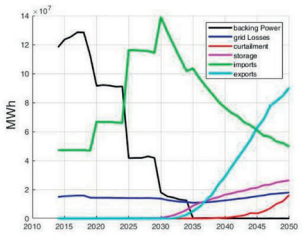
Analysis of the variable renewable energy in the Spanish power system based on kernel probabilistic distributions



Análisis de la energía renovable variable en el sistema eléctrico español basado en distribuciones probabilísticas de nucleo

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RESUMEN

- El desarrollo de las energías renovables es sujeto principal en la transición hacia una sociedad baja en carbono. A pesar de los beneficios que aportan en materia de salud y resiliencia energética regional, la elevada variabilidad de estas fuentes energéticas pone en compromiso la viabilidad técnica de dicha transición. Con el objeto de evitar el problema de la variabilidad, se torna en necesario un profundo análisis de la región en estudio. A partir de datos históricos y escenarios justificados, el presente artículo analiza algunas de consecuencias del crecimiento de generación eléctrica con fuentes renovables. Existe un número considerable de informes de evaluación de sistemas con elevadas cuotas de solar y eólica en el sistema. Objetivo de este texto es mejorar la precisión en este tipo de informes a través de una nueva herramienta de análisis horario. El uso de distribuciones de probabilidad kernel permite modelar adecuadamente los perfiles de generación y demanda para la posterior gestión de los desbalances entre ambas. España ofrece múltiples peculiaridades que la hacen de interés para actividades en esta rama de investigación. En este texto, se analiza un informe oficial a través de tres casos de estudio: España como isla energética sin almacenamiento; esta región como isla energética con almacenamiento; y finalmente se modela España con almacenamiento e interconexiones internacionales. Los resultados en 2050 indican una infravaloración de la generación eólica y solar (19% de sobrecapacidad), además de serios desafíos para el operador del sistema eléctrico, tales como 19 horas consecutivas de sobreproducción. Un resultado general merece especial atención: en escenarios con cuotas muy altas de eólica y solar, se requiere de una creciente flexibilidad en el sistema si se pretende mantener una alta eficiencia en el mismo.

- **Palabras clave:** Energía Renovable Variable (VRE), distribución probabilística del núcleo, almacenamiento, informes de energía, análisis del sistema de energía.

ABSTRACT

The development of renewable energies has been highlighted as a driver of the energy transition towards a more sustainable society. Despite the well-known benefits in health and regional energy resilience when those sources are leveraged, wind- and solar-based technologies bring about flexibility challenges in the power system. The variability in the generation of energy from renewable sources is probably its greatest weakness. This problem can be alleviated in different ways, but a detailed statistical analysis of the situation in each country is necessary to find the optimal solution in each case. This article analyses, from historical data and possible scenarios, some consequences that must be taken into account in the growth of electric power generation with renewable sources. Many assessment reports have been published to analyse high shares of the variable renewable energy supply (VRES) contribution in the electricity mix. This article aims to improve the accuracy in such reports through a novel analysis tool. Hourly timescale and the use of kernel probability distributions allow the well-represented supply and demand profiles necessary for an in-depth insight into electricity management. Spain offers multiple peculiarities which make our native region of interest for research activities. Here, an official report is analysed for three case studies: Spain as an energetic island without storage; Spain as an energetic island with storage; and Spain with both storage and international interconnections. According to this scenario, in 2050, the results indicate an underestimation of VRE generation (19% of renewable overcapacity) leading to very important challenges to the power system operator in the management of situations with 19 consecutive hours of electricity overproduction. In