Nauru pumped hydro storage

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Our estimates show that the global technical and economic potential for water and energy storage with SPHS is vast, but with an unequal spatial distribution across the world. Considering all the energy storage projects with the cascade, the total storage capacity is equivalent to 17,325 TWh, or ~79% of the world electricity consumption in 2017. Whilst we have considered a maximum of one SPHS per 1-degree grid square (100 x 100 km), in some locations a series of SPHS plants in cascade could further increase the energy storage potential.

a Water storage costs and capacity curve in km3. b Energy storage without considering hydropower plants in cascade costs and capacity curve in US$ MWh-1. c Energy storage considering hydropower plants in cascade costs and capacity curve in US$ MWh-1. d Additional generation capacity costs and capacity curve in US$ kW-1. e Percentage of the reservoir that is filled with the river inflow into the SPHS reservoir. f Average land requirement for energy storage in different basins.

The cost of 1 GW PHS capacity varies from 370 to 600 US$ kW-1 (Fig. 2d). This excludes dam and land costs. The costs are segmented in different steps due to the variation in length of the tunnel, which starts at 3 km with additional increments of 3 km. A cost comparison of other short-term energy storage technologies can be found in ref. 28.

The percentage of inflow from the tributary river to fill up the reservoir varies for each project (Fig. 2e). The remaining percentage consists of the water that is pumped into the SPHS reservoir from the river below. Three of the proposed projects, over more than 1000 projects, have 100% of the inflow coming from the tributary river. In these cases, a reversible turbine would be interesting only to allow the project to store energy in daily and weekly cycles, given that the seasonal cycle is already accomplished with the river flow.

Given that this is the first global assessment for SPHS, the model was developed with the intent of focusing on its technical potential. Other restrictions that impact socio-economic feasibility, such as population, land use, biodiversity, transmission, etc. were not included in this work with the intent of presenting the existing potential and not its viability. Regional studies such as, Rogeau et al. 21 already tried to eliminate irrelevant sites due to conflicts with existing land use.

With the needs for reducing CO2 emissions to mitigate the impacts of climate change, SPHS provides short-term and long-term energy storage services allowing the development of 100% renewable energy grids.

SPHS also increases water security in regions with unsuitable topography for conventional dams, high evaporation, and sedimentation rates. It is, thus, a prominent alternative for sustainable development on a worldwide scale.

a Topographical data input from the Shuttle Radar Topography Mission (SRTM)30. b River network Strahler data input from the Global River Network (GRIN)31. c Finding rivers close to the SPHS site. d Looking for possible dams. e Limiting the number of proposed SPHS projects. f Creating and finding reservoirs. g Hydrological data input32. h Representation of a possible SPHS project in the Zambezi river basin. i Cheapest SPHS projects in 1-degree resolution. j Location with several SPHS projects proposed.

The seasonal and interannual variability of river discharge used in the Hydrological Analysis Stage is calculated with the Eqs. (1) and (2). They are important to calculate the water available for storage in the SPHS reservoir, with the objective of producing a constant river flow. If the river has no seasonal variation, then the water available for storage would be equal to zero. This is because, if the SPHS deregulates the flow of the river, the hydropower potential of the dams in cascade or the water supply downstream could be negatively affected.

Using the values calculated for SV and IV (Supplementary Fig. 2) and the percentage of river annual discharge available for storage (Supplementary Fig. 1), the water available for storage QA (Eq. (3)) is calculated by

The variation of the water and long-term energy storage costs with the water available for storage is presented in Eq. (4). The costs for additional short-term energy storage are presented in Eq. (5). For more details on Eqs. (1)-(5) please refer to the Supplementary Table 2.