Control Power and Variable Renewables

A Glimpse at German Data

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1. Overview

Balancing power (regulating power, control power) is used to quickly restore the supply-demand balance in power systems. Variable renewable energy sources (VRE) such as wind and solar power, being stochastic in nature, ceteris paribus increase the need for short-term balancing. Their impact on reserve requirements is heavily discussed in academic and policy circles and often thought to be large. This paper provides a comprehensive overview of balancing systems in Europe and examines the role of VRE based on a literature survey and descriptive statistics of empirical market data from Germany. Despite German VRE capacity doubled during the last five years, balancing reserves decreased by 20%, and procurement cost fell by 50%. Other factors, such as increased TSO cooperation, must have overcompensated for the growth in VRE. To the extent this specific German experience can be generalized, one can interpret this as an indication that balancing power is not necessarily a major barrier to VRE integration at moderate penetration rates. In addition, we propose a number of policy options to stimulate the participation of VRE in balancing markets and to improve the incentives to forecast accurately.

2. Balancing Systems

We use the term "balancing system" to describe the set of technical and economic institutions that have evolved to maintain and restore the active demand-supply power balance in integrated electricity systems. This includes determining the required reserves, procurement and activation of balancing power, the allocation of its costs, and the incentives for market actors to avoid imbalances.

Three types of actors play a role in balancing systems: transmission system operators, balance responsible parties, and suppliers of balancing power. "Program responsible parties" or "balance responsible parties" (BRPs) are market entities that have the responsibility of balancing a portfolio of generators and/or loads. Transmission system operators (TSOs) operate the transmission network and are responsible to balance injections and off-take in their balancing area (control area). Balancing areas are geographic regions, usually of the size of countries. The balancing area imbalance is the sum of all BRP imbalances. TSOs activate balancing power to physically balance demand and supply if the sum of BRP imbalances is non-zero. Specifically, TSOs have four obligations:

1. determine the amount of capacity that has to be reserved for balancing, ex ante (section 3 of the paper)
2. acquire that capacity and determine the price paid for capacity and energy, ex ante (section 4)
3. activate balancing power in moments of physical imbalance, real time
4. determine the imbalance price, and clear the system financially, ex post (section 5).

Suppliers of balancing power reserve positive or negative capacity, and deliver energy once activated by the TSO.

The findings, interpretations, and conclusions expressed herein are those of the authors and do not necessarily reflect the views of Vattenfall or the Potsdam-Institute. Corresponding author: Lion Hirth, Vattenfall GmbH, Chausseestraße 23, 10115 Berlin, lion.hirth@vattenfall.com, +49 30 81824032.

3. Reserve Requirement

The German TSOs use a probabilistic approach to determine $SC^{+/-}$ and $TC^{+/-}$ capacities, sometimes called the "Graf/Haubrich approach" (Consentec 2008, 2010, Maurer et al. 2009). First, the individual density functions of all random variables are estimated, either from historical data or theoretical considerations. The joint density distribution is then derived by statistical convolution. Thereby it is assumed that the individual factors are independent from each other. Finally, positive and negative reserves are set in a way that the integral of the density function equals a pre-defined security level. Figure 1 gives a high-level overview.

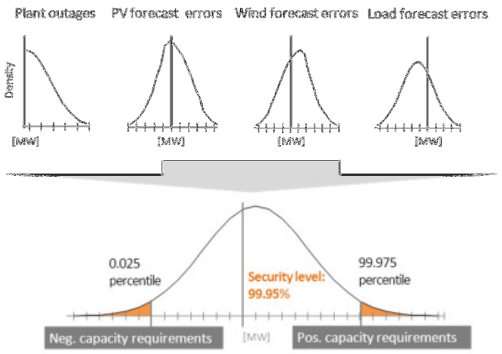

Figure 1. Probabilistic approach for ex-ante determination of reserves.

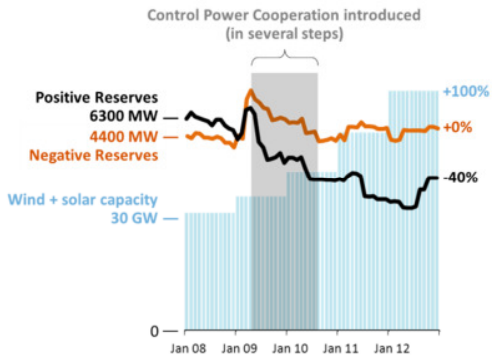

Figure 2. Balancing reserves and VRE capacity in Germany. Despite the installed capacity of wind and solar power doubling since 2008, the demand for balancing power decreased. One reason was the cooperation between TSOs introduced in 2009/10.

4. Policy Options

Throughout the paper we have also suggest a number of policy options, summarized in the table below. We propose to switch to dynamic dimensioning and price-elastic reserve procurement, and suggest to target deterministic imbalances such as schedule leaps with an appropriate instrument.

Reserve requirements (section 3)	Dynamic dimensioning (today static)
	Price-elastic procurement (today inelastic)
	Target deterministic imbalances with specific measures (today all covered by balancing reserves)
Balancing power market (section 4)	Tender PC and SC daily (today weekly)
	Reduce contract duration to hours (today blocks of four hours or peak/off-peak)
	Marginal pricing (today pay-as-bid)
	Tendering via Power Exchange
Imbalance settlement (section 5)	Publish imbalance price shortly after real time (today months later)
	Marginal pricing (today average with mark-up) (obsolete if marginal pricing is introduced in baklancing power markets)
	Allocate costs of capacity reservation via imbalance prices (today grid fees