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The Smoothing Effect in an Afro-Eurasian Renewable Power Grid

Maria Krutova (1,2,3), Alexander Kies (1,2), Bruno Schyska (1,2), and Lüder von Bremen (1)

(1) ForWind - Center for Wind Energy Research, University of Oldenburg, Germany (alexander.kies@uni-oldenburg.de), (2) Institute of Physics, University of Oldenburg, Germany, (3) Department of Wind Energy, Technical University of Denmark, Denmark

A vision of a global renewable electricity grid was described in [1] and [2]. Such a power grid might consist of renewable power generation around the Earth, connected to the major centers of consumption by long distance high voltage transmission links. Most renewable generation facilities like wind turbines or solar modules have highly fluctuating feed-in profiles. This makes their system integration a challenging task. Contributions to the solution of this problem might be an optimal mix of wind/PV [3] or transmission grid extensions to profit from the smoothing effect of fluctuating renewables. In the final consequence, the ultimative extension of the grid leads to the aforementioned global grid, which has recently drawn further attention: The Chinese President Xi Jinping proposed discussions on a "global energy internet" in a keynote speech at the UN Sustainable Development Summit in September 2015 [5] and the concept of this was also discussed in more detail by the State Grid Corporation of China [6].
In this work, backup and transmission needs of a highly renewable power system covering Europe, Africa and Asia are computed. This system is assumed to consist of major load centers (estimated by an economic outlook for 2050 [4]), connected to renewable generation harvesters by high voltage long distance transmission links. Ten years of generation are modelled from global reanalysis data (MERRA) for the renewable sources wind and photovoltaics (PV). For Europe, this data is described in detail in [3]. First, for each aggregated region in the system, the optimal mix of wind and PV generation is determined. Together with empirically modelled load data, the flows in the power grid are simulated using a common DC flow approximation for the AC power flow equations. The resulting infrastructure needs (transmission, backup energy, backup capacity) are analyzed. Finally, the influence of each weather year on the findings is investigated.
It is shown and will be presented that sufficient interconnections between Europe, Africa and Asia lead to a relative reduction of the total backup energy need of ca. 50% (from 15% of the consumption to 7.5%). From the results, it can be concluded that under certain cost assumptions [2], the realisation of an Afro-Eurasian grid seems to be an economically meaningful way towards a renewable future - despite all political uncertainties.
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