Photo courtesy of CleanCo

Pumped hydro in our energy system

Our changing market

Renewable energy now accounts for over 20% of Queensland's electricity generation and the deployment of new projects over the past five years has significantly changed the way our electricity system operates.

Under our current system design, demand for electricity is matched to output from our fleet of coal-fired generators, with gas providing additional supply during peak demand periods.

With more Queenslanders deploying rooftop solar, demand for electricity during the day is now much lower than in the past. At the same time, the output of new large-scale wind and solar generation is highly variable and increasingly difficult to match with demand.

As the amount of renewable generation capacity in our system increases, attention is now focused on how a grid designed around predictable demand and supply patterns can absorb the variable output of technologies like wind and solar.

Figure: How pumped hydro can support the system

Grid stability

Pumped hydro can provide instantaneous generation to balance supply and demand, maintain grid frequency, and prevent surges and blackouts.

Supply security

Pumped hydro stores energy as back-up for periods of low generation from renewables, or sudden outages from thermal generation sources.

Network support

Pumped hydro can provide a range of services to the network including voltage support and relieving network constraints.

Pumped hydro — giant water batteries

Pumped hydro systems use reservoirs to store bulk energy over several days, weeks, or even seasonally. To pump water from the lower to upper reservoir, the system draws electricity from the grid, or from a dedicated renewable energy source such as a nearby wind or a solar project.

The ability to store energy in the upper reservoir of the system is why pumped hydro is often likened to a giant battery. Electricity can be generated almost immediately by releasing water back into the lower reservoir, giving pumped hydro fast and efficient ramping capabilities.

The battery-like qualities of pumped hydro make it an ideal technology to absorb the surplus electricity generated by wind and solar — pumping water between lower and upper reservoirs during the day, and discharging during peak demand periods.

Our future system

Coal and gas generation have played an important role in the development of economic and reliable electricity systems across the world, including Queensland by providing stable baseload and dispatchable generation during periods of high demand.

Renewable generation can supply sufficient energy to meet Queensland's future electricity needs but requires firm generation to support its intermittent and variable output. This type of support is currently supplied by coal and gas. As the system moves to net zero emissions by 2050, a replacement will be needed to supply these services.

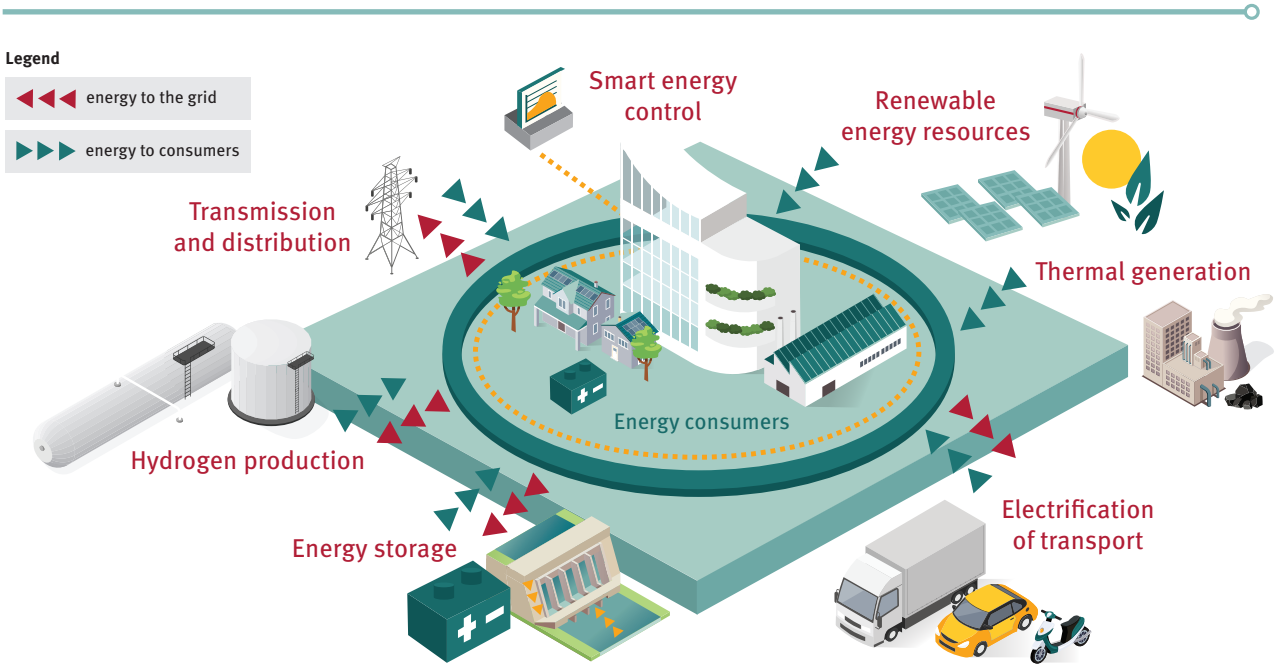
Technologies like battery storage are expected to play an important role in meeting the needs of Queensland's future electricity system. However, only large-scale pumped hydro energy storage (PHES) schemes are currently capable of economically supplying the volumes of storage required to ensure the reliable supply of electricity at very high penetrations of variable renewable generation.

For example, it has been estimated that Queensland would require storage capacity equivalent to an entire day of electricity supply once the level of renewable output exceeds 90% of total generation. At current levels of demand this would require over 700 batteries of the size of the Hornsdale Power Reserve, currently the largest battery in Australia.

To ensure the continuing reliable supply of electricity, this storage capacity must become available as Queensland's coal fleet gradually retires over the coming decades.

Due to the long development lead times for major PHES projects, the Queensland Government will continually assess the future system to ensure that sufficient PHES capacity is deployed to ensure the continued economic and reliable delivery of electricity to consumers.

Figure: Queensland's future energy system



Hydroelectricity

When water flows downwards, its stored energy can be converted to electricity by directing the flow of water through an electricity generator known as a turbine. This type of electricity generation is known as hydroelectricity.

Hydroelectric generation that uses the power of water flowing through a river system is known as 'run-of-river' hydro. This type of technology is typically able to be operated 24 hours a day, but the amount of water available for generation is limited to the size of the river and can be vulnerable to seasonal changes in precipitation.

To increase the amount of water available for generation, storage dams are often constructed across a river, flooding a large area to provide more water, with stronger gravitational force. This technology is known as 'reservoir storage' hydro and is multi-purpose in that the dams are also used for flood mitigation, drought relief, irrigation, water supply and recreation.

Pumped hydro

Pumped hydro energy storage is a closed water system that moves between two large reservoirs constructed at different heights.

A tried and tested technology, pumped hydro accounted for 97% of energy storage worldwide in 2020[1].

To operate, a pumped hydro generator uses electricity from the grid or nearby renewables to pump water from the lower reservoir into the upper reservoir. To generate electricity, water is then released back into the lower reservoir through a turbine.

The amount of energy a pumped hydro generator can store is the product of the mass of water in the upper reservoir, and the height between reservoirs (referred to as "head").

Roughly speaking, 1 Gigawatt hour (GWh) of energy storage, requires 1 Gigalitre (GL) of stored water for 400 m of head.

[1] Australian National University (2020)

Figure: How pumped hydro works