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THE AUSTRALIAN WATER PARTNERSHIP

POLICY BRIEF

Pumped Storage Hydropower for the Mekong Region

Australia – water partners for development

100% renewable grids and the rationale for pumped storage hydropower

Low carbon electricity grids will rely heavily on variable renewable energy (VRE) sources such as wind and solar, as they are the world's cheapest sources of electricity after conventional hydropower (IRENA 2021).

As VRE sources grow as a proportion of the electricity generation mix, there is a concurrent growth in the need for electrical energy storage (EES) (Figure 1), even when innovative power system services are incorporated into planning.

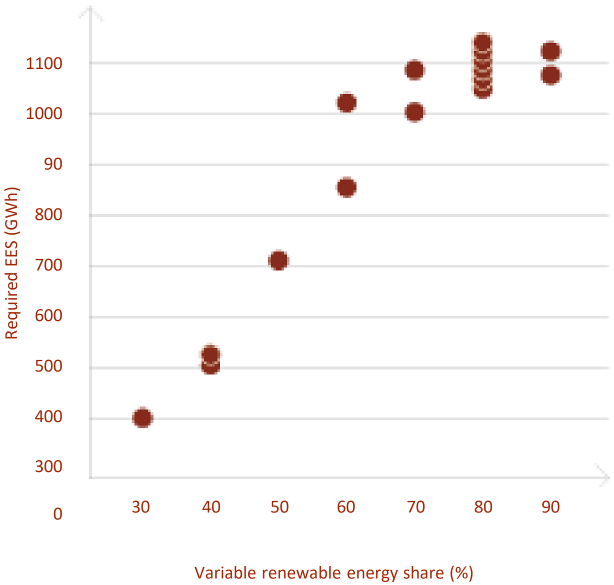


Figure 1
This model shows the relationship between growth in variable renewable energy sources and requirements for electrical energy storage, using data from the United States.
Source: Adapted from Cebulla et al. (2018)

Pumped storage hydropower

Pumped storage hydropower is the most mature and well-proven of six EES technologies suitable for use on a grid-scale.

Compressed air energy storage (CAES)

Two demonstration plants have been built (1978 and 1991), and a third is under development. CAES is cheaper than PSH when salt caverns provide storage, but requires natural gas or other fuel to be burnt to release the stored electricity.

Flow batteries

Flow batteries such as vanadium flow redox batteries (VRFB) are capable of supplying up to around 40MW of power for several hours.

Sodium sulphur batteries

Sodium sulphur batteries have similar characteristics to VRFB and operate at around 300°C.

Lithium-ion batteries

Lithium-ion batteries are currently capable of supplying 100MW of power for several hours, expensive and CO_2 intensive.

Hydrogen energy storage systems (HESS)

Hydrogen is very energy dense, but HESS round-trip efficiencies are only around 32%, and storage of hydrogen is still being researched.

Pumped storage hydropower is the, **most attractive large-scale storage technology** with the following advantages:

- It is the most mature, technically proven EES technology
- It has low CO_2 equivalent emissions compared to other EES technologies such as Li-ion batteries
- It has the highest energy storage per dollar invested after CAES using salt caverns for storage
- It can be co-located with variable renewable energy generators (eg. floating solar panels)
- It can be designed to have minimal (or even positive) environmental impacts
- Large number of charge-discharge cycles compared to other EES technologies
- System construction costs are largely spent locally

What is pumped storage hydropower?

Pumped Storage Hydropower (PSH) works by pumping water from a lower reservoir to an upper reservoir when there is an excess supply of electricity, and releasing the water from the upper reservoir through a hydropower turbine when there is demand for electricity (Figure 2).

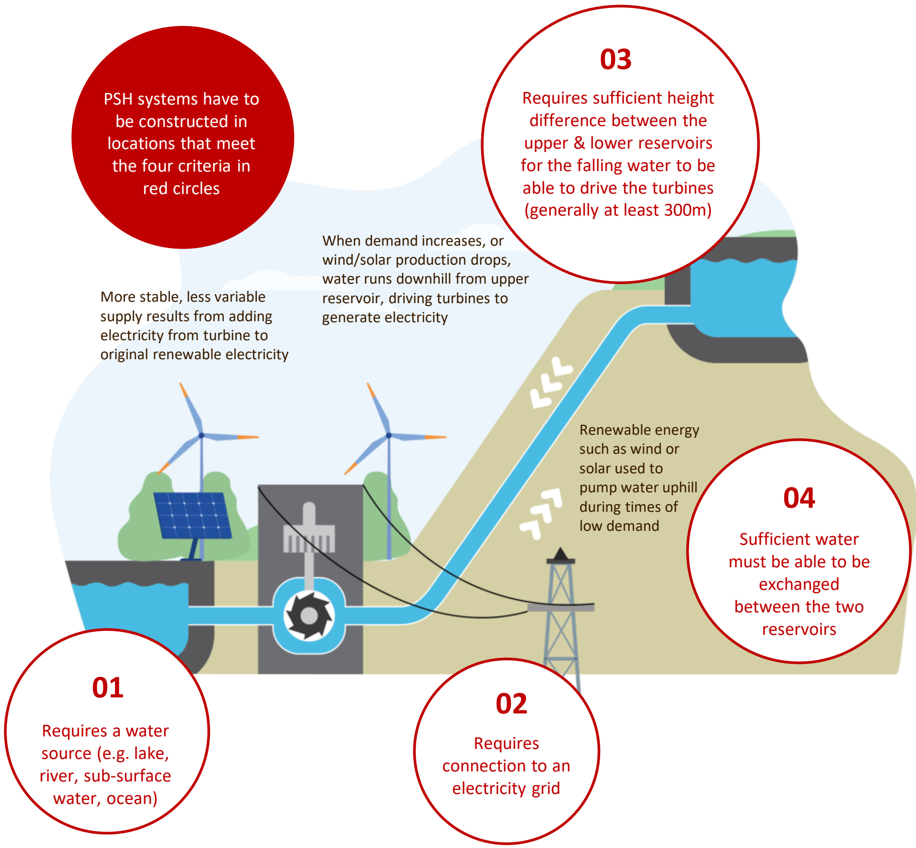


Figure 2
Schematic of a typical PSH configuration (Source: Adapted from ARENA (2021)

Pumped storage hydropower and sustainability

PSH systems fit into two broad categories:

Open-loop where the system is connected to a naturally flowing waterway (e.g. to a river, lake, or the ocean). Open-loop systems tend to have higher social and environmental impacts

Closed-loop where both reservoirs are stand-alone reservoirs so that day-to-day operations do not affect naturally flowing waterways

Within these categories, PSH systems can be developed on greenfields sites (where there has been no previous development), or on brownfields sites (such as decommissioned mines).

Individual PSH sites will need to be assessed separately, however the environmental and social impacts of a PSH system range on a spectrum from very high (negative) through to positively impacting on socio-economics and the environment.

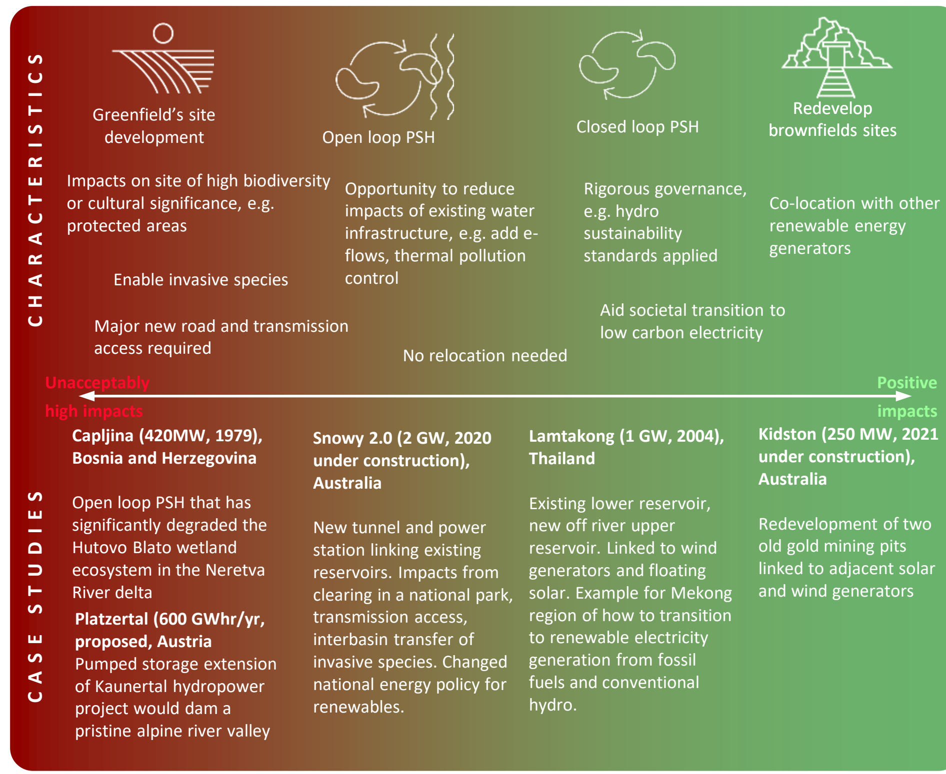


Figure 3 Spectrum of social and environmental impacts from PSH projects

Status and potential for pumped storage hydropower in the Mekong region

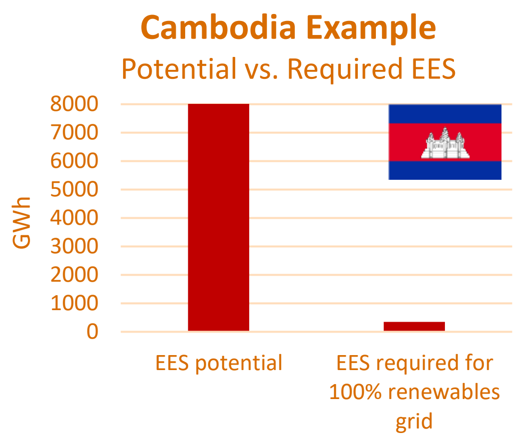
Country	Most recent renewable energy generation data		Renewable energy target	Energy storage existence (yes/no)	Energy storage planned (yes/no)	Grid reliability issues (yes/no)	Cross-border electricity transmission grids (yes/no/planned).	Existing PSH capacity (GW)	Planned PSH (yes/no)	Potential PSH (No. of sites)*	Potential PSH (GWh)*
	Total	%									
Cambodia	155MW (2019)	~9% of capacity	415MW by 2022	No	Yes	Yes	Yes – Lao PDR, Thailand, Viet Nam	-	No evidence	190	8,005
Lao PDR	41MW (2016)	0.656% of capacity	951MW by 2025	No	No	Yes	Yes – Cambodia, Myanmar, People's Republic of China, Thailand, Viet Nam	-	No evidence	5,605	188,156
Myanmar	173MW (2019)	3% of capacity	12% by 2025	No	Yes	Yes	Yes – Lao PDR and possibly Thailand	-	No evidence	13,163	435,176
People's Republic of China	415GW (2019)	21% of capacity	35% of generation by 2030	Yes	Yes	Possible	Yes – Hong Kong SAR, Myanmar, Lao PDR, Vietnam, and Russia Planned – ROK	30	yes	115,871	3,766,868
Thailand	21,402GWh (2019)	10.1% of generation	20.77GW by 2037 (26.9%)	Yes	Yes	None evident	Yes – Lao PDR, Cambodia, Myanmar, Malaysia	1	yes	2,120	62,590
Viet Nam	No data	No data	12.5% by 2025 21% by 2030	No	Yes	Yes	Yes – Lao PDR	-	yes	6,233	202,518

Table 1 Renewable Energy and PSH status and potential in the Mekong region

Note: Potential PSH data from (RE100 Group 2021), other data from (Gilfillan & Pittock, forthcoming)

The table above shows the range of experiences with EES, including PSH, in the Mekong region. Two of the six countries have existing storage that in both cases includes PSH, and five of the six countries are planning EES. Three of these five are planning PSH installations. All six countries have high levels of potential PSH.

In an advanced economy, per million people, 20GWh of EES is enough to support a 100% renewable grid (RE100 Group 2021)



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Benefits and advantages of pumped storage hydropower in the Mekong region

High growth in historical and projected electricity generation

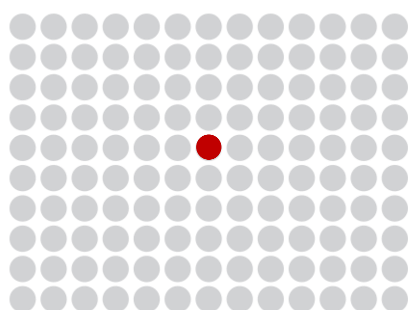
High growth in renewables installations, particularly in China, Thailand and more recently Viet Nam

High number of potential sites and high potential storage: Over 4,600,000GWh of potential storage, compared to 34,000 GWh required for a population of around 1.7 billion people

The Mekong region has

130 x

The storage potential required for 100% renewables-based grid



PSH Storage potential

Required EES capacity for 100% renewable grids in the Mekong region

With such high potential storage, ecologically sensitive sites and sites of high cultural value (e.g. where ethnic minority group livelihoods depend on the ecosystem services and natural resources of an area, or culturally significant sites) can be easily avoided when planning and developing PSH.

Conclusions and next steps

As VRE grows as a proportion of installed electrical energy generating capacity, there will be growing need for electrical energy storage. PSH is the most attractive large-scale storage option for the Mekong region because of its maturity, low cost, low carbon credentials, and because of the large number of potential sites identified. With sound planning and management, PSH can be designed to have minimal (or positive) environmental and social impacts.

There are four recommended next steps for supporting renewables growth in the Mekong region through the development of PSH.

1. Mapping out and scoping PSH potential on-the-ground, at a country level
2. Assessing the potential of using PSH in projects to inter-connect the regional electricity grid
3. Identifying and summarizing information availability (and information gaps) on renewable energy potential and electricity market operations (to inform energy storage investments)
4. Preparing a summary of electricity market settings that encourage investments in energy storage, drawing on international best practice economies

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