From: Ritchie, Robert
To: Paul Hyslop
Cc: Owen Kelp
Subject: Re: Snowy 2.0 - and UNGI [DLM=For-Official-Use-Only]
Date: Thursday, 20 December 2018 7:26:37 PM

Many thanks Paul - much appreciated.
Hope to speak soon - and all the best for the holiday.
Rob

Rob Ritchie
Managing Director
Infrastructure and Project Financing Agency
M: s 22(1)(a)(ii) [redacted] E: Robert.Ritchie@ipfa.gov.au<mailto:Robert.Ritchie@ipfa.gov.au>

On 20 Dec 2018, at 11:33 am, Paul Hyslop s 47F [redacted]> wrote:

Hello Rob,

As you can imagine, I was not surprised by the decision by the Snowy Board. However, I have a sense that the project will end up costing a lot more than 4.5 billion – time will tell.

In relation to the technical advisor work, I feel that we are very well placed to help the department. We have the detailed modelling capability that you flag but we also have experience with commercial electricity contracting, the different types of instruments that might be used and a deep understanding of the use and application of options, including real options. s 47F s 47F [redacted]

I have copied in Owen Kelp, one of my colleagues as a second point of contact. We have done work for Treasury very recently around Snowy, the NEG and also for Energy and Environment with respect to emissions projections – so both Owen and I should be well known to a number of relevant people in both Departments.

Please let me know if there is anything else you need from us at this stage.

Paul

From: Ritchie, Robert <Robert.Ritchie@ipfa.gov.au<mailto:Robert.Ritchie@ipfa.gov.au>>
Sent: Thursday, 20 December 2018 5:09 AM
To: Paul Hyslop s 47F [redacted]>
Subject: RE: Snowy 2.0 - and UNGI [DLM=For-Official-Use-Only]

For Official Use Only
Hi Paul
Hope all well.
You'll be aware the board has taken FID. Government are now looking at the company's final recommendation and supporting documents, ahead of making their own decision as to whether to approve.
On a separate note, I wonder if you could provide some guidance in connection with the Government's Underwriting New Generation Investment program, originally proposed in response to recommendation 4 of the ACCC's electricity retail price inquiry.
The Department is looking for a technical adviser to assist in developing an instrument which might provide a floor price to new projects of the kind contemplated in the ACCC's recommendation: you might recall this was aimed at addressing a perceived lack of PPAs for new generation with a term of more than 5 years (and thus preventing new projects from raising bank finance) and which, if triggered, would pay sufficient to cover debt service only.
I expect the work will involve forecast price modelling, the development of alternative instruments and the

detailed design of a final version which, at this stage, the Department expects may take the form of a Government put option offered to a successful applicant.
Who do you think might be interested in taking on this task? Any names you might have (including, perhaps, your own?) would be extremely helpful.
Many thanks in advance, Paul – very much appreciate your advice.
Rob

From: Paul Hyslop s 47F [redacted]
Sent: Monday, 3 December 2018 2:30 PM
To: Ritchie, Robert <Robert.Ritchie@ipfa.gov.au<mailto:Robert.Ritchie@ipfa.gov.au>>
Subject: RE: Snowy 2.0 [SEC=UNCLASSIFIED]

Hello Rob,

I published the article on Linked-in and it got picked up by Renew Economy as well.

Considering it's arcane nature it received quite wide interest with almost all respondents in agreement that Snowy 2.0 is being unnecessarily rushed, that there is no immediate need and that the modularity of alternative investments likely make the alternatives a better match for the market need. In a nutshell this means that the Snowy 2.0 investments in very risky and has a high likelihood of being quickly underwater. This can be avoided by delaying the investment until the need is clearer and also that there is more clarity over the alternative technologies and their ability to undermine the Snowy 2.0 investment.

Interestingly I got no response from Snowy but the stats indicate that eight people in Snowy read it and 13 people from their consultant (MJA) also read it.

Let me know if you would like to discuss further.

From: Ritchie, Robert <Robert.Ritchie@ipfa.gov.au<mailto:Robert.Ritchie@ipfa.gov.au>>
Sent: Monday, 12 November 2018 2:24 PM
To: Paul Hyslop s 47F [redacted]
Subject: RE: Snowy 2.0 [SEC=UNCLASSIFIED]

UNCLASSIFIED
Many thanks, Paul. Very good to reconnect. I'll look forward to reading with interest.
Rob

Rob Ritchie
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E Robert.Ritchie@ipfa.gov.au<mailto:Robert.Ritchie@ipfa.gov.au>

ipfa.gov.au<http://ipfa.gov.au>

<image001.jpg>

From: Paul Hyslop s 47F [redacted]
Sent: Monday, 12 November 2018 1:22 PM
To: Ritchie, Robert <Robert.Ritchie@ipfa.gov.au<mailto:Robert.Ritchie@ipfa.gov.au>>
Subject: Snowy 2.0

Hello Rob,

We met at a CEDA lunch last month. Appropos our discussion, I have attached a piece that I have done on Snowy2.0. I thought you might like to read it.

Best regards

PAUL HYSLOP
CHIEF EXECUTIVE OFFICER

M s 47F [redacted]
D
s 47F [redacted]

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SNOWY 2.0 – IS THE REWARD WORTH THE RISK?

Paul Hyslop, Chief Executive Officer

"Quicquid id est, timeo Danaos et dona ferentis" (Virgil, *The Aeneid*).

Overview

Snowy Hydro Limited (Snowy Hydro) has proposed and is currently developing Snowy 2.0; a plan to add 2 000 MW of pumped hydro to the existing Snowy Mountains Hydro-Electric Scheme. This involves constructing 27 km of tunnels between the Lake Tantangara and Lake Talbingo storages and a power station inside a cavern deep inside a mountain between the two lakes.

There are large questions over the estimated costs of the proposed scheme when benchmarked against other equivalent projects. The largest cost item appears to be tunnelling for which there appears significant risk. The CEO of Snowy Hydro has admitted that there will need to be a "massive amount of reinforcing of the tunnels" (Broad, 2017) because of the poor and weak structure of the rock that they will be tunnelling through.

Understandably, Snowy Hydro has not released its commercial business case. However, and somewhat unusually, it contracted a consultant to calculate the market benefits of the project which were estimated to be between $4.2 and $6.8 billion, depending on the scenario assumed. The market benefits were estimated over a rather heroic 56-year study period (50 years of Snowy 2.0 operation). However, the consultant's analysis appears very narrow and does not cover the expected range of scenarios and states of the world that would be typical for a market benefits assessment. It might even be argued that the consultant has assessed favourable scenarios and ignored less favourable scenarios. For example, there are several competing projects that do not appear to have been considered. And the costs of competing technologies appear unusually high, which when displaced by Snowy 2.0 in the analysis, produce more benefits than would otherwise be expected.

Market benefits is a regulatory concept used to assess the benefits of regulated investments in the NEM. It estimates the increase in consumer/producer surplus where the market is competitive. The estimated market benefits are not relevant to the likely returns to Snowy Hydro, except that in a competitive market environment, they represent the maximum that Snowy Hydro could extract in returns; but this assumes that there would be no free riders and that Snowy would not have to share any of the benefits with other market participants. Practically, this would never be the case.

Therefore, in a competitive market, Snowy Hydro returns would be expected to be a fraction of the estimated market benefits. Even using the low-end cost estimates provided by Snowy Hydro and assuming a competitive market environment, it would appear that Snowy Hydro would not recover the cost of the Snowy 2.0 investment, even where it is prepared to wait 50 years to do so.

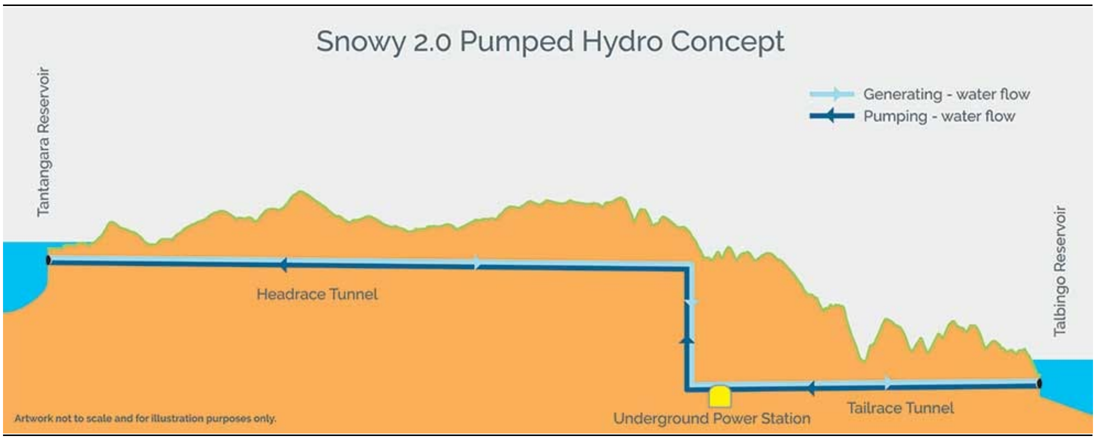
An even bigger threat to Snowy 2.0 returns comes from alternative modular technologies, especially battery energy storage systems (BESS). Snowy 2.0 is a large capital and irreversible investment – once committed it cannot be unbuilt. Alternative technologies, especially BESS are modular and have little economies of scale. They can be committed in small quantities at many locations and can be expanded to adapt to the market over time. Snowy Hydro investing in Snowy 2.0 has none of this luxury and rather must hope that it can pick the market for up to fifty years into the future.

Snowy Hydro appears to be moving with haste to commit to Snowy 2.0. Yet there is nothing in the outlook for the market that would justify this haste. If there is a market need for Snowy 2.0, it is likely to be from the mid-2030s when significant coal fired plant are expected to close. In working through the costs and risks associated with the proposed Snowy 2.0 project, it has been difficult to understand how the rewards as we understand them justify moving quickly to FID. It appears to be a textbook case where a rational investor would wait and use the period of waiting to gather better information.

The proposal

Snowy Hydro has put forward a plan to develop a 2,000 MW pumped hydro storage scheme as an adjunct to the existing 4,100 MW hydroelectric scheme. Possibly to give it an entirely modern flavour, it has been branded Snowy 2.0. The proposed scheme would establish a network of headrace and tailrace tunnels of around 26 km in length. The new power station is proposed to be located several hundred metres underground by constructing a 600-700 metre vertical shaft and a cavern at the bottom to house the power station. The conceptual design of the Snowy 2.0 scheme is shown in Figure 1.

FIGURE 1 CONCEPTUAL DESIGN FOR SNOWY 2.0



SOURCE: HTTPS://WWW.SNOWYHYDRO.COM.AU/OUR-SCHEME/SNOWY20/ABOUT-SNOWY-2-0-2/

Electricity from Snowy 2.0 will be produced from water released from Lake Tantangara to the Snowy 2.0 headrace tunnel. The water will flow along the tunnel and then drop down through the vertical shaft and pass through the Snowy 2.0 hydro-electric turbines to produce electricity. The water will then flow through the tailrace tunnel to Lake Talbingo, the headwater storage for the existing 1,800 MW Tumut 3 power station. Lake Tantangara will be resupplied by pumping water from Lake Talbingo using pumps installed at the Snowy 2.0 power station. Utilising the Lake Tantangara and Lake Talbingo storages in this manner should have no net effect on the water yield and electricity generated from the existing Snowy scheme.

The preliminary cost estimate of the project (Snowy Hydro, 2017) is $3.8 to $4.5 billion ($1,900 to $2,250 per kW). However, this does not include $1 to $2 billion (TransGrid, 2017) for additional transmission capacity to transport electricity to New South Wales and Victoria at peak times (when Snowy 2.0 is most likely to be generating). This would take the total cost of the project to $4.8 to $6.5 billion ($2,400 to $3,250 per kW). Snowy Hydro's decision to exclude transmission costs appears to be based on a view that transmission network service providers will upgrade the connections to New South Wales and Victoria at the electricity consumers' cost (Broad, 2017).

Allowing a broad estimate of say $1 billion for the cost of constructing the power station cavern and power station[1] leaves $2.8 to $3.5 billion for the 27 km of headrace and tailrace tunnels – approximately $110k to 135k per metre. This tunnelling cost appears in line with global experience[2] for large-scale *unlined* hydroelectric tunnels. However, these costs are highly dependent on the nature of the geology which the tunnels traverse. Some types of rocks are well suited to hydroelectric tunnels with limited leakage. Other types are subject to high amounts of water leakage.

The CEO of Snowy Hydro, in an interview with Michael McLaren on 2GB in December 2017, stated that investigation of the tunnel route "found the rock in pretty poor shape", pretty weak". He then went

[1] Power station includes turbines, generators, control systems, electrical connections, access tunnels and surge tanks. Transmission upgrades to New South Wales and Victoria to facilitate the flows from the additional capacity to be provided by Snowy 2.0 have not been included by Snowy Hydro in the cost estimates.
[2] For example, the Niagara project tunnel of around 10 km with a diameter of 12.7 metres and a capacity of 500 m^3/s, cost around $150k per metre. The Snowy headrace and tailrace tunnels are expected to be around 9 metres in diameter with a maximum flow of around 420 m^3/s.

on to note "so we've got to do a massive amount of reinforcing of the tunnels" and "you got to reinforce it, you got to put lining in these things" (Broad, 2017).

As stated by Broad, leaky tunnel structures would need to be lined or grouted with cement to overcome the leakage, which would significantly increase the cost of constructing the tunnels. Assuming a 50 per cent increase in tunnel construction costs to reflect more lining and grouting, would add between $1.4 and $1.75 billion to the cost of the project with the total cost rising to between $5.2 and $6.25 billion. Snowy Hydro redacted the detailed costs chapter from the public version of the feasibility study, so it is unclear how contingencies have been costed and handled in the overall analysis.

Estimating market benefits

Understandably the public version of the feasibility study released by Snowy Hydro excluded the chapter covering the business analysis and market modelling of Snowy 2.0. Instead Snowy Hydro released a report covering the purported market benefits of the proposed Snowy 2.0.

Market benefits is a concept used within the National Electricity Market (NEM) in relation to regulated network investments. The market benefits test derives from benefit-cost analysis where the benefits and costs to society are tallied up to determine whether projects have a net benefit to society. In the case of the electricity market, society consists of electricity consumers and producers.

The market benefit is the sum of the net change in both producer and consumer surplus associated with a proposed investment compared with the counterfactual, which is usually 'not to build the asset in question'. Therefore, the market benefit includes the savings in producer costs and may include an increase or decrease in production/consumption where changes in prices lead to changes in consumer and producer incentives. The market benefits test assumes that the market is competitive. In a real sense this represents the maximum benefit that a project could capture from all other participants in the electricity market, where the market is competitive.

In a competitive market, the proposed investment would expect to capture only a fraction of the market benefits. The remainder would go to electricity consumers and some producers. Therefore, assuming the NEM is a competitive environment, the returns to Snowy would be expected to be much less than the estimated increase in benefits to all electricity producers and consumers in the report provided by Snowy Hydro's consultant.

Snowy Hydro's consultants estimated market benefits (largely consisting of capital and operating cost savings) for two scenarios compared with the counterfactual of Snowy 2.0 not proceeding. The range of these benefits were $4.2 – $4.9 billion for the so-called LRET and VRET scenario and $6.1 – $6.8 billion for the so-called LT commitment scenario (which appears to be the LRET and VRET scenario plus additional renewable generation investment to meet a target of 60% of NEM generation by 2040 – including embedded rooftop generation). These benefits were estimated over the period 2018 to 2074 (50 years of operating life).

Where the market is competitive, Snowy might be expected to capture 50 per cent of these benefits as returns against the investment (between $2.1 and $3.4 billion to 2074). This would mean Snowy Hydro would not be able to fully recover the cost of its investment by 2074, even when using the apparently optimistic costs estimated in the feasibility study.

While the consultant's market benefits report extends to 150 pages, there is limited detail about the assumptions behind each of the scenarios considered. While several factors affect these market benefits, the critical assumptions in any analysis of Snowy 2.0 are the assumed costs of competing technologies which, in the case of Snowy 2.0, are:

- other pumped hydro storage projects[3] as complete competitors in energy arbitrage and dispatch firming
- BESS as complete competitors in both energy arbitrage and dispatch firming

[3] A recent ANU report identified 22,000 pumped hydro storage sites with 67 TWh of storage in Australia including around 17,000 sites with 43.5 TWh of storage across the NEM (refer http://www.anu.edu.au/news/all-news/anu-finds-22000-potential-pumped-hydro-sites-in-australia)

— dispatchable capacity entry (which is open cycle and combined cycle gas-fired turbines in the consultant's analysis).

The consultant's report provides limited information about assumed competing technology costs and how those costs are assumed to change over time. However, from the data that is provided and when compared with ACIL Allen's understanding of generation capital costs and learning curves, capital and operating costs are overstated for gas turbines[4], BESS capital costs are overstated, and BESS learning curves are understated.[5] This has the effect of overstating benefits (savings in capital and operating costs) where gas turbine generation plant and BESS are displaced by Snowy 2.0.

This differential in capital and operating cost estimates results in a reduction in the present value of estimated market benefits of Snowy 2.0 of around $0.6 billion to 2040 and around $1.2 billion to 2074 for the LRET/VRET scenario using the discount rate assumed by Snowy's consultant. For the LT commitment scenario, the estimated market benefits are lower by around $0.5 billion to 2040 and $1.1 billion to 2074. Making these adjustments to the total estimated market benefits (to 2074) gives:

— $3 billion to $3.7 billion for the LRET/VRET scenario
— $5 billion to $5.7 billion for the LT commitment scenario.

This compares with Snowy Hydro's cost estimates of $3.8 to $4.5 billion for the project and $5.2 billion to $6.25 billion where assumed tunnelling costs increase by 50%. This is not to say that these revised market benefits and potentially higher costs are more accurate than those provided by Snowy Hydro and its consultant, but rather to highlight that the market benefits and costs have a great deal of uncertainty.

In highlighting this uncertainty, it is noted that the Australian Energy Regulator's guide to assessing market benefits requires the proponent to consider all credible options and all states of the world for each credible option (AER, 2017, pp. 14-15). Snowy Hydro's consultants provided two scenarios based on different emissions reduction policies. But it did not consider other credible options or comprehensively incorporate all states of the world. For example, Hydro Tasmania's proposed Battery of the Nation project could be considered a credible alternative option, or it could represent one of the states of the world to be considered in each credible option considered. The timing of Snowy 2.0 may also form several credible alternatives. The option proposed appears to be the earliest possible timing but not necessarily the optimal timing. Delaying for 5, 10, 15 years is likely to be more optimal where the market need for additional dispatchable capacity, such as Snowy 2.0, is later following the closure of more coal-fired plant.

Other pumped hydro projects might also represent credible alternative options or at least be represented in different states of the world. The presence or absence of the proposed interconnector between New South Wales and South Australia should probably have been included as different states of the world through scenarios.[6] And as costs of competing technologies are highly uncertain, especially over the rather heroic 56-year study period[7], variations in these costs should also have been considered.

Therefore, as an exercise in assessing the project's market benefits, the consultant's estimates appear to be inadequate, in that the exercise appears to be incomplete. It might even be argued that the scenarios and states of the world that have been considered are highly favourable to the project whereas other credible options and states of the world that are less favourable have not been considered.

Real options

Of course, as a basis for investment, the market benefits study is irrelevant except that it provides a theoretical upper limit on the benefits that Snowy Hydro might capture in a fully competitive market

[4] OCGT overstated capital by around 50%, CCGT overstated capital by around 33% – FOM around 100% higher for both OCGT and CCGT and VOM around 25% higher for both (compared with ACIL Allen's understanding of costs.

[5] Batteries 10% overstated capital costs in 2018 and learning curve falls around 33% in real terms to 2040 compared with around 65% fall for ACIL Allen's outlook for BESS.

[6] The proposed interconnector could substantially affect Snowy Hydro's ability to export the additional capacity from Snowy 2.0 to New South Wales.

[7] The degree of uncertainty associated with looking forward 56 years can only be described as huge.

environment, where there are no free riders and Snowy Hydro does not have to share any of the benefits with other market participants. However, electricity markets are at best workably competitive and at times exhibit oligopolistic characteristics, especially in the so-called peak end of the market.

The peak end of the market are those periods where extreme demand conditions require most, if not all available supply, to meet demand; i.e., no involuntary load shedding. At such times, a relatively small number of peaking plants mixed with small amounts of voluntary load shedding have pricing power to set the price at, or close to, the market price cap. The fewer the number of independent peaking plant providers, the greater their pricing power.

Storage (BESS, pumped hydro and potentially other technologies) will potentially play a key role in satisfying extreme peak demand as environmental constraints lead to coal-fired power station closures and more non-firm renewable generation.

BESS are modular, have almost no economies of scale and can be deployed over short periods of time and in multiple locations throughout the market. BESS can be deployed in small or large volumes with the unit price for capacity (per kW) and energy storage (per kWh) being largely constant. This means that BESS can be deployed in small quantities initially and grown as the market grows and adapts. Equally importantly, growth plans can be deferred or abandoned where the market environment changes and the additional investment is no longer warranted. And BESS can be easily redeployed to other regions where there is no ongoing need at the current deployment location. Unlike Snowy 2.0, BESS can be deployed close to load centres to maximise benefits to consumers and minimise power system losses and the need to expand networks.

These characteristics of BESS suggest that it is likely to be deployed by many parties in smaller quantities to firm up intermittent renewable capacity and to arbitrage energy prices intraday and within weeks. In this case, it would be expected that there would be a much greater degree of competition to supply capacity during peak periods of the day, which is especially important during days with extreme peak demands. Greater competition will limit oligopolistic behaviour during such periods and it is therefore more likely that prices paid by consumers would be efficient.

The characteristics of Snowy 2.0 are opposite those of BESS. Snowy 2.0 is a large and irreversible capital investment with a long lead time. There are large economies of scale in developing it in large tranches (tunnels, caverns etc.). Planning to develop the project as a 2 000 MW pumped hydro project reduces the average capital cost per MW of pumped hydro installed (economies of scale), but the marginal value of much of the planned capacity in the early years following its commissioning is expected to be small or even zero.

Some of the additional capacity to be supplied by Snowy 2.0 may be required to meet demand reliably from 2025, but it will take the market many years, possibly decades, to absorb all the planned capacity. There are credible futures where it will never be fully absorbed; e.g., where alternative technologies are developed and make Snowy 2.0 obsolete.

In very simple terms, Snowy 2.0 is not modular and is not able to be adapted and redeployed as the future unfolds and as market environment and circumstances change (unless 2 000 MW is considered modular). It requires a very large upfront commitment to an irreversible investment at a time when the future of energy markets including the policy outlook, technology, consumer preferences (use and investment in own embedded supply) and types of consumption are all highly uncertain.

In their landmark work, *Investment and Uncertainty*, Dixit and Pindyck (1994) developed what is now known as real-options theory. Dixit and Pindyck argued that when considering making large irreversible investments in an environment of uncertainty, that it is better to wait rather than jump in and make an investment decision and use the period of waiting to gain better (not necessarily complete) information about the future and hence reduce uncertainty.

Snowy Hydro's CEO has stated on several occasions that Snowy 2.0 FID would be taken in December 2018. If this is the case, the FID will be taken in an environment of great uncertainty with respect to several factors including:

— Commonwealth and state environmental and energy policy
— technology, especially the development path of BESS
— consumer preferences in relation to electricity demand and the use of embedded generation

— transmission upgrades that are required to support the additional flows from Snowy 2.0 to the main centres of demand in New South Wales and Victoria.

Faced with these uncertainties, it is surprising that the Board of Snowy Hydro would be willing to make such a large irreversible capital investment rather than wait for more and better information.

Market concentration

Snowy Hydro is a unique business in the NEM and dominates the peak end of the market in Victoria and New South Wales with around 4 100 MW of hydro capacity with an average capacity factor of around 12.5 per cent (characteristically peaking plant). In addition, it owns and controls around 1 300 MW of gas peaking capacity (620 MW installed in Victoria and 687 MW in New South Wales). It owns and controls around 5 400 MW of peaking capacity and has considerable pricing power during peak periods, especially extreme peak periods. Therefore, it appears to have a strong interest in maintaining value in the peak end of the market – higher overall prices.

A proliferation of small and independent BESS provides a real and credible threat to Snowy Hydro's peak end pricing power. However, the reverse is also true, so with the benefit of first mover advantage, Snowy 2.0 might be considered a 'knock-out' blow to prospective BESS in order to protect Snowy Hydro's position and pricing power in the market. Snowy 2.0 would allow Snowy Hydro to increase its dominance of the peak end of the market in Victoria and New South Wales by controlling 7 400 MW of peaking capacity across the two NEM regions.

There is no apparent restriction on preventing Snowy Hydro from increasing its dominance of this part of the market through the development of Snowy 2.0. However, its owners, the Commonwealth Government, have recently been extolling the virtue of intervening in the market to pressure participants to lower prices for consumers. Allowing a government-owned entity to establish such a dominance in the peak end of the market in both Victoria and New South Wales does not appear consistent with these recent statements and actions.

A solution to the problem of concentration might be to establish Snowy 2.0 as a separate pump hydro business operated independently from Snowy Hydro with its own board and management team. As Snowy 2.0 is expected to use no net water from the remainder of the Snowy Scheme, there would appear to be no loss of operational efficiency in operating them separately. Coordinating and managing water use from the shared storages of Lake Tantangara and Lake Talbingo is very straightforward regardless.

An example of how an independent pumped hydro business could be operated viably is given by the UK pumped hydro business based on the Dnorwig and Ffestiniog pumped hydro power stations (around 2 100 MW of capacity). They operate as an independent business under the ownership of the First Hydro Company, a subsidiary of Engie Energy International. It provides an excellent example of how a separated Snowy 2.0 could operate viably where the overall investment is warranted; i.e. would be expected to provide a return on investment without relying on increased pricing power.

A good test of Snowy Hydro's intentions with respect to Snowy 2.0 and the increased pricing power it will achieve would be to inform Snowy Hydro that, once Snowy 2.0 is commissioned, it would be moved to a fully independent company/market participant, controlled and operated by a board and management team that is fully separate and independent from Snowy Hydro. It would be interesting to see under such circumstances whether Snowy Hydro would continue to develop Snowy 2.0 with such haste.

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