| Energy storage

# Pumped storage: powering a sustainable future

In an exclusive Q&A, **Richard Herweynen**, Technical Director at Entura, delves into the significance of pumped storage in enabling the clean energy transition, its economic advantages, and its promising role in a world increasingly reliant on renewable energy sources

***In your opinion, what makes pumped storage such a crucial component of the hydropower industry?***

Without a massive increase in energy storage, the clean energy transition simply can't happen at the pace and scale that is so critical to limiting global warming. The low levelised cost of wind and solar power and the retirement of fossil-fuelled power generators are driving an urgent need for more storage solutions in increasingly complex energy grids.

Pumped storage hydropower projects are a natural fit in an energy market with high penetration of renewable energy as they help to maximise the use of weather-dependent, intermittent renewables (solar and wind), fill any gaps, and make the integration of renewables into the grid much more manageable. Pumped storage provides a 'load' when the wind is blowing and the sun is shining, and it also provides a reliable and immediate source of dispatchable energy when the available renewable generation can't meet demand. By pumping the water uphill when generation exceeds demand, the pumped storage scheme is essentially 'storing' energy for later use. With the extra storage, stability and consistency provided by pumped hydro, there's less need for coal, gas or diesel generation. Pumped storage hydropower has an advantage over batteries, as they can provide "deeper storage", that is much longer duration storage.

A functioning AC power system needs inertia, fault level, frequency and voltage control as well as energy sources to function to an acceptable standard. Pumped storage assets can provide all of these important contributions to a stable and successful power system, levelling out the fluctuations in availability of wind and solar energy, and helping to regulate voltage and frequency. Pumped storage projects therefore help the grid to retain equilibrium, maintain stability, and quickly remedy disruptions.

***In terms of system flexibility, how does pumped storage enhance the overall efficiency and reliability of hydropower operations?***

The flexibility provided by pumped storage allows hydropower operations to adapt and respond quickly to fast-moving energy market dynamics. Pumped storage hydropower in a hydroelectric system enables better strategic planning and optimisation of electricity generation to maximise revenue and grid support.

Conventional hydro storage is typically used in a seasonal or multi-year cycle to support the power system through uneven rainfall, droughts, and above average rainfall periods. Pumped storage provides more capacity for a hydropower system to store short term energy surpluses from other renewable sources allowing greater capture of this clean energy.

***What are the main advantages of pumped storage compared to other energy storage technologies?***

The rise of renewables will lead to a diversity of storage and supply solutions. With green hydrogen still at a very early stage in Australia, the main players in the storage market are batteries and pumped storage hydropower. Ultimately, there is a place in the market for both, and they may even complement each other in certain circumstances.

The key advantage of pumped storage is its ability to provide storage durations much longer than currently possible with batteries. It's a proven technology with a very long lifespan and low operational costs, and is cost-effective at storing and releasing large amounts of energy. Batteries are more cost-effective at delivering small amounts of stored energy over a short time at high power levels.

Pumped storage has more complex site-selection constraints and takes longer than battery energy storage systems (BESS) to move through planning, design and construction; however, once operational, the pumped storage scheme has a life expectancy many times that of utility-scale batteries. Capex costs therefore aren't immediately comparable but need to be calculated across the estimated lifecycle.

Another advantage of pumped storage hydropower is that its degradation is close to zero. With appropriate maintenance, peak output can be sustained indefinitely. In contrast, batteries degrade as they age, which decreases the amount they can store. To maintain a reliable and steady capacity for storage as batteries age and degrade, large-scale battery plants will require ongoing staged installation and replacement of batteries.

In terms of grid support, pumped storage is based on well-established synchronous generation, providing critical ancillary services to the grid, through the provision of inertia, frequency and voltage support and sufficient fault level support. In contrast, while batteries can provide fast response times, they are yet to demonstrate their ability to provide the full range of ancillary services needed to support the grid. The potential for batteries to provide 'synthetic inertia' or fast frequency response is high but this is balanced by their reliance on system strength to be able to deliver this support. They offer minimal support with fault levels but can still provide some support to system frequency and voltage regulation.

***What are the economic benefits associated with pumped storage projects, both in terms of revenue generation and cost savings for the energy system?***

As our electricity mix evolves, so will the economics of storage. Forecasting revenue for an asset with a lifecycle of up to 100 years requires detailed modelling of a wide range of factors influencing the electricity market. While forecasting revenue for storage projects in the Australian electricity market is still an uncertain business, there are many opportunities in both the existing and emerging markets to guarantee project revenues to a level sufficient to satisfy a lender's requirements.

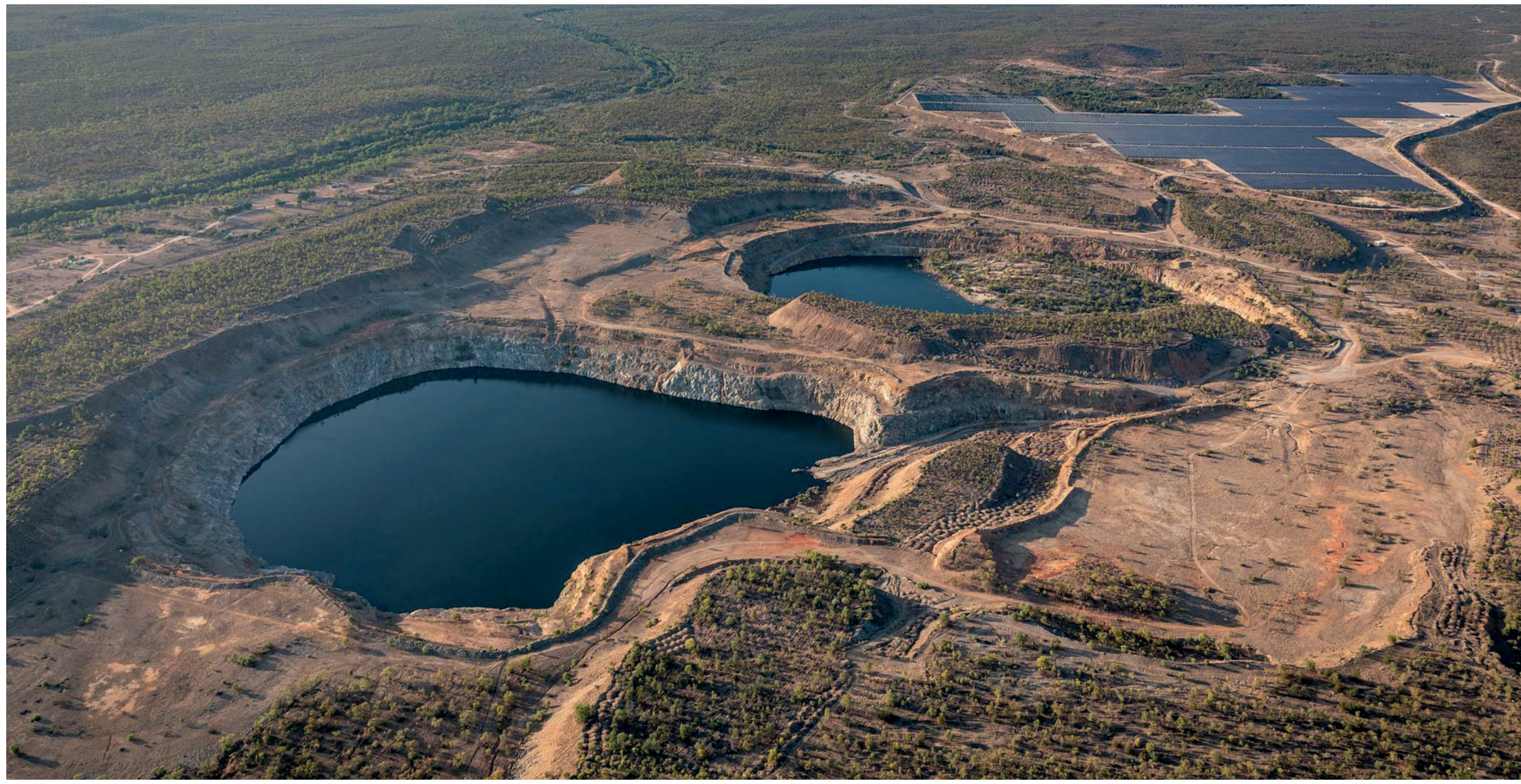
The traditional revenue source for pumped storage is arbitrage – in other words, making the most of generating when the spot price is high, and pumping when the spot price is low. But this relies on a certain level of predictable variability in the electricity market, and for that variability to continue into the future. Retirement of coal-fired power stations and continued investment in renewables are likely to cement a market in which variability in power generation and volatile energy prices are the norm.

Services such as frequency control, inertia and fault level control have increasing value in a grid with significant amounts of non-synchronous generation. At this stage, the markets for these network support services are very shallow and competition is increasing. However, the need for such services is likely to increase to the point where more significant markets are required and can provide an extra revenue stream for pumped hydro projects.

***From a technical standpoint, what are the key considerations and challenges involved in planning, designing, and operating pumped storage facilities?***

Pumped storage projects require significant capital for development. Key to the successful development of a project are identifying a good site. Choosing the right location is a matter of identifying a site with ideal topography and geology (for two reservoirs separated by a significant change in elevation), an adequate source of water, minimal social and environmental impacts, and good proximity to and location within the transmission network to maximise efficiency of the power's round trip and minimise losses. With many thousands of potential sites, a developer needs smart methods of filtering to reduce the many possibilities to just a few ideal sites.

One of the greatest potential complications and causes of delay in a pumped storage hydropower project is an unwelcome surprise, whether this is an unknown geological condition, or an unacceptable environmental impact. As a result, it is critical to understand the project risks, and to use the early stages of the project to appropriately investigate the project, thus mitigating these risks and reducing the unknowns. These initial investigation costs are an investment worth taking.



Above: **Entura completed a feasibility study for Genex Power's Kidston Pumped Storage Hydro Project in North Queensland in 2015-16. The project is now in construction and Entura is serving as Owner's Engineer**

***Looking ahead, what role do you envision for pumped storage in the future energy landscape, particularly in the context of increasing renewable energy penetration and decarbonization goals?***

Worldwide, increased levels of renewable energy will lead to a greener grid. With the massive expansion of wind and solar farms and the movement away from fossil fuels, the future is bright for pumped storage hydro and for storage. There will continue to be a need for long-duration storage (8+ hours), which batteries cannot currently provide. However, no energy solution can exist outside of the real and competitive pressures of the market. Technical viability and environmental benefits won't be enough to get projects over the line if they can't demonstrate financial soundness.

In Australia, despite the significant potential and benefits of pumped storage hydro projects, only three projects are currently operational (two in New South Wales and one in Queensland) and two are under construction – the Kidston project in Far North Queensland and Snowy 2.0. A number of other sites have been identified for new opportunities for pumped storage hydro, but so far very few have been developed beyond concept level. State and federal governments are looking at mechanisms to support the development of more large-scale storage projects – whether they be pumped storage or long-duration utility-scale batteries – to meet the significant storage requirements estimated necessary by the Australian Energy Market Operator as coal generation retires from the market over coming decades.

***Can you provide examples or case studies that highlight the specific benefits of pumped storage projects in supporting renewable energy integration?***

Entura completed a feasibility study for Genex Power's Kidston Pumped Storage Hydro Project in North Queensland in 2015-16. The project is now in construction and Entura is serving as Owner's Engineer. The project is highly significant because this will be the first pumped storage hydro project constructed in Australia in decades. It will complement the company's adjacent solar and wind projects, forming part of Genex's Renewable Energy Hub.

The project is located on the abandoned former site of the historic Kidston Gold Mine, which features two large open pit mines, which are utilised as the reservoirs for the project. Following detailed market studies undertaken by Genex and its financial consultants to assess the pricing and revenue impacts of the various options considered, it was determined that a 250MW scheme with 8 hours of continuous generation, totalling a nominal 2,000 MWh of energy storage capacity, would be the optimal size.

Entura is part of Hydro Tasmania, which has operated an extensive hydropower system in the Australian state of Tasmania for over 100 years. As part of an assessment of the potential for Tasmania to make a greater contribution to Australia's National Electricity Market, a concept study was completed on Tasmania's pumped storage hydro potential.

Pre-feasibility studies, jointly funded with the Australian Renewable Energy Agency (ARENA), were completed on 14 potential pumped storage projects identified during the concept stage. The objective of the pre-feasibility studies was to identify viable projects that would be suitable to progress to feasibility assessment, in the context of future Australian grid projections, timing of new interconnection development, and existing assets and water resources.

Detailed feasibility studies were undertaken on 3 of the best pumped storage hydro projects based on a multi-criteria assessment. From this process, the Cethana PHES project was selected as Hydro Tasmania's preferred site as part of their Battery of the Nation (BotN) works. ●

Below: **Cethana lake in Tasmania, Australia. The Cethana PHES project was selected as Hydro Tasmania's preferred site as part of their Battery of the Nation (BotN) works**