Energy and reserve markets: in(ter)dependent in a high-RES world

Kenneth Van den Bergh, KU Leuven, +32 16 321 086, kenneth.vandenbergh@kuleuven.be
Erik Delarue, KU Leuven, +32 16 322 521, erik.delarue@kuleuven.be

Overview

Today, markets for electric energy and reserves in Europe are separated and organized in the following sequential order: (i) electric energy is traded in forward and day-ahead markets, (ii) reserves are procured and allocated to reserve providers, and (iii) reserves are activated real-time to deal with imbalances.

However, energy and reserve markets are interdependent. Generation capacity used to trade electric energy can not be used for (upward) reserve provision and vice versa. This interdependency is reinforced by operational power plant constraints such as minimum power output. A power plant might need to operate at minimum power output in the energy market to sell fast (upward) spinning reserves in the reserve market. As such, there is benefit in joint energy and reserve markets to optimally account for the interdependencies between both [1].

The interdependencies between energy and reserve markets are impacted by intermittent renewable generation from wind and solar. First, the need for reserves increase with the amount of wind and solar, reinforcing the interdependencies between energy and reserve markets. Second, wind and solar can provide (cheap) reserves without operational constraints such as minimum power output, weakening the interdependencies between energy and reserve markets. Third, wind and solar reduce the residual load to be covered by conventional power plants and, as such, reduces the online conventional capacity that can deliver fast reserves [2,3].

This contribution aims to quantify the impact of intermittent renewables such as wind and solar on the interdependencies between energy and reserve markets. Based on this quantitative analysis, recommendations will be formulated to organize energy and reserve markets in a high-RES power system.

Methods

Two different scenarios are considered for increasing levels of wind and solar penetration:

1. Separate energy and reserve markets;
2. Joint energy and reserve markets.

Both scenarios are compared in terms of total system cost (after activation of reserves) and reliability. To quantify both criteria, a detailed unit commitment model is used to simulate the day-ahead market, reserve market and real-time reserve activation [4]. Wind and solar forecast errors are considered as main source of uncertainty.

Two different case studies are addressed. First, a strongly simplified case study, consisting of ~10 conventional power plants, is investigated. Second, a Central Western European case study is performed, based on the scenarios developed in the EU-SysFlex project [5].

Results

The following results are expected, in terms of cost savings from joint energy and reserve markets (w.r.t. separate energy and reserve markets):

1. At low RES levels, flexible conventional generation units (“peakers”) are online to deliver energy and can as such simultaneously deliver fast reserves. There are no to little cost savings from joint markets.
2. As of a certain RES level, flexible conventional generation units are no longer needed to deliver energy and they need to be brought online specifically to deliver reserves. Hence, the cost savings from joint markets become increasingly apparent.
3. At higher RES levels, flexible conventional generation units are needed to deliver the low and highly variable residual load, and are as such online again to deliver reserves as well. Hence the cost savings from joint marktes decreases again.

Conclusions

Energy and reserve markets are interdependent; the clearing in one market impacts the other market and vice versa. These interdependencies become stronger and weaker as the amount of intermittent wind and solar in the system change. This contribution outlines the relationship between renewables (wind and solar) and the in(ter)dependency of energy and reserve markets, with the aim to formulate recommendations on market design.

References

[1] González, P., Villar, J., Díaz, C. A., Campos, F. A. (2014). Joint energy and reserve markets: Current implementations and modeling trends. Electric Power Systems Research, 109, 101-111.

[2] Ahlstrom, M., Bartlett, D., Collier, C., Duchesne, J., Edelson, D., Gesino, A., ... & O'Sullivan, J. (2013). Knowledge is power: Efficiently integrating wind energy and wind forecasts. IEEE Power and Energy Magazine, 11(6), 45-52.

[3] Tuohy, A., Zack, J., Haupt, S. E., Sharp, J., Ahlstrom, M., Dise, S., ... & Black, J. (2015). Solar forecasting: methods, challenges, and performance. IEEE Power and Energy Magazine, 13(6), 50-59.

[4] Van den Bergh, K., Bruninx, K., Delarue, E., & D'haeseleer, W. (2014). LUSYM: a unit commitment model formulated as a mixed-integer linear program. KU Leuven, Working Paper.

[5] The EU-SysFlex Consortium (2019). EU-SysFlex Scenarios and Network Sensitivities. Available at http://eu-sysflex.com/documents.