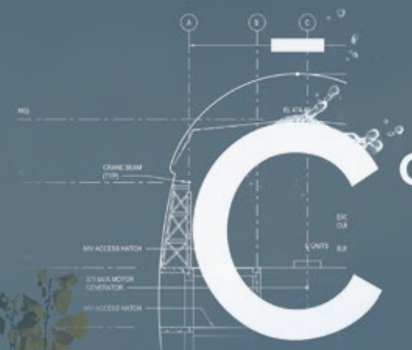
SNOWY 2.0

Project and business case overview

snowyhydro

snowy2.0



Contents

Our story

Our Snowy story is well-known.
It's one of vision, engineering wonder, nation building and mateship.

Today, we embark on the next chapter with a strong vision and a new project. Snowy 2.0, along with the mighty Snowy Scheme, will underpin Australia's renewable energy future for generations to come.

The National Electricity Market (NEM) has passed the tipping point. Renewables are now the most economic form of new energy generation. With more intermittent generation coming into the NEM, the critical role Snowy Hydro plays in keeping the lights on is more important than ever.

The Snowy Mountains Hydro-electric Scheme (known today simply as the Snowy Scheme) was the realisation of a long-held dream to harness the potential of the Australian Alps. From the beginning, it had a dual purpose: to irrigate the Murray-Darling Basin and provide a source of clean, reliable electricity generation. These two essential functions remain to this day.

It's hard now to imagine life without the Snowy Scheme, so fundamental is its operation to the daily lives of millions of Australians. However, its development was not inevitable. It took a boldness of vision and long-term thinking. It required a willingness to take risks. It was, as Prime Minister Ben Chifley declared, the greatest single project in our history.

The real heroes of this venture were, of course, the diverse community of Australians and immigrants from war-torn Europe, who worked in challenging conditions. Their dedication and sacrifice gave form to what would become one of the civil engineering wonders of the modern world.

We are respectful and proud of our history, but there's much more to us today than our pioneering past.

Machine hall excavation at Tumut 1, 1957

The modern Snowy Hydro

The Snowy Hydro of today is a modern, corporations law company.

We are the fourth-largest energy player in the NEM and provide much-needed competition in the market. This helps to exert downward pressure on energy prices and drives better outcomes for consumers.

We are committed to continuing to grow our portfolio of assets, to maximise competition in the electricity market and deliver more value to consumers. Snowy Hydro is building a portfolio that operates efficiently and reliably in a highly competitive NEM, and Snowy 2.0 and our newly-contracted 888 megawatts (MW) of renewable energy from eight wind and solar projects, are key to this.

We currently operate 15 power stations across three states and, through our fast-start assets and energy storage capabilities, we keep the lights on at times of peak electricity demand.

We employ 2,000 people here in Australia and serve over a million customers through our retail businesses, Red Energy, Lumo Energy and Direct Connect. We are one of the largest providers of renewable energy in this country.

The next phase of the energy revolution is upon us. The inexorable improvements in the economics of wind, and solar power prices, and Australia's commitments to the Paris Agreement, have made a low-emissions future all-but inevitable. Snowy Hydro is ready to play a key role in managing the challenges posed by this transition and underpinning Australia's renewable future.

Snowy 2.0, like the original Snowy Scheme, is a nation building project. This significant expansion of the Snowy Scheme will provide the storage and on-demand generation needed to balance the growth of wind and solar power and the retirement of Australia's ageing fleet of thermal power stations. In short, it will keep our energy system secure.

Snowy 2.0 is not only a sound business investment for Snowy Hydro. It also represents the most cost-effective way to ensure a reliable, clean power system for future generations to come.

Part of the community

We are proud to be born and raised in the Snowy Mountains and for almost 70 years we've considered ourselves one of the community. Today, we employ 400 locals to manage the Snowy Scheme and are a major purchaser of local goods, products and services.

Snowy Hydro backs community organisations and local activities both big and small. We have a long track record of partnering with the community on a range of initiatives, including the Country Universities Centre Snowy Monaro, school nurse pilot program in Cooma and Tumut, Police Citizens' Youth Centres, Young Driver Training Program and the Clontarf Foundation. We invest millions of dollars in sponsorships and support about 40 local events throughout the region every year.

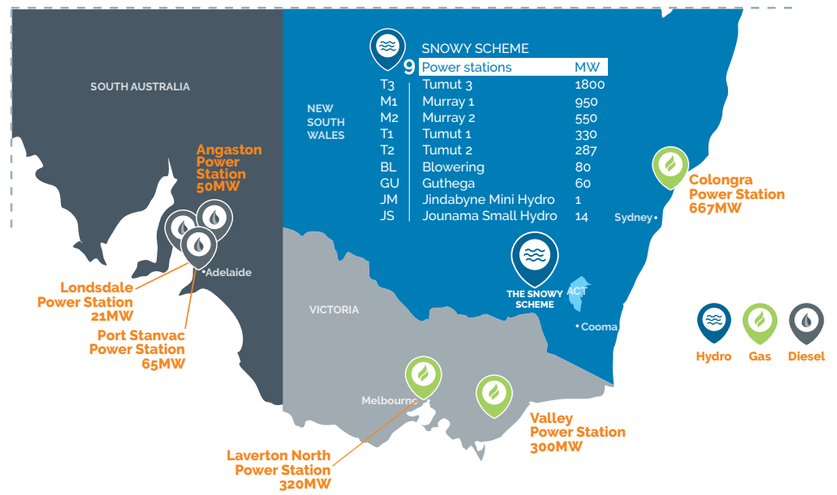
Our energy assets

Almost 70 years ago, construction started on the mighty Snowy Scheme.

From those modest beginnings the Snowy Scheme took shape and is considered to be one of Australia's greatest engineering achievements.

Today, Snowy Hydro operates the Snowy Scheme (nine hydro power stations including pumped storage at Tumut 3 Power Station and Jindabyne Pumping Station), along with six gas and diesel-fired power stations across New South Wales, Victoria and South Australia. We have a total generation capacity of 5,500MW and provide electricity price insurance and other products that deliver security of supply and price certainty to customers in the energy market.

Snowy Hydro's power stations specialise in peaking generation. They operate at times of peak demand to keep the lights on across the NEM states. Snowy Hydro's peaking generators work alongside baseload energy plants. We can quickly bring large amounts of generating capacity online at times of peak demand (morning/evenings or during hot weather), as well as 'fill the gaps' when supply is needed, for example when wind or solar output is low or a baseload generator has an outage.



About Snowy 2.0

Snowy 2.0 is a pumped-hydro expansion of the Snowy Scheme which will significantly add to our existing energy generation and large-scale storage capabilities.

Snowy 2.0 will increase the Scheme's existing generation capacity by 2,000MW. Snowy 2.0 has large-scale energy storage capacity of 350,000MW hours. It can generate for up to 175 hours at full capacity without refilling. The project will link two existing Scheme dams - Tantangara and Talbingo - through 27km of underground tunnels and an underground power station with pumping capabilities.

Snowy 2.0's pumped-hydro capabilities are on-demand and can be switched on and off at a moment's notice. Once hydro energy has been generated by Snowy 2.0, the water can be held in the lower dam and pumped back up to the upper dam in a 'closed' system. The water can essentially be recycled through the power station and used over and over again. The altitude of the Snowy Scheme means there is minimal evaporation from its water storages. Large volumes of water can be stored in the upper dam as 'energy in waiting' and used to generate energy on-demand to power homes and businesses within minutes, at peak times.

Pumped-hydro helps improve the efficiency of the NEM by absorbing and storing excess energy at times of low demand. This could mean pumping with excess energy from wind farms generating in the middle of the night, and from solar plants in the middle of the day, when the demand for energy is low. Without reliable, large-scale storage, excess energy is wasted or curtailed.

Snowy Hydro already has pumped-hydro capabilities at Tumut 3 Power Station - it is proven technology used across the world. The first power produced from Snowy 2.0 is expected in late 2024-2025. We expect its operating life to be consistent with the Snowy Scheme's existing assets, which continue to operate reliably and have been upgraded and technologically improved over the last 50 years.

Wind and solar energy

Why Snowy 2.0 is so critical to the NEM and Australia's renewable energy future

The Snowy Scheme, with its 16 major dams, already has the capability of storing huge amounts of energy. While this is sufficient for the current NEM, it will not be enough as we transition to a lower emissions economy, powered by wind and solar generation that is cheap but with supply patterns that are difficult to predict. The NEM covers New South Wales, ACT, Queensland, Victoria, South Australia and Tasmania.

The supply of electricity in the future will be increasingly generated by renewable sources such as wind and solar, as coal-fired power plants progressively retire. Most renewables are intermittent, so their generation doesn't always coincide with the energy demands of households and businesses.

Depending on the weather conditions, there can also be long periods of low renewable energy output. For example, solar generation will be low if it rains for a few days. Snowy 2.0 and its fast-start, clean hydro-power and large-scale energy storage will work together with renewables by filling the gaps in generation and managing system instability.

The combination of intermittent renewables, underpinned (or 'firmed') by on-demand generation by Snowy Hydro and Snowy 2.0, will help ensure that households and businesses have reliable, stable and affordable energy into the future. The ability for hydro, gas or diesel peaking energy to 'firm' renewable energy, turning wind and solar into a reliable end product, is already occurring in the energy market and Snowy Hydro is at the forefront of these developments.

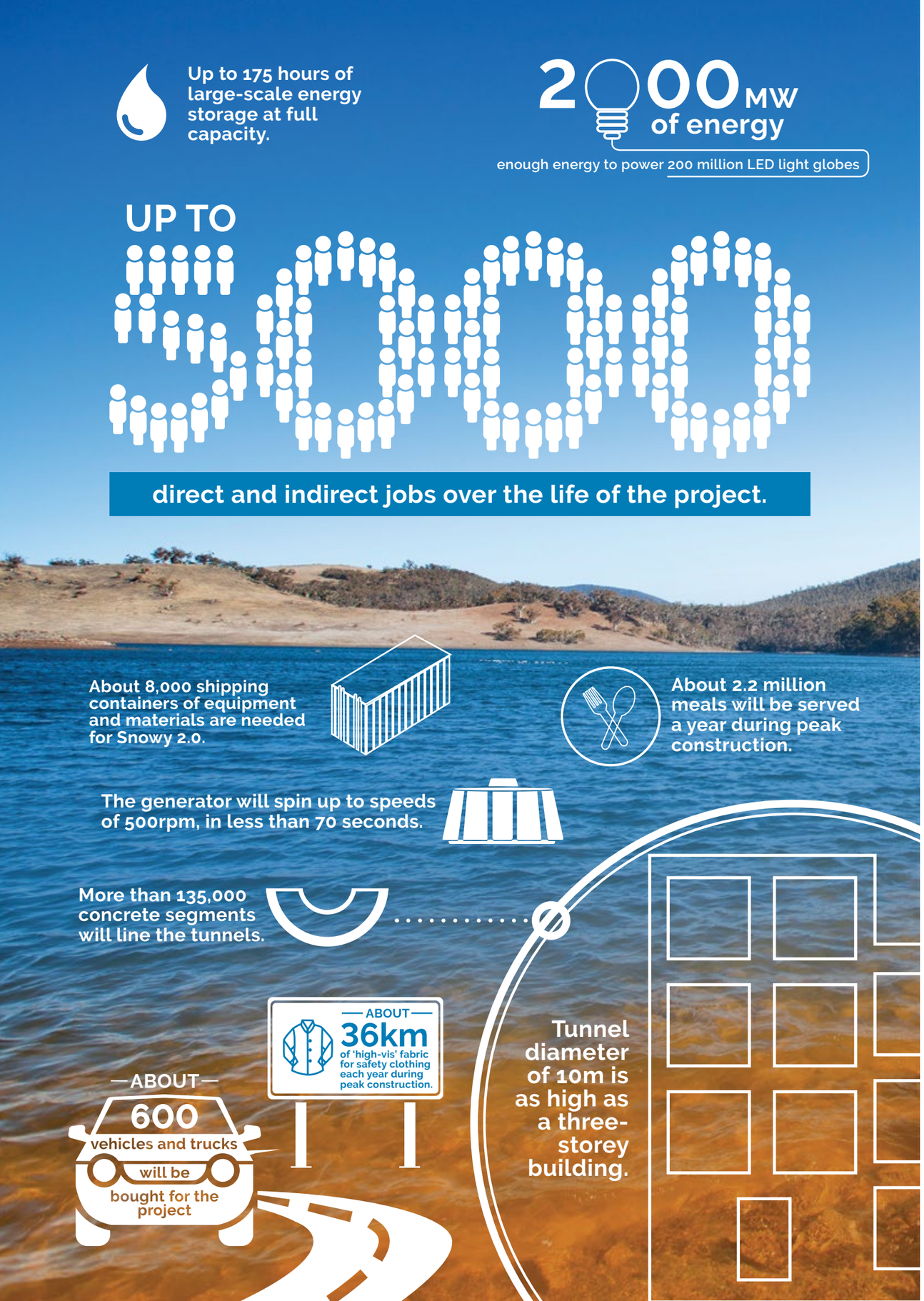
Snowy 2.0's fostering of new renewables, and additional supply of hydro generation, will create extra competition in the NEM to help lower energy prices for consumers. It will support new competition from renewables and increase the efficiency of the NEM by buying surplus energy, using it for pumping and storing it as water (potential energy) in the upper dam, before generating when the energy is required by consumers.

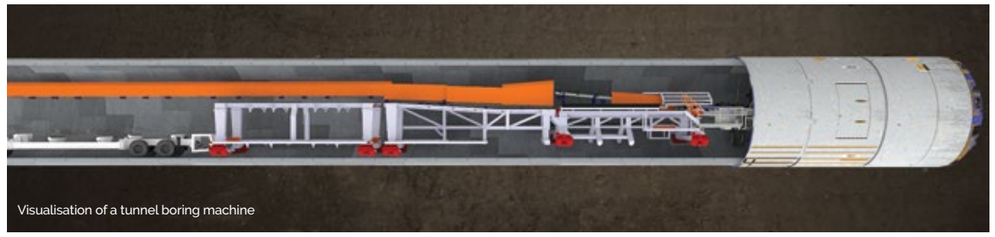
The capacity of Snowy 2.0's dams will help ensure the stability and reliability of the NEM even during prolonged weather events, such as wind or solar 'droughts'. Snowy 2.0, along with the existing Snowy Scheme, will more efficiently deliver electricity to the major load centres of Sydney and Melbourne at times of high demand.

The cost and zero emission advantages of renewable energy will only be realised if a sufficient amount of energy from these intermittent renewable energy sources can be stored for later use when required. Snowy 2.0 is the least cost, large-scale energy storage solution for the NEM as the economy decarbonises, according to an independent economic analysis prepared by leading financial and economic consultants Marsden Jacob Associates.

If Snowy 2.0 is not built, the likely alternative to meet the needs of the market is a combination of gas peaking plants paired with commercial-scale batteries. This option would cost at least twice as much as building Snowy 2.0.

While Snowy 2.0 is a significant step in bolstering the NEM's electricity storage, far more will be needed across the NEM. Other pumped hydro projects, commercial and household batteries and demand response will be part of the future energy and storage mix.




Visualisation of a tunnel boring machine

Engineering and construction on a massive scale

The Snowy 2.0 project will involve underground excavation and tunnelling works between Tantangara and Talbingo dams. About 27km of power waterway tunnels will be constructed to link the two existing dams and these tunnels will be about 10m in diameter.

The power station complex will be located approximately 800m underground. Two main caverns will be constructed.
The machine hall will be about 240m long, 50m high and 30m wide and next to that is the transformer hall, at about 200m long, 50m high and 20m wide.

Six galleries will run between the two halls and carry cables that connect the generators with the transformers. To reinforce the structure where required, rock bolts of 15m to 20m in length will be drilled into the rock at the top and sides of each cavern.

The power station will consist of six reversible Francis pump-turbine and motor-generator units. Three units will be synchronous (fixed) speed and three will be variable speed, which enhance the operating flexibility of the power station.

Snowy 2.0 will create economic opportunities for local businesses and significant employment. To date, more than 50 businesses based in the Snowy Mountains have been involved in the project. Snowy 2.0 is expected to create up to 5,000 direct and indirect jobs over the life of the project.

Safety is our number one priority

Safety is, and always will be, Snowy Hydro's number one priority. Our safety vision and high expectations for the management of all safety risks will be adopted by all those working on the project. We will not compromise safety on any aspect of the project including schedule.

Before appointing contractors to Snowy 2.0, exhaustive due diligence was undertaken to ensure their safety systems, performance and processes were of the highest standards. Snowy Hydro and all contractors on the project are committed to continuously monitoring and improving safety standards. We are also committed to sharing any safety learnings and improvements with the wider industry.


Visualisation of Tantangara adit

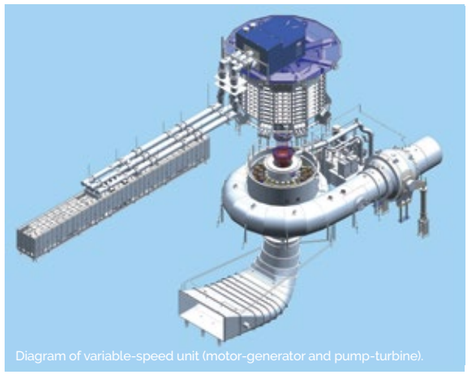


Diagram of variable-speed unit (motor-generator and pump-turbine).

Rigorous and exhaustive environmental and planning assessment

Snowy Hydro has a proven track record over many decades of operating responsibly in the Kosciuszko National Park (KNP). We see the KNP as our backyard and have carefully considered the potential environmental impacts of the project and where possible this has been reflected in the project's design. Where impacts cannot be avoided they will be minimised, mitigated or offset.

While the New South Wales Government is ultimately responsible for allocating the environmental offsets for the project, Snowy Hydro is very supportive of the local community's view that financial offsets should be used to directly fund environmental projects and initiatives in KNP.

In the early design stages of Snowy 2.0, a deliberate decision was made to place most of the project's construction underground to minimise the project's footprint on the surface. Critically, and unlike almost all other pumped hydro projects, Snowy 2.0 utilises existing dams and storages and does not require the construction of any additional dams. In this regard, the Snowy 2.0 business case is fortunate to be able to leverage the dams constructed during the original Snowy Scheme development.

On 7 March 2018, the NSW Minister for Planning declared Snowy 2.0 to be State Significant Infrastructure and Critical State Significant Infrastructure (CSSI) under the NSW Environmental Planning and Assessment Act 1979 (EP&A Act), on the basis that it is critical to the State for environmental, economic or social reasons.

Snowy Hydro prepared a thorough Environmental Impact Statement (EIS) for the Exploratory Works which covered potential environmental, social and economic impacts of the project. A number of studies and surveys were undertaken by world-leading technical and scientific experts, including the CSIRO, as inputs into the EIS. The studies conducted for the EIS identified changes to the project plans that improved environmental outcomes and which were adopted (for example changing access roads to avoid impacts to flora and fauna). The Exploratory Works EIS totalled thousands of pages and is available on a dedicated portal, accessed from the Snowy Hydro website.

Following the NSW Government's assessment of the Exploratory Works EIS, planning approval for this stage of the project was granted and work has commenced. Snowy Hydro will provide $10.5 million in environmental offsets for Exploratory Works and the New South Wales Government has indicated this funding will go to the National Parks and Wildlife Service for local projects.

Snowy Hydro is currently preparing an EIS for the Main Project Works, which will be submitted mid-2019. Just like the Exploratory Works EIS, this second EIS will be comprehensive and robust, and will assess all potential impacts of Snowy 2.0, informed by world-leading, independent expert advice.

No impact on downstream water users or environmental flows

The Snowy Scheme operates under a strict water licence issued by the New South Wales Government. Snowy 2.0 will not in any way impact on Snowy Hydro's continued compliance with the water licence.

There will be no change to Snowy Hydro's water release obligations from both the Murray and Tumut developments, and no change to environmental release obligations. Therefore, Snowy 2.0 will not have any impact on downstream water users or environmental flows. Snowy 2.0 will also be less affected by water inflows, so it will be less impacted by droughts. Snowy 2.0's pumping capabilities work in a 'closed' system - water is recycled between the two dams so the same water can be used to generate power more than once, making the most of available water.

Khancoban Dam

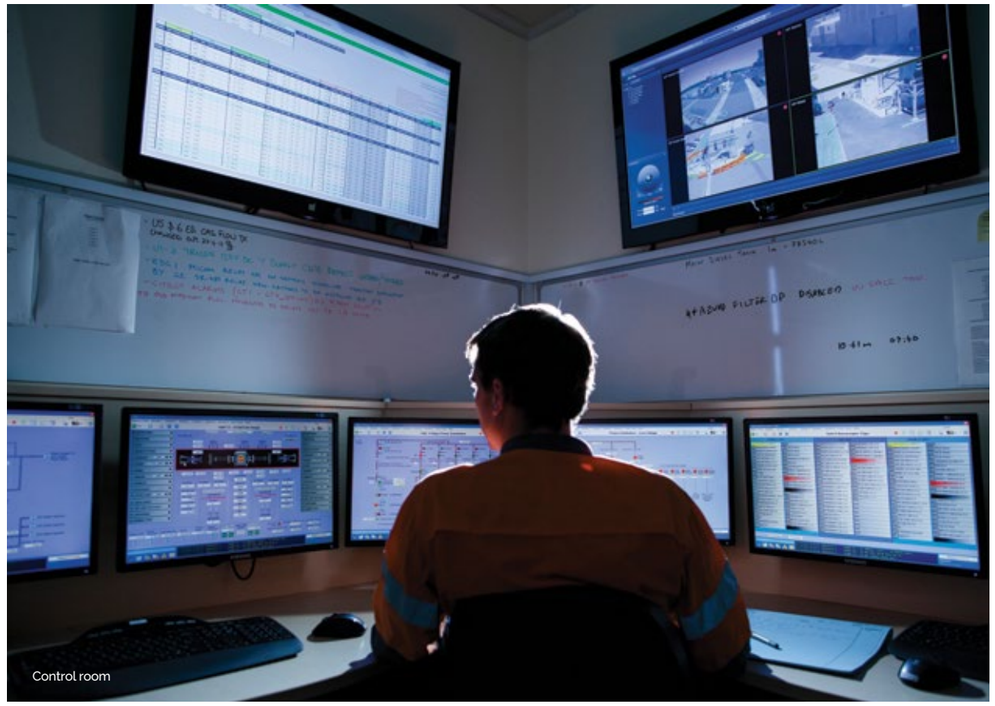
Snowy 2.0 is a commercial investment decision by Snowy Hydro

Despite historically having government shareholders, and from July 2018, being wholly owned by the Commonwealth Government, Snowy Hydro operates like any other independent commercial entity competing in an open and fiercely competitive market. We are a company incorporated under the *Corporations Act 2001* (Commonwealth), with an independent Board of Directors.

The company is pursuing Snowy 2.0 because it meets our stringent investment criteria. The internal rate of return (IRR) for the project has been modelled at more than 8%, which is strong for this type of project.

This project was based on the original Snowy Scheme design in the 1960s, but it was not constructed at that time because the business case was not feasible due to the availability of cheap thermal generation.

Fast forward to today and the NEM is changing, with coal-fired generation retiring and more intermittent and variable renewable energy sources coming online, creating significant impacts on system stability and reliability. In today and tomorrow's energy market, this project is a solid investment and one that is critical for Snowy Hydro's growth and continued ability to compete in the market for the benefit of consumers.



Control room

Competitive procurement process

Snowy Hydro commenced its competitive procurement process for Snowy 2.0 in early 2017. The process progressed through an Early Contractor Consultation (ECC) phase, an Expression of Interest phase, progressive shortlisting, and issue of formal tenders.

Snowy Hydro involved potential contractors at an early stage of the feasibility study through its ECC process. This was designed to draw on the construction experience and capabilities of contracting and manufacturing firms, which could then flow into the feasibility design and later into the definition of the Employer's Requirements for tender.

Snowy Hydro's primary goals in this process were to identify and reduce overall project risks through contractor input to cost estimate, schedule, and constructibility, and reduce the overall project schedule.

More than 20 companies were approached as part of the ECC process. After extensive tender evaluation, Snowy Hydro appointed Australian and global experts in construction, engineering and hydropower as preferred tenderers for the Snowy 2.0 project.

They are:

- Civil works - 'Future Generation Joint Venture', a partnership between Australian construction and engineering company, Clough, and global hydropower and tunnelling specialists, Salini Impregilo.
- Electrical and mechanical works - Voith Hydro, a world leader in hydro power engineering and equipment supply.
- Exploratory Works and pre-construction activities - Australian company, Leed Engineering.

These contracts are currently being finalised and are expected to be ready for execution shortly. The project will be executed under an Engineer-Procure-Construct (EPC) contract structure.

The key benefit of an EPC contract to Snowy Hydro is that the contractor takes full responsibility for the cost of completion for lump sum items, the time for completion, the safety and quality of the design, the works delivered under the contract and the final performance of the facilities, subject to certain specific accountabilities retained by Snowy Hydro.

Snowy Hydro gains the advantage of world-leading expertise in the design and construction of these facilities.

While a widely-used and recognised standard, the contract form has been customised to reflect Snowy Hydro's particular context and requirements for the project and the level of underground works.

Snowy Hydro, through its consultants, has developed an independent Project Cost Estimate and Schedule that takes into account the selected EPC strategy and has been validated against information provided by the preferred tenderers.

Extensive geological investigations program

Snowy Hydro pursued opportunities to de-risk the project, including undertaking a significant geotechnical investigations program to identify the geological conditions along the Snowy 2.0 alignment. Core samples at depth were critical to establish geological baseline data, especially at key sites such as the underground cavern location.

As the geological data became available, the project design and engineering was continually refined.

Staff at a Snowy 2.0 investigative drill site

Robust and sound business case

The decision to construct Snowy 2.0 is projected to be materially value-accretive to Snowy Hydro. The business case reflects the ability of Snowy Hydro to fund the project on its own balance sheet.

- Snowy 2.0 is projected to provide a rate of return in excess of 8%.
- Snowy Hydro will continue to pay dividends to its Shareholder throughout the construction period.
- The funding strategy, based on a combination of internally-generated cash flow and senior debt tranches, is projected to result in a credit rating of A- for the base case, and no worse than BBB- for the downside sensitivities considered.
- In response to Snowy Hydro's proposal to utilise retained earnings to fund the project, the Shareholder will make an equity investment of $1.38 billion from 2020.
- The projected financial outcomes are based on discounted cash flow modelling of the project's construction period, 50 years of operations and zero terminal value.
- The estimate for the project's construction costs remains in-line with the figures from the 2017 Feasibility Study of $3.8 to $4.5 billion (December 2017 real). While final negotiations on the EPC contract are ongoing, the binding price received from the preferred tenderers gives Snowy Hydro confidence in the assumed build cost. This is also reflected in the business case.

The contribution of debt financing is expected to be accomplished by a program of senior bank debt facilities, with tenures of between three and seven years, which may be bridged into longer-dated bonds or other senior facilities. The average, all-in cost of debt financing is projected to be 5.7% per annum, including the cost of fixed-rate hedging of between 80% and 90% of the total debt.

Project economics - background

The genesis of Snowy 2.0 lay in the need for:

- additional firm, dispatchable capacity to augment NEM generation; and
- a cost-effective, reliable method of storing large amounts of electricity over days, months and potentially much longer time periods. These needs are being driven by the influx of utility-scale, intermittent renewable generation, which is being accompanied by the gradual retirement of ageing thermal plant.

With regard to firm, reliable capacity and energy, the cost of providing raw, un-firmed wind and solar energy has fallen by approximately two thirds over the past decade. In the context of escalating prices of gas and coal supply, wind and solar generation is now a cost-competitive source of raw energy. Snowy Hydro, and Snowy 2.0, have the ability to transform the raw renewable energy into a 'firmed' product that can be used to supply 24/7 power to end-use customers.

Following Snowy Hydro's tender for 888MW of renewable energy in late 2018 - which is projected to begin supplying electricity in January 2020 - Snowy Hydro and Red Energy have already sold a number of long-term, firmed, renewable energy products to Commercial and Industrial (C&I) customers, at market-leading prices and without risk of price re-sets for the entire contract terms.

In relation to energy storage, wind and solar energy production suffers from some degree of positive correlation, which results in either a deficit of production (compared to the average), or an excess. Pumped-hydro is the only means of economically absorbing and storing the vast amounts of excess energy projected to be produced in the NEM over the coming decades.

Pumped-hydro maximises the economic efficiency of the NEM and helps keep downward pressure on electricity prices for consumers. It is the only proven technology that provides large-scale, firm capacity, as well as energy storage.

Capitalising on this capability, Snowy Hydro is forecast to make major inroads into the C&I sector, based on price and the complete absence of price risk, over whatever term is desired for the buyer. The 888MW renewable tender has been an effective anchor for the Snowy 2.0 project economics in other ways.

Visualisation of Snowy 2.0 machine hall interior

The price of pumping that has been derived from economic modelling research has been effectively verified by the contract energy prices from the tender. The 'buy' price set by Snowy Hydro for approximately 2.9 terawatt hours (TWh) of renewable energy gives the company the ability to use this energy in a number of ways. At one extreme, 2.9TWh could underwrite more than 70% of the pumping energy that is projected to be consumed annually by Snowy 2.0. More likely, the bought energy will be blended, with the renewable energy produced in peak times used as the basis for firming products, and the energy used in off-peak times to pump by Snowy 2.0.

Snowy Hydro's 888MW tender attracted more than 17,600MW of interest from proposed projects located across the east coast. Snowy Hydro has signed eight contracts for the 888MW, with four wind and four solar projects, for terms of up to 15 years.

Market Modelling

Independent specialist economists, Marsden Jacob Associates (MJA) were commissioned to undertake an economic modelling exercise and have delivered two detailed public energy market reports. These reports investigated:

- the NEM's future market state and options to address the associated NEM price and reliability issues, and the benefits and comparative economics provided by Snowy 2.0;
- a multi-stage approach to the assessment of the economic and market benefits and potential value of the project through a least-cost planning simulation approach, characterised by macro assumptions and policy that may influence this, including additional economic entry of intermittent generation;
- rationale for the project, future NEM mix, the technologies available for generation and energy storage and associated cost outlooks; and
- an assessment of how these benefits would be shared and the resulting impact the project would have to wholesale electricity energy prices and resulting customer prices.

The MJA market modelling reports are available on the Snowy Hydro website:

snowyhydro.com.au/snowy20

Summary of revenue sources and drivers

Snowy 2.0 benefits from Snowy Hydro's strong track record as a corporate entity with robust, diversified cash flows and the ability to weather severe shocks such as drought and a global financial crisis.

Unlike a project-finance development, the debt load to which Snowy Hydro is exposed is projected to reach its peak before the end of the construction period. By the date of expected commissioning, the debt peak has passed and the incremental cash flows from Snowy 2.0 are applied to paying down debt, as well as paying dividends to the Shareholder.

The economics and financing are relatively resilient to delays that may be experienced leading up to the project's commissioning date. Downside scenarios that have been tested with Standard & Poor's illustrate Snowy Hydro's financial resilience, including 'worst case' downside capex scenarios that result in a forecast credit rating scenario of BBB-. In reality, however, the expenditure of this downside case would most likely be caused by delay, so the capex would be spread over a longer period. This would partially negate the projected impact on the debt peak and the credit rating.

The robustness of the business case is based on the primary drivers and the four key revenue streams (discussed below). The projections of revenue for the underlying business during the construction period, and for the combined business thereafter, benefit from the ability to effectively arbitrage between the revenue streams, simply by calibrating the focus on the individual business segments. This leads to two conclusions that may appear counter-intuitive:

- The projected financial outcomes are indifferent to the level of retail customer growth, because the wholesale products provided to Red Energy and Lumo Energy are priced 'at market'.

  Therefore, the value of the energy and capacity assumed to be sold through Red Energy and Lumo Energy is not contingent on being sold through the retail channels. These products can be readily re-allocated to the other revenue streams.

  The net value loss, in the event of lower retail growth, is therefore limited to the net retail margin, which is a small component of the value of Snowy 2.0. A retail downside scenario is provided, to demonstrate the sensitivity of the valuation to this variable.

- The 'traditional capacity' revenues are projected to replace the 'firming' revenues by the early 2030s: This is driven purely by the fact that the hierarchy of NEM products and services that Snowy Hydro and Snowy 2.0 are required to provide ranks products related to 'insurance' or 'keeping the lights on', above products that firm renewables. This has two implications:

  - The NEM will need additional firming capability by the mid-2030s, which points to a clear need for Snowy 3.0 and/or other capacity and storage; and
  - If Snowy 3.0 is not built, the modelling implies that the existing Snowy Hydro business, in combination with Snowy 2.0 and other NEM participants, are fulfilling the market need for firming products. This, in turn, implies a foregone opportunity for Snowy Hydro, reinforcing the point above.

Primary drivers of revenue

Two primary drivers underpin the four major sources of revenue, namely capacity (the ability to deliver near-instantaneous, reliable generation for short periods) and storage (the ability to time-shift energy from low-demand, low-value periods to high-demand, high-value periods).

These revenue drivers, though not mutually exclusive, are additive; that is, Snowy Hydro and Snowy 2.0 benefit from both at the same time and do not have to choose between them to earn revenue. This is a key difference between Snowy 2.0 and other generating assets. For example, a gas-fired peaking station is almost entirely reliant on capacity revenue, whereas a wind farm relies solely on energy.

The following table summarises the sources of data for these two drivers, and their relevance to the projected financial outcomes. Where references are made to MJA, these refer to the two-year, exhaustive development of MJA's NEM projection tool.

Revenue drivers, assumptions and validation

REVENUE DRIVER	CORE ASSUMPTION	VALIDATION/SOURCE
Capacity	Capacity value is derived as: capacity quantity (MW) x capacity price ($/MW/hour) Capacity is a component of: ▸ traditional capacity ▸ renewable firming	The quantity of demand for capacity products is taken directly from the MJA model, across the entire 50-year projection period. The price of capacity products is provided by Snowy Hydro, noting: ▸ The New Entrant Price is based on the price at which the cheapest new entrant is able to provide capacity. ▸ This is a conservative assumption, because the price of every subsequent increment of peaking capacity will suffer, compared to the single cheapest next new entrant, from higher costs for gas supply and/or storage, higher costs of grid access (including remediation of fault levels), lower efficiency (open-cycle gas fired power stations lose efficiency at higher altitudes) and higher transmission costs.
Storage (the spread between pumping cost and generating revenue).	The spread is derived as: Generating quantity (GWh) x generating price ($/MW/hour), minus pumping quantity (GWh) x pumping price ($/MW/hour) The pump/generate relativity is a component of: ▸ renewable firming ▸ retail diversification ▸ storage revenue	▸ The quantities of pumping and generation are taken from the MJA model. This model simulates supply and demand by creating bid stacks of generation, which are then applied to half-hourly demand. ▸ The prices of pumping and generation, by half-hour, are also taken directly from the MJA model. Capacity factors of pumping and generating are critical parameters in pricing. ▸ On the pumping cycle, the capacity factor in the late 2020s remains around 24%, meaning Snowy 2.0 can be selective about the timing of pumping, and that pumping will be restricted to low-demand times when coal plants and renewables are competing for load. Consequently, the price of pumping is projected to benefit from increasing instances of NEM price of zero. ▸ Modelling shows that the majority of pumping occurs at prices below $50/MWh. However, the range of projected pumping prices extends to above $70/MWh, reflecting the supply/demand dynamics modelled to occur at particular times. ▸ The 888MW tender has effectively removed the risk inherent in this assumption, because the price of contracted energy is below the pumping price assumed for Snowy 2.0. ▸ On the generating cycle, the 2020s capacity factor of 17% ensures that Snowy 2.0's generating price is set by competition with the gas-fired portion of the supply stack. The projected average generating price during this period is only marginally above the fuel cost of gas plants.

Snowy 2.0's revenue streams

Snowy 2.0 has four revenue streams.

1. Storage products

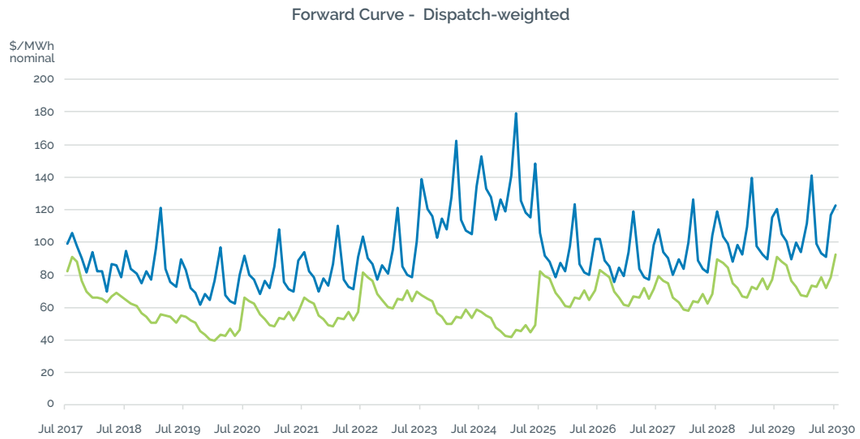
Storage products involve buying energy at low prices and selling at higher prices. Snowy Hydro will use the price differential to 'time shift' and store energy. Snowy 2.0's size and scale provides up to 175 hours of energy storage at full capacity, or 350,000MWh.

The size of the price differential in the wholesale market is a key factor to the value of these products. MJA's projections relating to this 'spread' when modelling the value of by storage products are as follows:

- Flat price ($70/MWh - 2019 to $85/MWh - 2030).
- Average peak-to-off/peak spread (all price periods):
  • 2025: $85/MWh (off-peak $50/MWh, peak $135/MWh).
  • 2030: $30 (off-peak $75/MWh, peak $105/MWh).
- Generating capacity factor (6 hrs/working week days i.e. 17% p.a.).

Figure 1 (source data - MJA report) shows that when fully commissioned in 2025, Snowy 2.0 will reduce the peak to off-peak spread, dampening volatility and providing greater certainty of revenue for variable renewable generators. Critical factors for consumers are that:

Figure 1



- Snowy 2.0 will be by far the cheapest source of new capacity, due in part to the diversity of revenue streams that Snowy 2.0 accesses. The reduction in peaking prices to consumers will therefore be maximised if the sources of supply include Snowy 2.0.
- The support for renewable generators, (by providing a significant source of demand at times when renewable generation would otherwise be excess to market needs), will encourage significantly more renewable generation entry than would otherwise be the case. This action of attracting new, independent supply to the NEM, will also encourage lower prices to consumers overall.

2. Capacity products

Capacity products are a type of 'insurance' to provide price certainty to market participants and protect them from price shocks. Such products are crucial to the viability of smaller retailers, which usually do not have upstream generation assets to manage the risk of price spikes.

Modelling of capacity prices can be complex as they are highly dependent on new entrant technologies and long-term cycles such as weather, asset pricing, financial markets and the broader economy. Allowing for all these influences, Snowy 2.0 has been modelled using a standard price through to July 2021, and a higher price when five-minute settlement begins in July 2021.

For capacity pricing, Snowy 2.0 is at least 30% cheaper than the indicative capacity price required for reciprocating gas engines to be economic.

3. Firming products

Firming products are contracts with intermittent renewable generators where Snowy generates to make renewables both physically reliable and financially viable, so they can commit to supply contracts.

Note: 1MW of hydro can 'firm up' more than 1MW of wind and solar.

Figure 2 (Source: AEMO 2016) refers to the South Australian electricity market conditions, and shows that Snowy 2.0 would pump using the wind in the early hours of the morning and then generate when the wind drops off during the day and into the early evening.

Figure 3 (Source: AEMO 2016), shows that Snowy 2.0 could pump using the solar generated in the middle of the day and generate before sunrise and after sunset. The dispatchability of hydro power also means it can be switched on/off to cover cloudy periods.

Snowy Hydro offers contracts that take a non-firm, intermittent energy source such as solar, and convert it into a 'firm' source of electricity to match demand, as shown in Figure 4 and Figure 5.

In these graphs, Snowy Hydro provides the 'Residual - Solar' supply. Our modelling shows that the pricing of a 100% renewable energy firming product is, depending on the profile of a customer's load, competitive with current and projected market pricing for non-renewable energy.

4. Retail diversification

Retail diversification is a revenue stream that allows Snowy's customers to benefit from the fact that Snowy's commercial and residential customers don't experience maximum demand at the same time. This allows Snowy Hydro to allocate a given unit of capacity to multiple sources of demand, which allows all customers to benefit from their unique individual load 'shape' by receiving discounted prices based on the degree of negative correlation with the net system load profile.

For example, a school with a demand profile that peaks before 3pm, and an industrial business whose demand extends to 5pm, both benefit from Snowy Hydro's pricing of capacity, because Snowy Hydro does not have to cater for coincident maximum demand of the two loads.

Other revenue sources

Drought protection is an additional source of revenue and risk mitigation that has the potential to be significant in periods of below-average inflows to the Snowy Scheme. In the millenium drought, which reached its zenith in 2007, the capabilities of the Tumut 3 Power Station, a pump/generate facility, was a material factor in Snowy Hydro maintaining its investment-grade credit rating.

Similarly, the 'closed-loop' nature of the Tantangara/ Talbingo storages, connected by Snowy 2.0, would safeguard Snowy Hydro's energy security in the event of another severe, long-term drought. The financial effects of such a scenario are, however, considered to be too speculative to include in the Snowy 2.0 revenue projections, at anything other than an immaterial level.

Snowy 2.0 also supplies ancillary services to the NEM, enhancing the product offerings that Snowy Hydro currently provides. These include services such as frequency control, voltage stabilisation, black-start capabilities. The central location of the Snowy Scheme - its close proximity to NSW and Victoria - supports its ability to provide these services, but this is a relatively minor source of revenue.

Figure 2

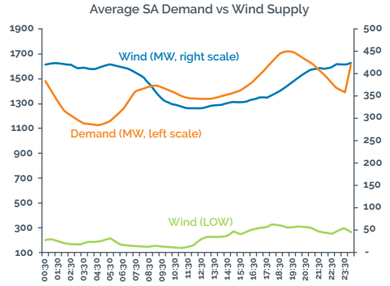


Figure 3

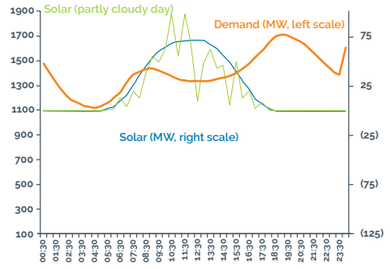


Figure 4

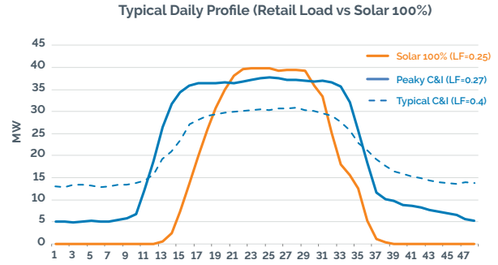
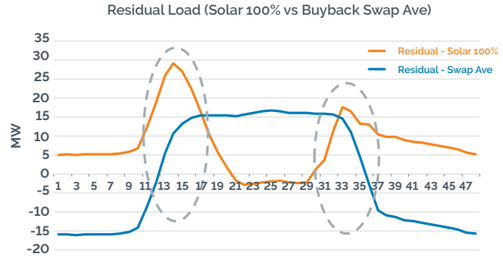


Figure 5



Guthega

Talbingo Dam

National Electricity Market benefits

Snowy 2.0 will underpin the stability and security of the NEM into the future.

- Snowy 2.0 will increase competition in the NEM and put downward pressure on energy prices. MJA modelled as much as a 10% price reduction in NSW (the biggest NEM state).
- It uses very cheap, large sources of existing energy storage. The levelised cost of storage for Snowy 2.0 is assessed at $25-35 per MWh (compared with batteries at $195-254 per MWh).
- It is centrally located, between the major load centres of Sydney and Melbourne.
- Longevity: Snowy 2.0 will be a 100 year-plus asset while batteries typically need to be replaced every 10 years.
- Snowy 2.0 supports the growth of new renewables, through physically 'firming up' intermittent energy generation and financially supporting financial contracts.

Without Snowy 2.0, the most likely scenario is that a combination of batteries paired with gas and diesel plants would be built to meet the market's needs. This would cost at least twice as much as the Snowy 2.0 project. Compared to solid-state batteries, Pumped-Hydro Energy Storage (PHES) has a lower comparative cost, higher capacity, firming capability, longer continuous generation, longer life, and greater contribution to network stability (inertia and interconnection).

Moreover, large-scale PHES will lower consumer prices, stabilise the power grid and enable deeper penetration of variable/intermittent renewable generation, directly addressing all three elements of the electricity trilemma:

- Affordability - increased wholesale competition and reduced or stabilised spot prices;
- Security - increased resilience of the NEM; and
- Environmental - long-term enabler of additional least-cost renewable generation.

A day in the life of Snowy 2.0 and how this will change

The modelling of the Base Case Scenario provided for the daily operations of Snowy 2.0 (and all other generators) to be observed on a day-by-day basis. It illustrates the variability of Snowy 2.0 operations due to factors that include season, day-type, amount of variable renewable energy (VRE) installed, weather impact of wind/ sunshine, demand, and generator outages.

The general principle is for Snowy 2.0 to act as a storage for VRE whereby excess VRE supply is consumed by Snowy 2.0 pumps and then is later used to generate during supply shortages in peak demand periods. The extreme variations in VRE energy output will increase as the amount of installed VRE increases across the NEM and therefore the requirement for the pump-storage capability of Snowy 2.0.

Wind and solar energy

Medium VRE Day

This will be a typical day for Snowy 2.0:

- Snowy 2.0 generates at the start and finish of the day.
- Snowy 2.0 pumps in the middle of the day (to soak up the high solar output).
- This will be a typical day when Snowy 2.0 initially enters the market.

Very low VRE Day

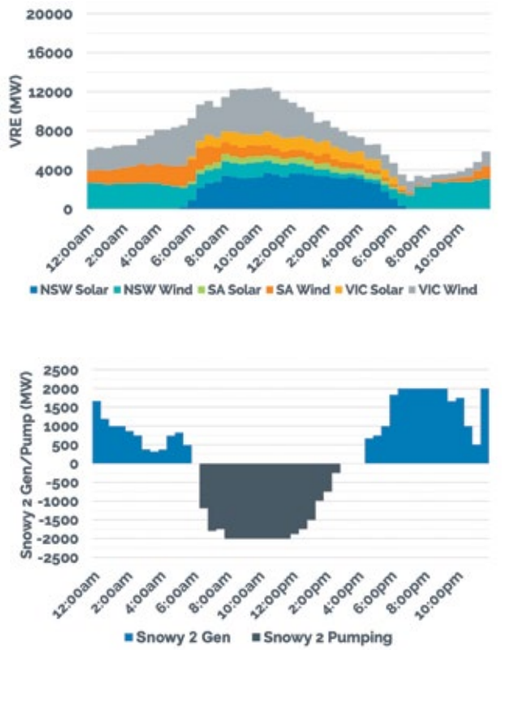
This will be a low VRE day for Snowy 2.0, which will become more typical as VRE increases over time:

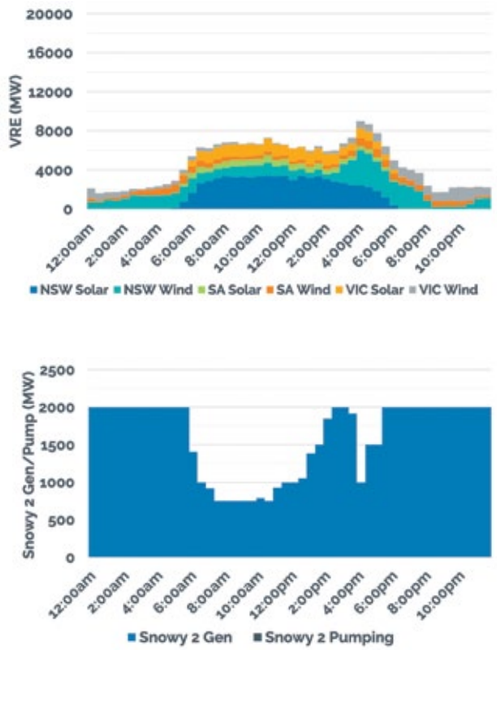
- Snowy 2.0 generates all day, with generation reducing somewhat in the middle of the day. This corresponds to the relatively high solar output replacing the requirement for Snowy 2.0 to generate.
- In general, Snowy 2.0 provides generation capacity when VRE is low and when coal/gas generators are unavailable.

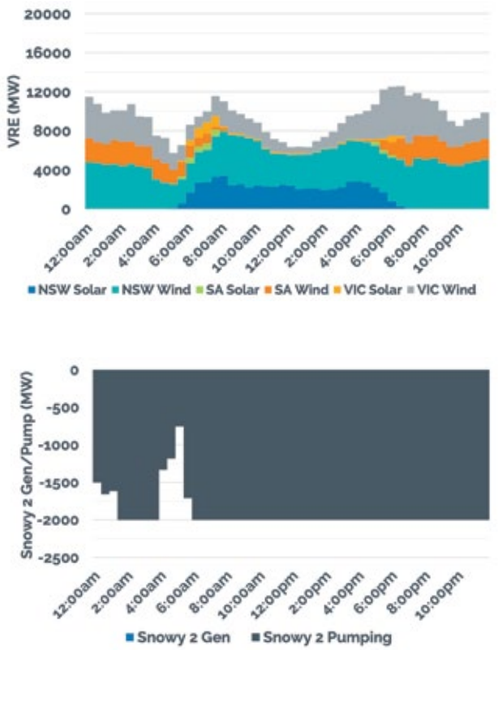
Very high VRE day

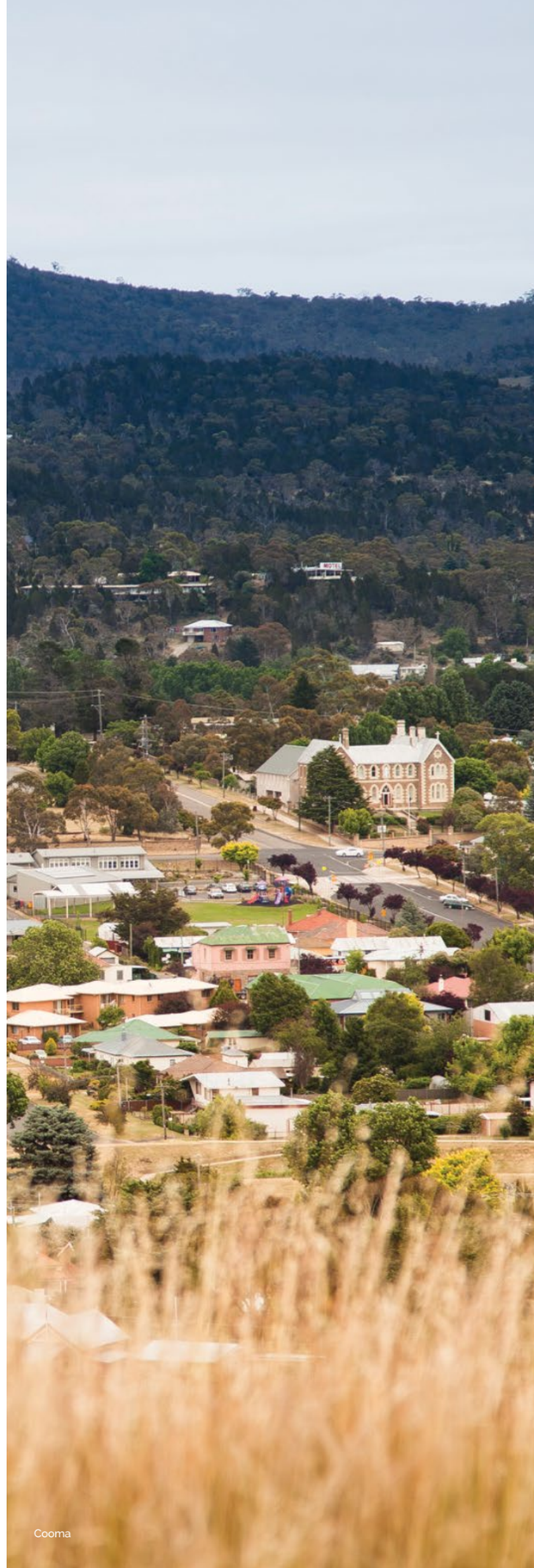
Very high VRE days for Snowy 2.0 will become more typical as VRE increases over time:

- Snowy 2.0 pumps all day with only a small reduction due to a small peak in VRE generation in the middle of the day.
- Snowy 2.0 stores surplus VRE generation to be saved over a whole day for later use when the market requires it most.

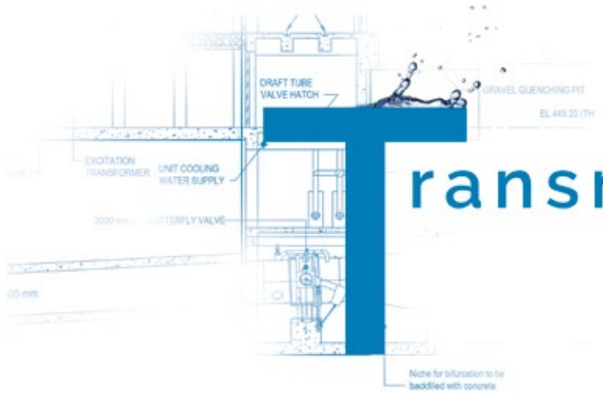








Cooma



Transmission

Upgrades must be prioritised independently of Snowy 2.0 to support the NEM. Most of Australia's existing transmission network was built decades ago, designed principally to transmit the output of now ageing coal-fired power stations.

With the gradual retirement of these assets, new transmission routes will be needed to connect new, geographically-dispersed generation, renewable energy zones and strategic storage projects across the NEM. Snowy 2.0 is just one of many new power stations that will require upgrades to the transmission network.

The Australian Energy Market Operator (AEMO) is responsible for forecasting and planning national transmission system requirements. In 2018, AEMO released its inaugural Integrated System Plan (ISP), which is designed to identify transmission system developments needed to meet future NEM requirements. The ISP supports strategic storage initiatives such as Snowy 2.0, which it recognises is required to 'firm up' the rapidly-growing renewable developments in NSW and Victoria, and indirectly, South Australia.

The ISP proposes upgrades to the shared transmission network that will facilitate the large volume of renewable energy generation and storage projects currently in planning phase or already under construction. There is a long-standing regulatory framework in place to determine funding of these upgrades.

As with any other generator, Snowy Hydro does not own or operate the shared network. For this reason, the costs associated with upgrading the shared transmission network (so-called deep augmentation works) have not been included in the Snowy 2.0 project costs.

However, the cost of lines needed to connect Snowy 2.0 to the shared network - the shallow connection works - will be funded by the project, as they are connection assets to be used solely by Snowy Hydro.

Key transmission upgrades must be brought forward for the benefit of the NEM

The ISP recognises the need for two major transmission upgrades, which will deliver the output from Snowy 2.0 to the major load centres of Sydney and Melbourne, as well as meet other market needs:

- BannabyLink, providing transmission access to New South Wales; and
- KerangLink, providing transmission access to Victoria.

The ISP provided initial indicative timing for these links of 2025 (BannabyLink) and 2034 (KerangLink). However, since the ISP was published in July 2018, there has been a growing recognition of the need to revise this timing and bring forward critical upgrades.

To ensure system security in NSW, the commissioning of Bannabylink must be brought forward to 2022. The scheduled closure of Liddell power station in 2022 will significantly diminish system security in NSW. Bringing forward BannabyLink to 2022 will mitigate the impact of this closure by unlocking up to 1,200MW of on-demand capacity from the existing Snowy Scheme, substantially plugging the gap left by Liddell. It will also avoid the need for costly, new interim generation capacity that would otherwise be required (before the commissioning of Snowy 2.0).

The criticality of Bannabylink is also supported by NSW's Transmission Infrastructure Strategy, under which NSW has provided a funding guarantee for early works required on the upgrade. BannabyLink will also play an important role in realising the benefits of Project EnergyConnect (RiverLink), a proposed interconnection between NSW and Australia by linking the terminal point of that project, Wagga Wagga, to Sydney.

Similarly, the timing of KerangLink must be brought forward to align its commissioning with Snowy 2.0 in 2024, to ensure a reliable and orderly transition of the energy system.

While the ISP acknowledges that KerangLink will be needed ahead of, and in preparation for, the retirement of existing coal-fired generation, it does not adequately recognise the unpredictability of the current fleet of coal plants and that the chance of one or more failing prematurely, before 2040, is very high.

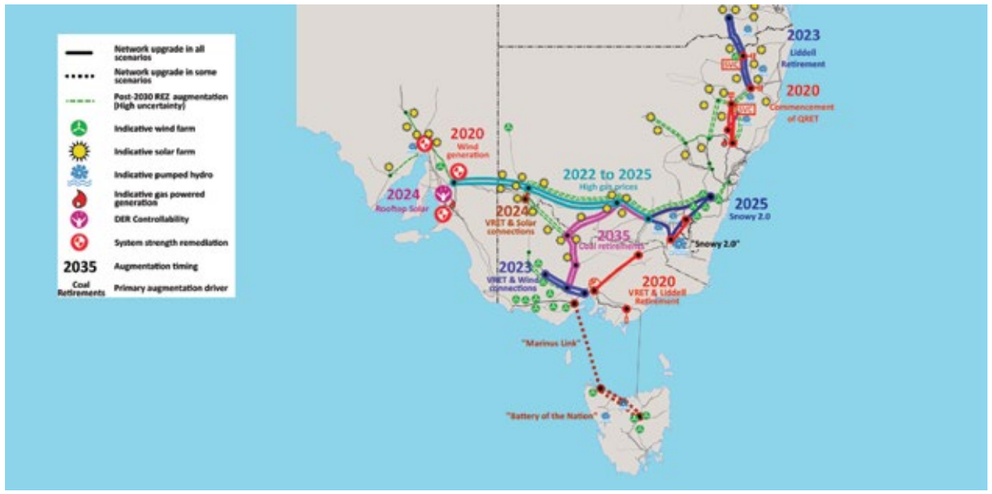
Without KerangLink, coal plant retirement in Victoria is likely to be accelerated by the Victorian Renewable Energy Target (VRET). The VRET will encourage large amounts of new renewable energy capacity in Victoria. This will dramatically increase market pressure on the existing coal fleet and hasten their retirement, reducing energy security and system reliability.

However, implementing KerangLink by 2024 will provide system resilience to cater for the unplanned early exit of coal plant, by allowing Snowy 2.0 to firm VRET output and capture excess or low-value generation for use during times of energy scarcity, and so facilitate an orderly transition to a renewables-dominated power system.

Bringing forward KerangLink will also provide route diversity for the existing VIC-NSW interconnection (which is regularly impacted by bushfires), mitigate against the Tasmania-Victoria Basslink cable failure (which has, in recent years, demonstrated its vulnerability) and help address market concentration issues.

By allowing generation to flow freely between the NEM's two biggest regions, KerangLink will alleviate the current market concentration. The risk of price 'islanding' will fall and the liquidity of inter-regional swaps will increase.

The map below shows indicative timing for transmission links including BannabyLink and KerangLink (referred to as SnowyLink North and SnowyLink in AEMO's ISP). Snowy Hydro is calling for commissioning of these links to be brought forward for the benefit of the NEM.



Source - AEMO. Integrated System Plan 2018.

For more information about Snowy 2.0

snowyhydro.com.au/snowy20