REPORT

Oven Mountain Pumped Hydro

1st December 2020

New England Visions 2030 Institute

Exploring major issues influencing the future of our wider region.

We are aiming to encourage
an agile community which is looking to the future
with strong leadership and an atmosphere of healthy competition.
We envision positive community networking,
the embrace of imaginative and creative ideas
and a willingness to experiment and take risks.
We also strongly encourage
an equitable, tolerant and empathetic community.

Executive Summary

Climate change and energy policies have dominated Australian politics for more than a decade. Australia is a country blessed with much mineral wealth and has for decades relied on coal to produce electricity. Australians have never embraced the nuclear option and never will, possibly because it was unnecessary due to all that coal, but also because it requires copious amounts of water, which we don't have and the fear of a meltdown, which has happened in different countries around the globe. Capitalists have enriched themselves digging up our coal and exporting it abroad but those days are numbered as other countries move towards renewables and increasingly don't require our coal any more. As more and more countries embrace zero emissions by 2050, there will be much pressure to produce electricity in the most non-polluting way possible. Emission loads will be built into trade agreements which will force laggard governments to improve their performance in this area.

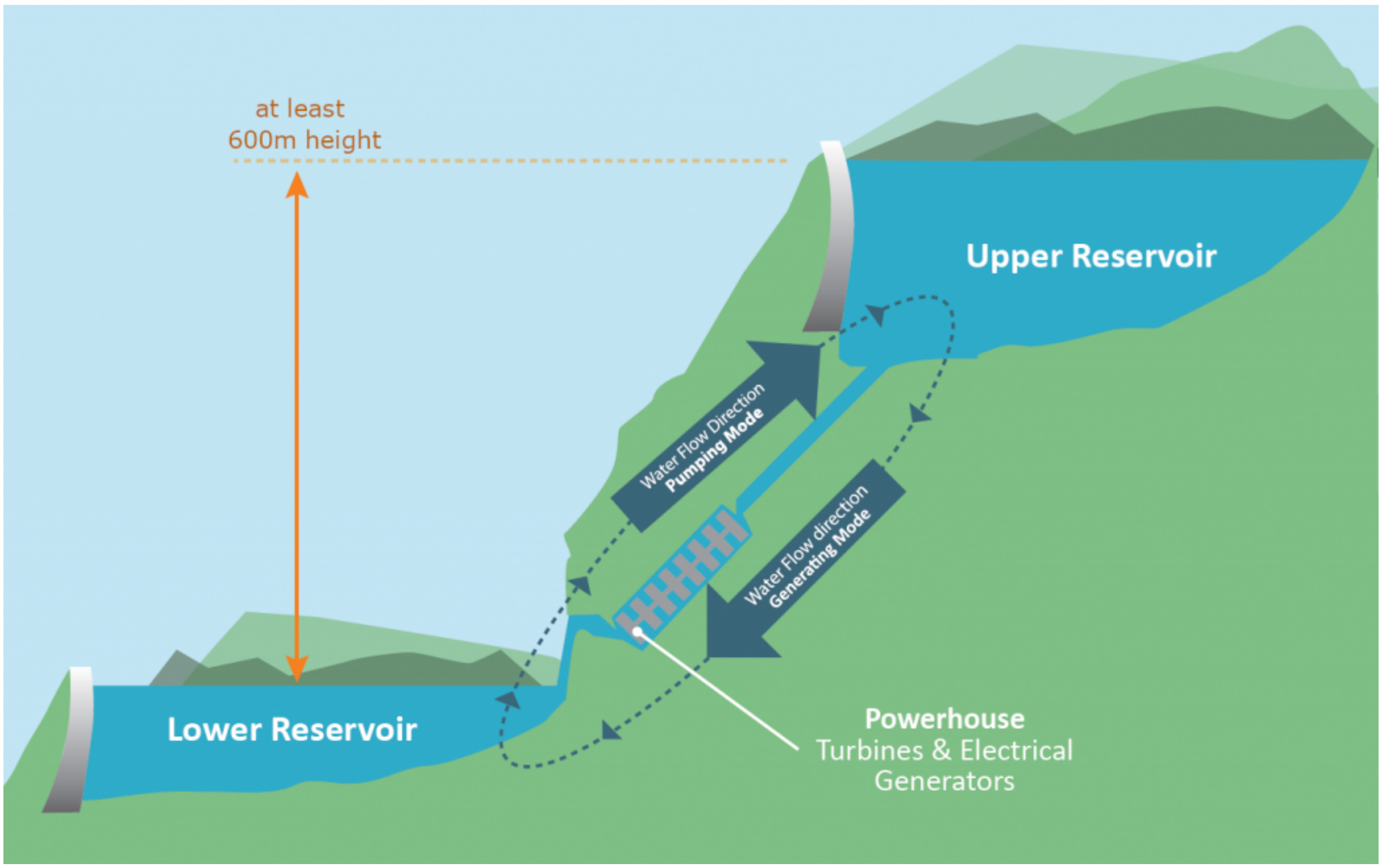
The enormous uptake of rooftop solar in Australia has resulted in cheaper energy for consumers at the household level but it has provided a headache for authorities which are responsible for a reliable grid. Plans are underway to build more high voltage lines that can accommodate all the extra energy being fed into the grid on sunny days. But there are gaps in the times when renewables feed into the grid. These gaps are currently being filled by base load power generated at coal fired power stations. As these power stations age and become decommissioned over time the Federal Government is recommending gas as an alternative. But gas is also a fossil fuel and at best can only be seen as a transition fuel.

Pumped Hydro has been suggested as a means of stabilising the grid in a non-polluting way. Snowy Hydro 2 was launched by Malcolm Turnbull with great fanfare. In our area planning for the Oven Mountain Pumped Hydro Project appears to be well underway. By the small number of responses we had to our questions, it appears that few local residents know much about this project. This report aims at informing you of the benefits and risks involved. Much of the information included in this report was gathered in a breakfast meeting our team held with Anthony Melov and Jeremy Moon of OMPH and by further research. Thank you to Don Hitchcock and Dr Dorothy Robinson for their excellent contributions.

The Project (from https://www.ompshydro.com/)

The Oven Mountain Pumped Hydro Energy Storage project is a 600MW development set to play a key role in transitioning our power grid towards renewable, affordable energy. It is being developed by OMPS Pty Ltd in partnership with Alinta Energy.

Using mature, long-life technology, the project will provide the flexibility and network services required to stabilise the grid and drive wholesale energy prices down. It is a perfect complement to wind and solar, allowing excess electricity to be stored and later used when it is needed most.



Situated on privately owned land between Armidale and Kempsey in regional New South Wales, the project is strategically located near the state's transmission backbone and in the New England Renewable Energy Zone.

We have partnered with Alinta Energy to co-develop this project. Alinta Energy has over 20 years' experience in the energy industry and boasts over 1 million gas and electricity retail customers. With its purpose to make energy more affordable for its customers, Alinta Energy is Australia's fastest growing retailer on the east coast. Alinta serves over 600,000 households and businesses in New South Wales, Victoria, South Australia and Queensland and has a staff base of over 800. Alinta Energy brings exceptional strength and credibility to the project development.

This Project received funding from ARENA as part of ARENA's Advancing Renewables Program.

Responses to questions

1. What do you know about the Oven Mountain Pumped Hydro (OMPH) scheme?

not much
The OMPH scheme is designed to stabilise the grid by providing base load facilities, utilising renewable energy to pump water above the power turbine and gravity to let it fall again, producing electricity as it does so. It falls in the geographical area of the planned New England Renewable Energy zone.

2. Do you understand what Pumped Hydro is?

Yes. Basically a gravity battery using water as a medium to produce power by dropping it from an upper reservoir through turbines into a lower reservoir when electricity prices/ demand is high; and then pumping the water back up when prices are low/electricity supply is in excess (ie. thereby restoring the potential energy in the water again in the form of a gravitational difference between the upper and lower reservoirs).
Yes

3. What do you think the function of the Oven Mountain PH scheme will be in the NSW Electricity Grid?

Producing short term dispatchable electricity at times of peak demand when the grid urgently requires it; more importantly to help fill the large electricity supply “gap” which will be created by the imminent closure / retirement of some major coal-fired power stations in NSW over the coming years. Also to provide “dispatchable” power (ie. available on demand) which is not subject to sun or wind availability at the time; which solar and wind farms cannot provide without their own battery storage
To flatten the curve of electricity production, making the grid more stable.

4. Should it be a public or private venture?

a blend would be good so local community investors can also participate and benefit.
Public. Privatised utilities run for profit not for public services. We don't want to be at the beck and call of a private company to guarantee our energy supply at reasonable rates.

5. Do you have any concerns about the OMPH scheme?

Yes. Environmental concerns will be large but am confident strict planning controls will address those. Given it is an “off river” project it does not have the same level of river impact concerns that other on-river dam schemes carry.

Will there be sufficient water to achieve the desired result? Is it better than using battery storage? Will the damming required have any impact downstream?

6. Do you see any benefits of the OMPH scheme for our region?

Yes. Benefits would include local employment during construction; required road upgrades so project will co-contribute to the improvement of the Kempsey Road corridor; water security improvement for the lower Macleay; contribution to cleaner air and lower carbon emissions across NSW.
One would hope that this would reduce the price of electricity in our region, but I am doubtful of that. It could become a tourist attraction and part of a high-tech vision for our area.

The role of Pumped Hydro explained and the OMPH Project
Don Hitchcock

I have thought a lot about this project, and I believe it should go ahead.

The important things to be borne in mind are:

1. There are no dams on top of Oven Mountain, nor is there a dam blocking the river below it. This is not obvious from the preliminary information available on most media. Oven Mountain is just a convenient way to refer to the area and find the approximate location on a map.

2. Instead, there are two dams on a hillside in the gorge country, the upper circa 600 metres above the lower, and will be pretty much hidden from view even of very occasional bushwalkers at the level of the river bed below. I have walked the whole length of the Dangars Falls/Salisbury Waters/Blue Hole/Gara River/ Macleay River systems to George's Junction a number of times, and trust me, you don't meet much more than quolls, who will not be affected by this development.

3. The dam walls are narrower than anyone had a right to expect, though they are necessarily high, and enclose deep reservoirs which have a relatively small surface area. They do not have extensive shallow flooded areas. The reservoirs are the best you could possibly hope for, if you had a clean slate and could design hillsides to order.

4. They are on a slope which is forested, on private land (not on national park land). There is little runoff. They are surrounded by steep land with minimal flooding of useful land, and they are thus small in surface area but deep. The forested and stable hill slopes in the project area means that the prospect of siltation of the dams is close to nonexistent. However the parts of the reservoirs that will be under water will have to be logged and cleared in a very careful manner.

5. The trickle of the small creeks feeding in to the reservoirs are a small but significant bonus. Any leakage from the reservoirs will simply reappear in the water table below the river, and ultimately augment its flow. They are not even visible from anywhere else, pretty much, so there is no adverse visual effect. Best of all, there is a very large altitudinal difference.

6. The reservoirs will provide (some) wetlands and certainly permanent water for bird and animal life, this is a plus. In addition, they will provide emergency water for fighting fires from helicopters. They are never, however, going to be important for drought relief further downstream. They contain too little water.

7. There is little need for extra water once the initial fill up has taken place at a time of high water flow in the river. After that, there is close to zero need for extra water, which in any case will only take place in times of high flows. The project will not take significant water from the system.

8. There are no pipes on view. Instead, there will be just one tunnel (more on that later) drilled through the granite substrate, connecting one reservoir to the others, with the turbines, of course, on the lower end just above the lower reservoir, where the tunnel splits into two to go through two turbines.

Tunnels through granite do not come cheap, but they are forever. And this one is mercifully short and thus cheaper than it would otherwise be. It can be waterproofed by lining it with sprayed concrete with an embedded double-bonded spray-applied membrane. This composite single shell liner is economical in terms of cost and time.

Frequency stability

Keeping the electricity supply at the Australian standard of 50 Hz, that is 50 cycles per second, the 'hum' you can sometimes hear from fluorescent tubes and loudspeakers (typically generated at a multiple of 50 cycles per second, usually 100 Hz) is vital if widespread blackouts are to be avoided.

Listen to it here - best heard with earphones if you are in a noisy environment:

https://www.youtube.com/watch?v=Cdi0jQtMqV8

It is not just that the frequency has to be 50 Hz, it has to be a uniform waveform. When a large coal plant goes offline unexpectedly, it can create all sorts of noise in the system, which if not fixed quickly, drops large areas into blackout, and can damage electronic equipment. One of the problems with most renewable energy (solar and wind) is that frequency stability is not easy to arrange with renewables (solar and wind) power sources.

There are bandaid solutions:

You can simulate frequency modulation/stability by electronics. If there is a decent amount of wind, you can cut down on electricity generation from wind turbines by feathering the blades to some extent, and thus get the blades to spin faster and up the frequency to 50 Hz. But they have to be set up to do this. By switching solar panels on and off you can also simulate frequency modulation. But neither of these solutions are nearly so easy to arrange, nor as effective, as it is for hydro or coal or gas electricity plants which have large, heavy (i.e. they have a lot of inertia) rotating masses that can provide frequency stability.

Nothing beats a large rotational mass connected electrically to the grid for keeping the frequency stable. This can be supplied by a suitably wired and well adjusted turbine as used in coal or gas fired electricity plants, or by a hydro plant.

But what do you do when you don't have much hydro, and your coal and gas plants are being phased out?

What you do is you create a rotating inertial component, similar to a typical turbine, but not producing significant electricity. Easy peasy. Technically, if not monetarily.

This could be and at the moment is being partially supplied by the relatively new installations of gas powered rotating components. I suspect this is what SA and WA are doing. A significant part of their energy, a rough estimate is one third, is supplied by gas plants. Partly because sometimes the wind does not blow and the sun does not shine, but also because it provides grid frequency stability at 50 Hz, even if all it is doing is spinning, not producing significant output.

However, there are other ways for ensuring grid frequency stability.

In electrical engineering, a **synchronous condenser** is a DC (direct current, as supplied by, for example, a big battery) synchronous motor, whose shaft is not connected to anything but spins freely. Its purpose is not to convert electric power to mechanical power or vice versa, but to adjust conditions on the electric power transmission grid. Its field is controlled by a voltage regulator to either generate or absorb reactive power as needed to adjust the grid's voltage, or to improve the power factor (energy efficiency). The condenser's installation and operation are identical to large electric motors and generators. (the two terms are effectively interchangeable, as when a hydro powered electricity generating turbine is used as a motor to pump water uphill to the upper reservoir).

Their principal advantage is the ease with which the amount of correction to the grid can be adjusted. The kinetic energy stored in the rotor of the machine can help stabilise a power system during rapid fluctuations of loads such as those created by short circuits or when electric arc furnaces are starting up.

There was, in 1966, such a solution in place in Templestowe, Victoria, of a synchronous condenser which provided that frequency stabilisation. See: https://wongm.com/2020/05/history-synchronous-condensers-state-electricity-commission-victoria/

Another one was built at Fishermans Bend a few years later, and a third one in 1971 at Brooklyn. Because of poor maintenance and privatisation, they were retired circa 2016.But the basic principle remains, and everything old is new again.

The UK is putting in bulk horizontally oriented synchronous condensers, with very much improved electronics, from Siemens. As you know the UK has invested a lot in onshore and offshore wind turbine generation of electricity. They need grid stability since they are looking towards a renewable energy regime. Not too many coal fired plants in the UK, there are just four left with a total generating capacity of 5.8GW. They will all be gone by 2025, or even 2024.

Though there have been few synchronous condensers in Australia, they have been rarely needed up until now, that has changed with the increase in solar and wind energy, and their requirement for external frequency stabilisation. The recently installed 190 MVAr Kiamal Synchronous Condenser is the largest synchronous condenser in Australia and is currently in operation at the Kiamal solar farm. It is also a Siemens unit, just like the UK ones. See: https://kiamalsolarfarm.com.au/synchronous-condenser/

So, all you have to do with (**necessarily**) very large solar and wind farms is to tack on a humungous Tesla battery, a Siemens horizontal synchronous condenser, appropriate software, and you are in business. No coal plants, no gas plants, no hydro plants are needed. The solar and wind renewables are thus certainly able to stand alone, as in my dream of a clean energy nirvana without coal and gas turbines.

I am well aware that synchronous condensers do not come cheap, we are talking tens of millions of dollars each, but they are going to be essential for the stability of rooftop solar and small solar farms and small groups of wind turbines - they are going to have to be paid for by state or federal infrastructure funds, just as highways and bridges are. Bear in mind the original electricity grid did not pay for itself initially, it was just deemed a public good, and the smallest little uneconomically viable village got electricity. As it should.

But hydro power can not only act as a battery, it can be a very useful addition to the grid by providing frequency stability for little extra cost. My understanding is that there should always be, in this project, inertial rotation providing frequency stability, presumably at 3000 rpm or some multiple, to provide the 50 Hz signal you need.

However there is only one tunnel being proposed, which divides into two at the bottom of the slope above the lower reservoir to go through two turbines.

It would be far better to have two tunnels, with associated turbines and electronics. Multiple tunnels means ease of maintenance downtime for one of them at a time as needed, with the other taking up the slack. Thus when you are producing electricity through the tunnels, you have the requisite inertial stability for grid dropouts. Having just a single tunnel means that the prospect of serious downtime is much greater.

When you are pumping water up from the lower to the upper reservoir, at a time when electricity is cheap, as in the middle of the day, or in the early hours of the morning when coal plants are spinning, but nobody wants the electricity, or when you have finished filling the upper reservoir and are twiddling your thumbs, you can have the other turbine spinning without water (except probably for cooling), providing grid stability. You do this because the operators of the grid pay you to do it. Money for old rope. When swapping over from no generation to generation, at a time when electricity becomes expensive, you keep the idle turbine spinning until the other comes online, then swap the idle turbine over to useful production of electricity. At all times there is provision for grid frequency stability.

One thing that hydro proponents spruik is that batteries only last twenty years. Not true, they typically start to degrade at about that time, though they do not shut off when the time is up, they just become a little less efficient, they go from 100% to 90 % or whatever in a smooth transition. Same for rooftop solar panels, which most of you have on your houses. Nobody uses that fact as a reason not to have rooftop solar panels.

We are on our second iteration of solar roof panels, with a third iteration coming up soon. The second lot have not degraded significantly over a number of years, they still work well, they have far more than paid for themselves, but more is better. And panels and inverters are now a lot cheaper for a much bigger output.

People usually find that the earlier versions have (far) more than paid for themselves, and with each replacement system you ramp up the amount of electricity you are harvesting from the sun, the earlier versions have more than paid for themselves, sure, but so will the new installation, even more so, and within a few short years, after that it is money in the bank. The costs are coming down, and the output is going up, year by year.

Car batteries don't last forever either, you simply replace them as necessary.

But let us look at the economics - the solar panels on your roof, and in this case the huge batteries used for storing electricity from the grid, will have more than (far, far more than, see the lucrative South Australian experience, they are laughing) paid for themselves by the time they are replaced. The batteries should be regarded as something which needs replacement every now and then, a consumable, like car tyres or the batteries in your smoke alarms. In the meantime they have been doing their job.

In the case of Hydro plants, they have consumables too - ok, the tunnels probably don't degrade much, but everything else does - the turbines, the computers, the impeller blades, the valves, the electronics, on and on. What is needed is a realistic assessment of the costs of the hydro plant, set against their benefits.

That said, I think that the pumped hydro plants such as the Oven Mountain version have far more advantages than disadvantages.

Apart from the benefits of employment during the construction phase, and the (much smaller) employment after completion, this project has the very significant advantages of:

i) An upgrade of the road to the plant - maybe it could even become the major road to the coast, replacing the pathetic excuse we have at the moment. I would cheer mightily if that came to pass.

ii) An upgrade of the high voltage line between Armidale and the coast (and the big line being built from circa Liddell, passing just to the west of Armidale to QLD, known as the Queensland - NSW Interconnector). This has to be a good infrastructure development.

iii) A reduction in the (average) cost of electricity. We are rapidly moving to a situation where the cheapest electricity is available between say 10 am and 2 pm AEST (when solar is at its peak (from solar farms and from rooftop solar operating behind the meter).

We can't be far from the situation where night time electricity prices are more than those in the middle of the day. Not by much, I guess, who is going to be switching on the kettle or firing up the oven at two am? But still, when the electricity is provided mostly by solar and wind, night time is not when either of those are at their peak. Solar is zero, of course, but my experience is that the wind usually drops at night also.

The project has a life of fifty years as the forward estimate, and the hole drilled through granite is not going anywhere any time soon. It is an investment in the future, and is pretty much future proof. It will not deteriorate in any significant way one would assume. Obviously there will have to be maintenance on pretty much the rest of the project, with regular refurbishment of the turbines and the electronics and the software, but those goals are easily achievable.

The project will help with frequency stabilisation. The project will be providing a service to the grid that will be rewarded in a monetary fashion by those charged with keeping the electricity grid in good condition. I would assume that this service will be provided in two ways, as alluded to above:

1. When the project is producing electricity, it is automatically providing frequency stabilisation, with an inertial system capable of reacting to grid problems.

2. When it is not providing electricity (because the economics dictate otherwise) the project will be using the cheap electricity (these days, when solar and/or wind are pushing down the cost of electricity on sunny and/or windy days, typically in the middle of the day) to recharge the upper reservoir with water.

3. That allows a smooth transition, transferring from electricity generation to using one or more of the turbines, without water being involved (except maybe for cooling as necessary) to the provision of inertial damping of frequency difficulties, as for example when a coal fired plant goes offline without warning. The advantage is that the turbine is already there, not doing a whole lot, paid for in its role as an electricity generator, and with a fair bit of inertia because of its size and the turbine blades and so on.

All in all, a win-win for the investors and the general public.

Councillor Dorothy Robinson

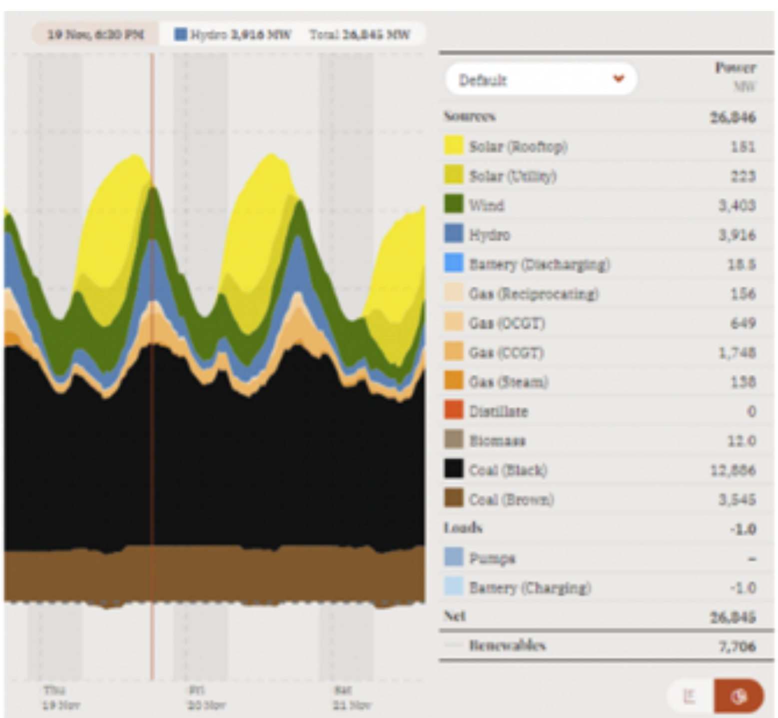
The Oven Mountain Pumped Hydro scheme is one of at least 2 pumped hydro schemes under consideration for short-term electricity storage in New England. The OMPH project is for 7,200 MWh of storage – 600MW of dispatchable generation capacity for up to 12 hours .

The Australian Renewable Energy Agency (ARENA) contributed ~$0.95 million towards a $2.2 million study to analyze the benefits of the OMPH project for a New England Renewable Energy Zone. The cost of a recent 50 MW (64.5 MWh) extension to the Hornsdale battery was $71 million, or $1.1 million per MWh implying that the equivalent in battery storage to the OMPH MWh could cost about $7.2 billion. The difference is that the Hornsdale battery can discharge in 1-2 hours, so is ideally suited for storing daytime surpluses for evening peaks, but the OMPH provides power at a lower rate for up to 12 hours (e.g. overnight, or during times of low wind generation).

Tesla's guaranteed capacity assumes a certain amount of degradation over time. Hydro schemes are likely be operating for many years after the current generation of batteries has reached the end of their useful life. However, the next generation of batteries might be much better and cheaper. The $2.2 million study will hopefully provide the information we need to assess the OMPH's viability, based on costs (including environmental costs) and benefits.

The function of this project is to store electricity that would otherwise be wasted. Even with current solar generation, wholesale electricity prices can go negative, then solar farms often switch off to avoid having to pay someone to use the power – The ability to store power for peak evening periods will reduce the need for expensive, environmentally-damaging fossil fuel power.

This graph from 19-21 November 2020 shows how the evening peak demand was met by increased hydro, gas and coal power.



Additional hydro could replace the need for gas and coal power. Other developments (e.g. using cheap midday power for water heating) could also have a dramatic effect on the need for coal-fired power, and also contribute to lower prices. The New England Renewable Energy Zone could see the installation of 8,000 MW of renewable energy.

The OMPH's 600 MW will cover only a small proportion of storage needs. However, other battery and pumped hydro storage are planned, including the Walcha Energy Project, which is said to include plans for 4 GW of renewable energy generation, with construction planned to start in 2021 and power generation from 2023 –

A new transmission line is planned to transport power from our region to the Hunter Valley, from where it can be sent along existing distribution networks. Legislation to enable NSW's Renewable Energy Zones (REZ) will be considered by the NSW Legislative Council on 24 November 2020. The draft legislation provides for the cost of new transmission infrastructure by auctioning capacity. Initial proposals in September 2020 mention up to 1,400MW (only a small proportion of the generation from an 8,000 MW REZ). However, the drafts also include proposals to produce renewable hydrogen that could use some of the power and perhaps create standby capacity. Prof Andrew Blakers' peer-reviewed analysis reported estimates of the levelised cost of renewable electricity (LCOE) with pumped hydro storage of about AU$93/MWh.

The draft REZ legislation includes proposals to safeguard the traditional owners of the land. Investment in renewables should bring jobs and cheap power to our region. However, the devil is always in the detail, so it would be better to see the $2.2 million feasibility study before answering this question. If ARENA paid almost half the cost, it will hopefully be a public document!

References and further reading:

https://reneweconomy.com.au/nsw-fast-tracks-1b-oven-mountain-pumped-hydro-project-41996/

https://arena.gov.au/blog/oven-mountain-pumped-hydro-planned-for-future-renewable-energy-zone/

https://www.pv-magazine-australia.com/2020/09/03/neoen-completes-hornsdale-big-battery-expansion/

https://arena.gov.au/blog/oven-mountain-pumped-hydro-planned-for-future-renewable-energy-zone/

https://reneweconomy.com.au/this-solar-farm-has-to-switch-off-every-second-day-due-to-negative-prices-63529/

http://www.walchaenergy.com.au/the-project.html

https://reneweconomy.com.au/transgrid-fast-tracks-first-stage-of-huge-new-england-renewable-zone-42760/

https://www.transgrid.com.au/what-we-do/projects/current-projects/New%20England%20Energy%20Zone

https://www.transgrid.com.au/news-views/news/2020/Pages/Strong-interest-in-TransGrid%27s-New-England-renewab infrastructure-development.aspx

https://www.sciencedirect.com/science/article/pii/S0360544217309568