Technology: Pumped Storage

Definition and Description

Pumped storage, also referred to as pumped hydroelectric energy storage (PHES), is a method of storing potential energy in the form of water stored at a high elevation. Water is pumped from a reservoir at a lower elevation to a reservoir at a higher elevation during low-cost off-peak periods and released from the higher elevation reservoir through turbines to produce electricity during periods of high cost peak demand allowing the utility company to balance its load demand.

Pumped storage can also increase the efficiency of intermittent sources of energy like solar and wind by providing the generator with the option of storing surplus energy from these renewable energy sources. Although the reservoirs used for pumped storage are relatively small when compared to hydroelectric dams and typically have the capacity to generate electricity for less than 12 hours, pumped storage, according to the US Department of Energy, accounts for 96% (168 GW) of all energy storage capacity globally[23]. A pumped storage unit is a net user of electricity (friction losses etc) however efficiencies can be as high as 80%[24].

In 2017, a research project entitled "Storing Energy at Sea" (StEnSea) successfully tested a pumped storage underwater reservoir. It is envisaged that in the future, hollow spheres approximately 30 metres in diameter will be anchored at depths of around 700 metres offshore (to create the lower reservoir). Each storage unit would produce ~ 20 MWh (4 hours of discharge time through a 5 MW turbine)[25]. These underwater reservoirs could be linked with offshore windfarms.

Potential in Grenada

There is currently no pumped storage in Grenada and commercially there is no off-peak differential in electricity prices. However, there is potential for the privately-owned electric utility in Grenada (GRENLEC) to enter into an agreement with the state-owned water authority (NAWASA) to deploy this technology. Pumped storage hydropower can balance loads, provide stability, and network frequency control (turbine generators can respond quickly to frequency deviations). Pumped storage could be used to balance the load and allow a large geothermal plant (Grenada is actively pursuing geothermal energy) to reach its peak efficiency.

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[23] http://www.energystorageexchange.org/

[24] http://energystorage.org/energy-storage/technologies/pumped-hydroelectric-storage

[25] http://forschung-energiespeicher.info/en/projektschau/gesamtliste/projekt-einzelansicht/95/Kugelpumpspeicher_unter_Wasser/

The topography of Grenada in particular, the presence of natural reservoirs in the firm of crater lakes e.g. Grand Etang – (elevation of ~ 550 metres) and Lake Antoine (elevation ~ 8 metres) would appear to imply that pumped storage may be a feasible technology to deploy. It is noted that Grenada is actively pursuing solar, wind (Intermittent) and geothermal (constant base load) generation technologies, all of which can be made more efficient if associated with pumped storage.

If underwater reservoirs prove to be commercially feasible, all small island states with easily accessible deep water (~700 metres) offshore would have significant potential to deploy this technology.

Mitigation to Climate

To estimate the mitigation potential in Grenada, data from the USA has been reviewed. A report on pumped storage from the DOE (2015)[26] indicated that a mix of fixed speed and variable speed pumped storage units could reduce the curtailment of solar and wind power plants by up to 22%, resulting in a 2% reduction in GHG emissions. In the USA pumped storage can store about 2% of the electrical energy used, whereas in Japan pumped storage represents 10% of capacity. 5-10% of capacity in Grenada would equate to 1.5 – 3 MW of storage potential.

According to Grenada's NDC, total GHG emissions in 2010 were ~ 250,000 tonnes of CO_2 and electricity generation made up 48% of all emissions. Assuming that pumped storage resulted in a net 2% reduction in GHG emissions from the electricity sector, the mitigation potential of pumped storage would equate to ~ 2,400 tonnes of CO_2/year

Advantages

- High efficiency energy storage potential
- Provides ancillary grid benefits
- Low lifecycle costs with a long service life of up to 75 years
- Allows for a higher penetration rate of intermittent generation technologies

Disadvantages

- Open loop systems that use natural reservoirs may have environmental impacts
- Moderate to high upfront capital costs with significant economy of scale penalties
- May require an off-peak price differential

[26] DOE, 2015. Pumped Storage and Potential Hydropower from Conduits. Report to Congress February 2015.

Costs and other financial requirements

Pumped storage is currently the most cost effective means of storing energy, even taking into account evaporation losses, 70 – 80% economic efficiency is achievable. However, small facilities will experience economy of scale penalties. Large-scale (> 1,000 MW) pumped storage units have had capital costs ranging from USD300 – 2,000/kW. The cost of storing a kilowatt-hour in batteries is about $400, it has been estimated that pumped storage could be as low as $100/kWh, depending on utilisation rates.

Status of the Technology in Grenada

A study in 1981 indicated that Grenada had about 7 MW of potential hydropower. In 1991, a further study confirmed the feasibility of small hydropower plants at (Birchgrove – 720 kW & Belvidere – 380 kW). None of these projects have been pursued (UNIDO 2013)[27]. There is currently no pumped storage technology deployed in Grenada.

[27] UNIDO 2013. World Small Hydropower Development Report 2013.