# Using batteries for frequency control in power grids with renewable sources

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The ambitious decarbonisation goals that many countries are pursuing to fight climate change present various challenges for the operation of power grids. In particular, the stability of the grid may be affected by the intermittent nature of renewable energy resources, such as wind and solar power. A way to assess grid stability is to study frequency fluctuations. The frequency of the alternating current produced by the generators has a fixed reference value of 50 Hz, but it is subject of random fluctuations due to the imbalance between production and demand.

A possible way to reduce frequency fluctuations is to introduce in the grid energy storage systems that can store the excess of energy produced by renewable sources and use it to balance demand peaks. In this work we analyse the effects of introducing a battery in a power system with conventional and wind generation and we compare two algorithms for the battery operation. The first battery control method responds only to wind fluctuations, while the second one is sensitive to both wind and demand fluctuations.

We use a simple model with just one conventional generator with conventional primary and secondary control [2, 3]. The model includes the classical swing equation for the frequency $\omega$, an equation for primary control which damps the frequency oscillations with a fast response time, and one for secondary control, in which the spinning reserve acts on a slower time scale to bring back the frequency to the reference value.

The first control method uses a battery that responds only to wind fluctuations and based on an optimisation technique called model predictive control. This method is aimed at smoothing wind power using a battery was introduced in [1]. It uses a model for the battery state of charge where the smoothed wind power is obtained solving an optimisation problem that minimises the oscillations of the battery state of charge. The output smoothed wind power substitutes the real wind production in the swing equation.

The second control method consists in using the battery as an additional primary and secondary control, and its equations are analogous to the ones in [3]. The battery power is added to the measured wind power in the swing equation.

As a case study, we consider the island of Gran Canaria, Spain, for which the data about wind production and consumer demand are publicly available in [4].

To assess the effectiveness of both methods we compute cumulative probability ranks $R(\Delta\omega)$ that estimate the probability of the occurrence of fluctuations bigger than a certain value $\Delta\omega$ and we also study the stress level of the battery state of charge.

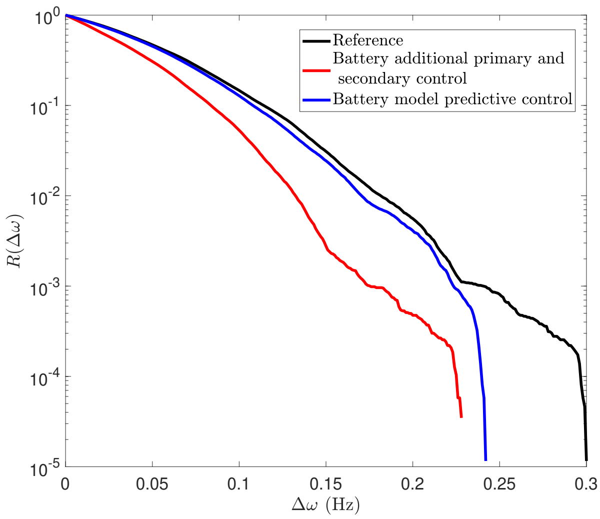


Fig. 1. Cumulative probability ranks calculated over one day (May 31st, 2021). Black line: reference case without battery. Red line: battery as additional primary and secondary control, capacity 0.5 MWh. Blue line: battery with model predictive control algorithm, capacity 5 MWh.

Our results show that both methods can reduce frequency fluctuations, although at different costs in terms of the size of battery needed. In Figure 1 we show an example of this fact for one day. In general, for the model predictive control method one needs a bigger battery to ensure that the optimisation algorithm converges. On the other hand, using the battery as an additional primary and secondary control is more effective with small batteries, in particular to reduce the part of fluctuations caused by the demand variability.


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