



Pumped hydropower storage in open-pit mines can provide substantial contributions to the EU energy transition – a case study for Germany

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Decommissioning of lignite mines in the course of phasing-out electric power generation from fossil fuels in the European Union (EU) is one of the strategic key pillars to reduce net greenhouse gas emissions by 55% compared to the 1990 levels until 2030, and achieving climate-neutrality by 2050. Germany's emission reduction targets are even more ambitious with 65% and 88% scheduled for 2030 and 2040, respectively.

Repurposing phasing-out open-pit lignite mines into Hybrid Pumped Hydropower Storage (HPHS) installations for excess energy from the electric grid and renewable sources contributes not only to the EU Green Deal and EU energy supply security, but additionally increases the regional economic value and stabilises the job market. Pumped hydropower is well established for storing excess energy from the electric grid and for load balancing with a total installed capacity of 7.89 GW in Germany and a current total share of 78.6% in the energy storage sector. Total round-trip efficiencies of up to 85% and extraordinary high storage capacities compared to battery-based solutions can be realised. Another advantage of implementing the technology in former open-pit mines is that costs of constructing the two required storage reservoirs are significantly reduced due to the presence of the open-pit hole. Multiple open-pit lignite mines were closed in Germany in the past decades, and nine are expected to cease operation by 2038.

Several studies assessing the potentials for PHS based on existing reservoirs have been undertaken, but these do not yet consider the additional potentials of open-pit mines. The aim of the present study was to investigate the potential theoretical and technical power production and storage capacities becoming available by repurposing open-pit mines into HPHS installations. For that purpose, a database of German open-pit lignite mines was established. An analytical model was employed to determine the power production and storage capacities of 34 German open-pit lignite mines, of which 13 meet the previously defined site selection criteria. The results of the present study show that the currently installed energy storage potentials in Germany can be extended by additional 1.42 GW (increase by >18%), increasing the installed PHS capacity by 22.9% at the same time. These findings are essential to guide policy and decision makers involved in the German and EU energy transition. The methodology will be extended to member states of the

European Union in the next step.

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