Djibouti city pumped hydro storage

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As we move rapidly towards ever-greater levels of wind and solar power in the network, increasing quantities of storage are needed to smooth intermittency and ensure secure supply. Pumped hydro energy storage and batteries are likely to do much of the heavy lifting in storing renewable energy and dispatching it when power demand exceeds availability or when the price is right.

We"ve previously compared the two technologies in terms of their costs, the speed with which they can be deployed, and their ability to support the grid. Here we compare their sustainability in terms of storage efficiency and capacity, safety, use of scarce resources, and impacts through all stages of their lifecycle.

For both batteries and pumped hydro, some electricity is lost when charging and discharging the stored energy. The round-trip efficiency of both technologies is usually around 75% to 80%. This level of efficiency for either technology represents a significant displacement of non-renewable generation if we assume that the stored generation would not otherwise occur.

A particular consideration for batteries is degradation. Batteries degrade as they age, which decreases the amount they can store. The expected life of the batteries that will be used for the recently announced battery storage project in South Australia is about 15 years (depending on how the batteries are operated). By the end of that time, the capacity of the batteries is expected to have dropped to less than 70% of their original capacity.

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 comparison, the degradation of pumped storage is close to zero. With appropriate maintenance, peak output can be sustained indefinitely.

No storage solution can be considered sustainable unless it is safe. The greatest risk relating to pumped storage is dam safety. If it occurs, dam failure can affect downstream communities and the environment, with its impact potential likely to be far greater than a battery safety incident. Nevertheless, pumped hydro technology is mature, dam risks are generally well understood and managed, and the frequency of dam safety events is low.

The main safety concern for batteries is thermal runaway leading to explosions and fires. The severity of this risk will depend on how a battery project is implemented. In a modular arrangement, thermal runaway would be localised, not affecting the whole bank. However, because of the very rapid deployment of evolving battery technologies, safety standards may not be rigorously enforced.

Pumped hydro and grid-scale battery plants may have environmental and land-use impacts. These impacts would vary depending on the sensitivity of the site selected.

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A grid-scale battery facility needs a relatively small parcel of land and is likely to be able to be created very close to the energy demand or where generation occurs. Land in these areas has often already been disturbed and the new operations may have little extra environmental impact. Land and water impacts of batteries relate more to their disposal at the end of their effective life, and to the extraction of the resources to produce new batteries.

Pumped hydro requires a relatively larger parcel of land with a very particular topography, and may be far from the location of the demand. Any potential environmental impacts associated with construction and operation need to be considered and mitigated, including those immediately associated with the site, as well as downstream.

In most construction of new pumped hydro, sites are selected where impacts can be mitigated to acceptable levels, for example by using existing reservoirs, or locating "closed loop" systems away from rivers. Although these arrangements will have lower overall impacts, some environmental challenges may still occur during construction when existing water is removed from the site as well as finding a source of water without impacting the environment and other users.

Environmental impacts during operation of pumped hydro are minimal. However, the ecology within the reservoirs will need to adapt to frequently changing water levels, reducing diversity in the system especially within fringing communities.