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Effects of Scandinavian hydro power on storage needs in a fully renewable European power system for various transmission capacity scenarios

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The penetration of renewable energies in the European power system has increased in the last decades (23.5% share of renewables in the gross electricity consumption of the EU-28 in 2012) and is expected to increase further up to very high shares close to 100%. Planning and organizing this European energy transition towards sustainable power sources will be one of the major challenges of the 21st century.
It is very likely that in a fully renewable European power system wind and photovoltaics (pv) will contribute the largest shares to the generation mix followed by hydro power.
However, feed-in from wind and pv is due to the weather dependant nature of their resources fluctuating and non-controllable. To match generation and consumption several solutions and their combinations were proposed like very high backup-capacities of conventional power generation (e.g. fossile or nuclear), storages or the extension of the transmission grid.
Apart from those options hydro power can be used to counterbalance fluctuating wind and pv generation to some extent.
In this work we investigate the effects of hydro power from Norway and Sweden on residual storage needs in Europe depending on the overlaying grid scenario.

High temporally and spatially resolved weather data with a spatial resolution of 7 x 7 km and a temporal resolution of 1 hour was used to model the feed-in from wind and pv for 34 investigated European countries for the years 2003-2012.
Inflow into hydro storages and generation by run-of-river power plants were computed from ERA-Interim reanalysis runoff data at a spatial resolution of 0.75° x 0.75° and a daily temporal resolution.
Power flows in a simplified transmission grid connecting the 34 European countries were modelled minimizing dissipation using a DC-flow approximation.

Previous work has shown that hydro power, namely in Norway and Sweden, can reduce storage needs in a renewable European power system by a large extent. A 15% share of hydro power in Europe can reduce storage needs by up to 50% with respect to stored energy.
This requires however large transmission capacities between the major hydro power producers in Scandinavia and the largest consumers of electrical energy in Western Europe.
We show how Scandinavian hydro power can reduce storage needs in dependency of the transmission grid for two fully renewable scenarios:
The first one has its wind and pv generation capacities distributed according to an empirically derived approach.
The second scenario has an optimal spatial distribution to minimize storage needs distribution of wind and pv generation capacities across Europe.
We show that in both cases hydro power together with a well developed transmission grid has the potential to contribute a large share to the solution of the generation-consumption mismatch problem.

The work is part of the RESTORE 2050
project (BMBF) that investigates the requirements for cross-country grid extensions, usage of storage technologies and capacities and the development of new balancing technologies.