PHD THESIS

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Integrating balancing markets in hydropower scheduling models

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Background

In the EU there are ambitious targets for increasing the renewable electricity generation, especially wind- and solar-power. Due to the stochastic characteristics of the renewable generation, additional balancing is needed to secure a stable power grid. The Norwegian government recently gave concession to build two HVDC cables, 1400 MW both to Germany and UK, giving Norwegian hydro producers access to balancing markets at the European continent. My PhD will focus on methods for implementing additional markets, such as the balancing reserves markets, in hydropower scheduling models.

Due to the underlying uncertainty of inflow and power prices, hydropower scheduling for long-term models are considerably difficult to solve. The amount of potential stochastic outcomes explode over time, potentially diminishing the computational tractability. In order to cope with this issue the method of Stochastic Dual Dynamic Programming (SDDP) has proven beneficial for solving these types of problems. The method is, however, based on Linear Programming (LP), such that to model the added complexity provided by balancing reserve markets, e.g. integer bids and minimum production limits, is cumbersome.

The main purpose of the PhD is to investigate and potentially develop methods for incorporating multi-market hydropower scheduling.

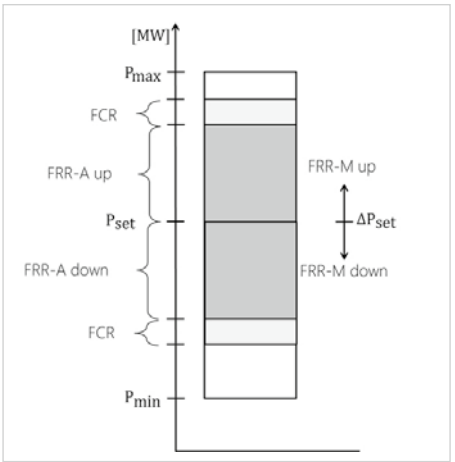

Illustration of different balancing reserves that could be provided from a hydropower station. FCR, FRR-A and FRR-M respectively refers to primary, secondary and tertiary balancing reserves