

Evaluation of Benefits from Flexibility Measures and their Integration in Power Systems Operation and Markets

A. Ulbig and S. Koch
ETZ Zurich, Switzerland

Abstract

Traditionally, power system operation is conducted having a precise idea of the underlying processes in mind: Electricity generation, mainly in the form of large power plants, reliably fueled with natural gas, coal or uranium, is considered to be fully dispatchable, i.e. controllable. Electricity demand, by households and industry, is considered to be non-controllable and stochastic in nature. Since load demand is relatively well predictable, power generation has thus simply to follow the load. The remaining variations between scheduled generation and actual real-time load demand are balanced via reserve capacities, which are at the disposal of the grid operator in the form of automated (primary and secondary control) or manual (tertiary control) power reserves. These control reserves are also necessary for unplanned outages of plants and power lines as emergency reserve.

This somewhat idealistic conception of what was going on in the power system pretty much matched the reality in power system operation for many years. This has changed in recent years due to the on-going wide-spread deployment of renewable energy sources (RES) in many countries has led to significant relative and absolute shares of intermittent, i.e. stochastic, power generation. This significantly increases the part of non-controlled power in-feed into power system. On the other hand, the envisioned deployment of smart meters in many countries will create the necessary infrastructure for appropriate demand response (DR) schemes in which loads are either steered by dynamic tariffs, which set an economic incentive for end-consumers, thus allowing a mild and partial load controllability for achieving load peak reduction and load valley filling, or directly managed by a controller, allowing a more stringent load controllability.

Both these ongoing developments create a major paradigm shift in the generation and load portfolios of many power systems, not only with regard to the question of controllability, which in the long-run also needs to be reflected in power system operation and market procedures.

Recent events such as the repeated occurrences of forced curtailments of power market activity as well as highly negative spot market prices in Germany have shown two things:

1. High amounts of uncontrolled, stochastic RES power in-feed can drive power systems towards their operational limits.
2. Flexibility in power systems operation and power plant dispatch has a value. This can be measured by the fact that inflexibility in power plant dispatch has a price in the form of ramping costs, start and stop costs of large conventional units. In the current power market setup these costs appear in the form of negative supply bids in the generation merit order.

The presentation will assess the benefits of additional flexibility measures such as larger conventional as well as non-conventional electricity storage capacities, for example in the form of PHEV/EV fleets, controlled wind/PV curtailment and controlled demand-side management (DSM) on power system operation. The benefits of these flexibility measures for power system operation are evaluated.

To be able to best benefit from the usage of such flexibility measures, market frameworks for ancillary service procurement may have to be rethought with the goal to better integrate the mentioned flexibility measures.

The evaluation setup employs the recently introduced Power Nodes modelling framework for power systems, which allows a straight-forward implementation of additional degrees-of-freedom, i.e. flexibility, in power system operation. The framework calculates balance terms of RES energy curtailed (spillage), electricity storage utilized, conventional back-up capacity utilized and shedded system load over the simulation horizon [1].

References

K. Heussen, S. Koch, A. Ulbig and G. Andersson, "Energy Storage in Power System Operation: The Power Nodes Modeling Framework", IEES PES Conference on Innovative Smart Grid Technologies Europe, Gothenburg, Sweden, 2010.