacity factor we work out the difference between the median price in the top 3% of all 30-minute prices and the median of the bottom 3% (adjusted for the pumping efficiency) prices. This assumes that if Snowy 2.0 only has a capacity factor of 3% it will be able to achieve an average sales price based on the median of the highest 3% of all prices in the year and conversely can achieve a purchase price based on the median of the bottom 3% (adjusted for the pumping efficiency) of all prices in the year.

Based on this methodology, in Figure 3 we show what the arbitrage margin would be in the years (since 2012) with the lowest arbitrage margins (the blue line), the average for all years (the red line) and the year with the highest arbitrage margins (the green line).

Figure 3. Possible arbitrage margins in the NSW spot market over last 8 years



At the 12% average annual capacity factor that AEMO projects, this gives an arbitrage margin based on the last 8 years of $15/MWh (minimum) and $110/MWh maximum with an average of $60/MWh. Even the highest margin in the last 8 years is only about a third of the $306/MWh that we saw in Figure 2 that Snowy 2.0 needs, to recover its outlay. This means that, based on historic price outcomes in the NEM, the conclusion must be that Snowy 2.0 has no reasonable chance of achieving the margins it needs to cover its capital outlay.

Is our analysis unduly pessimistic, can the likely arbitrage margin be assessed in some other way? Another way of estimating the likely arbitrage margin is by looking at the margins that have actually been achieved by Tumut 3 and Wivenhoe, two pumped hydro plants in the NEM, since 2011[6]. Looking at the past 9 years' data we find that Tumut 3 had an average annual capacity factor of 1.3%, while Wivenhoe had an average capacity factor of 1.8%. Operating so infrequently we might expect that they would achieve very high arbitrage margins since they should be picking only the very cheapest times to buy and the very most expensive times to

[6] We do not include Shoalhaven because its dispatch is affected by non-power water use, not just electricity market arbitrage.

sell. Tumut 3 achieved an average arbitrage margin of $107/MWh and Wivenhoe a little higher at $133/MWh. The arbitrage margins are evidently even lower than our analysis in Figure 2. This actual market evidence suggests that even the highest possible arbitrage margin is likely to be too optimistic of what Snowy 2.0 might actually achieve.

What would Snowy Hydro say in response?

Snowy Hydro's prediction of Snowy 2.0 production is shown in Figure 1. It gives an average annual capacity factor of 17%. From Figure 2 we see that the arbitrage margin that recoups the capital outlay assuming a 17% average annual capacity factor is $216/MWh. So, what then does Snowy Hydro say its actual arbitrage margin would be? We can know this from the "Final Investment Decision" report that Snowy Hydro's management prepared for its Board and Shareholding Ministers, and on which both the Board and Shareholding Ministers have relied to justify their decisions to proceed with Snowy 2.0. From that report we see that Snowy Hydro estimate that Snowy 2.0 will achieve an arbitrage margin of $81/MWh. This is still around three times below the $216/MWh margin it needs to recover its outlay (as noted earlier, even excluding the recovery of operating costs).

In fact, as we have pointed out before[7], taking the present value of Snowy Hydro's projected net market revenues, Snowy Hydro will only collect $1.7bn even if we assumed a 100 year life[8]. If instead of assuming a 100-year life, we used AEMO's assumption of an economic life of 30 years, this reduces to $1.3bn. And then what if, instead of using Snowy Hydro's projection of Snowy 2.0 production, we used AEMO's projection of Snowy 2.0+Tumut 3 production and assume, for argument's sake, that Tumut 3 actually produced nothing? In this case the present value of Snowy 2.0's revenues is just $0.98bn – less than a fifth of what Snowy Hydro claim that Snowy 2.0 will cost (and as noted that claim excludes many items likely worth several billion dollars).

Even using Snowy Hydro's assumptions, Snowy 2.0 has no chance of recovering its outlay from spot market revenues. Using AEMO's projection of Snowy 2.0 plus Tumut 3's production

[7] https://reneweconomy.com.au/snowy-2-0-who-will-be-held-to-account-for-this-giant-folly-48618/

[8] AEMO project to 2042 and so we assume that for the remaining period to 2125, that Snowy 2.0 produces at the rate it does in 2042.

almost *halves* the present value of Snowy 2.0's revenues compared to Snowy Hydro's projection.

How might Snowy Hydro respond to this? It might point to its claim that it will achieve income from swap and cap contracts that by implication is four times higher[9] than the income that it says it expects to collect from the spot market. This is an absurd claim and one that, inexplicably, Snowy Hydro's Shareholding Ministers seem to have accepted. How can it be plausible to imagine that market participants would buy contracts that are four times more expensive than they could pay in the spot market? The NEM may be less competitive than many of us would like it to be, but the suggestion that producers can gouge in contract markets to this extent, makes no sense.

How else might Snowy Hydro respond? It might insist that the future will be different to the past; that the transition to renewables means that Snowy 2.0 is essential. This too is empty rhetoric: even Snowy Hydro's own estimate of Snowy 2.0's arbitrage margin – $81/MWh – is not nearly enough to recover its outlay. AEMO's projection that Snowy 2.0 produces inconsequential amounts of electricity until 2033 drives yet another (large) nail in the coffin.

Conclusions and implications

This analysis has examined whether Snowy Hydro's owner – the Australian people – can expect to get their money back from Snowy Hydro's investment in Snowy 2.0. At every turn in this analysis we have erred in Snowy Hydro's favour. For example we assume Snowy Hydro's announced contract for the main works is a reasonable estimate of the project's total cost ignoring the many other items not included and their unstated "contingency" and we ignore the many of tens of millions of dollars a year that it will cost to operate Snowy 2.0. In analysing possible spot market arbitrage income, we have erred in Snowy's favour as clearly evident when we examine the actual outcomes achieved by Tumut 3 and Wivenhoe, i.e. much lower arbitrage margins than we estimate are possible. When analysing AEMO's forecast of deep storage, we assume that Tumut 3 produces nothing which means we give Snowy 2.0's

[9] Over a 30-year life the discounted present value of the spot market revenue that Snowy Hydro claims it will get from Snowy 2.0 is $1.3bn. The ratio of $5.1bn to $1.3 is 3.9. Adding allowance for uncosted capital spending (as identified) means that Snowy Hydro's claim that Snowy 2.0 is financially viable at an 8% discount rate must mean that Snowy 2.0 is assuming contract market income of at least four times more than it says it will make from spot market revenue.

production all the benefit of AEMO's deep storage forecast. In practice, Snowy 2.0's share of deep storage is likely to be much smaller than we have assumed considering that Tumut 3 is more efficient than Snowy 2.0.

In spite of giving Snowy 2.0 more than a fair benefit of the doubt, we conclude emphatically that Snowy 2.0 will not recover its outlay. Snowy 2.0 and the massive transmission augmentations needed to get its production to market will put lead in the pockets of Australian electricity consumers and taxpayers.

Some readers might be inclined to dismiss the argument that Snowy 2.0 will not recover its outlay on the basis that even if this is so, Snowy 2.0 greases the wheels for the transition to a renewable electricity generation system and if some amount of public money is needed to achieve this, then so be it. But in forthcoming research we present evidence that Snowy 2.0 (and "Battery of the Nation") can't compete with gas turbines or engines and even less so with batteries. With today's capital costs both are cheaper and AEMO expect that capital costs for batteries will halve from current levels by 2030. That they are far more capable and much less greenhouse gas intensive ways of facilitating the transition, should also weigh heavily.

AEMO shows that Snowy 2.0 makes no meaningful contribution to the NEM until after 2033. Elon Musk has shown that a 100 MW battery can be operational in six weeks. We all want the lights to stay on. The evidence shows there is no need to rush in order to achieve this. It would be good to try to snatch victory from the jaws of defeat, or at the very least avoid throwing good money after bad.