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Energy droughts in a 100% renewable electricity mix

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During the 21st conference of parties, 175 countries agreed on limiting the temperature increase due to global warming to 2°C above preindustrial levels. Such an ambitious goal necessitates a deep transformation of our society in order to reduce greenhouse gas (GHG) emissions. Europe has started its energy transition years ago by, for instance, increasing the share of renewables in the European electricity generation and should continue in this direction. Variable renewable energies (VRE) and especially those driven by weather conditions (namely wind, solar and hydro power from river flow), are expected to play a key role in achieving the GHG reduction target. However, these renewables are often criticized for their intermittency and for the resulting difficult integration in the power supply system, especially for large shares of VRE in the energy mix.
Assessing the feasibility of electricity generation using large contributions of VRE requires a deep understanding and characterization of the VRE spatiotemporal variations. In the last decade, many studies have focused on the short-term intermittency of VRE generation, but the persistency and the characteristics of periods of low/high electricity generation have been rarely studied. Yet, these particular situations require some demanding adaptations of the power supply system in term of back-up sources or production curtailment respectively.
This study focuses on what we call "energy droughts" which, by analogy with hydrological or meteorological droughts, are defined as periods of very low energy production. We consider in turn "energy droughts" associated to wind, solar and hydro power (run-of-the-river). Their characteristics are estimated for 12 European regions being subjected to different climatic regimes. For each region and energy source, "droughts" are evaluated from a 30-yr time series of power generation (1983-2012). These series are simulated by using a suite of weather-to-energy conversion models with generic power systems (generic wind, solar and hydro power plant) and observations or pseudo-observations of meteorological drivers. The daily river discharge series required for hydro power are generated using a hydrological model.
Our results demonstrate the diversity of characteristics of energy droughts not only from one energy source to the other, but also depending on the region and on the season considered. Wind power generally presents short but frequent energy droughts whereas hydro-power-related droughts are rare but generally long lasting. Solar power is mainly driven by the length of daytime resulting in long winter "solar drought" in Northern regions. We finally assess the energy droughts characteristics of an energy mix for which the three VRE sources are combined. The proportions of wind, solar and hydro power considered in the regional mixes are based on the work of François et al. (2016b). Mixing VRE sources efficiently reduces both duration and frequency of energy droughts leading to a more reliable power supply.

References :
François, B., Hingray, B., Raynaud, D., Borga, M., Creutin, J.D., 2016b. Increasing climate-related-energy penetration by integrating run-of-the river hydropower to wind/solar mix. Renew. Energy 87, 686–696. doi:10.1016/j.renene.2015.10.064