15. Symposium Energieinnovation, 14. bis 16. Februar 2018, Technische Universität Graz, www.EnInnov.TUGraz.at
ISBN 978-3-85125-585-0 DOI 10.3217/978-3-85125-584-3

FLEXIBILITY OPTIONS IN POWER SYSTEMS – A BENEFIT ANALYSIS ON THE MARKET VALUE OF VARIABLE RENEWABLE ENERGY

Anselm EICKE[1], Astrid BENSMANN[2], Richard HANKE-RAUSCHENBACH[2]

Motivation

The market value of variable renewable energy sources (VRE) such as wind and solar decreases at increasing shares of the respective generation type (e.g. Hirth 2013). The hypothesis of the present contribution is that this effect can be mitigated by increasing the flexibility of the underlying power system. To verify and quantify this hypothesis, a numerical market model is used to assess the impact of different flexibility options, namely energy storage, international network transfer capacities (NTC) and increased flexibilities in the conventional power plant fleet, on the market value of renewables in Central and Northern Europe.

To comply with the emission reduction target under the Paris Agreement, high shares of renewable energy sources will be introduced into the power system in future. Increasing the share of VRE cost efficiently is one crucial precondition to maintain societal and political support. However, under the current market design, self-cannibalization of renewables will decrease their market value at increasing VRE shares and thereby increase the integration costs (Hirth et al. 2015). Understanding the mechanisms and the magnitude of the impact of flexibilities on this value drop helps to realistically assess the thread of increased market value drops.

Various authors already analysed the possible development of VRE market values (e.g. Hirth 2013, Winkler et al. 2016, Welisch et al. 2016). However, qualitative literature assessing the impact of storage and interconnection is sparse since is requires more complex models with high accuracy of the resulting electricity price. Thus, compared to previous research on market values, a more sophisticated description of energy storages and modelling of flexibilities will be used in the present contribution.

Methods

For a meaningful analysis of the described research question, a detailed model of inherent flexibilities and inflexibilities of the power system is necessary. For this purpose, the mixed-integer linear programming (MILP) model DISPA SET from the Joint Research Centre of the European Commission (Quoilin Sylvain et al. 2014) based on the CPLEX GAMS solver is employed. It allows for simulating individual plant commitment. The model simulates hourly dispatch of power generation for a given system with special respect to renewable shares, NTC and storage capacities. With the exogenously given generation time series of VRE and the modelled market prices, the market value (MV) of VRE for each year (T=8760) is calculated as following

$$MV_{VRES} = \frac{\sum_{t=1}^{T} Generation_{\mathrm{VRE},t} \cdot MarketPrice_t}{\sum_{t=1}^{T} Generation_{\mathrm{VRE},t}}$$

In the model, each generation facility is considered with inherent constraints on ramping rates, up and down times and minimum partial load. Additionally, the model considers decreasing efficiencies at reduced load and costs for starting and ramping of plants. Furthermore, an advanced model for storage operation is applied which includes perfect foresight for two days. Thereby, the potential of short-term storage is evaluated.

Transmission restrictions within the studied countries are not part of the investigation due to the considered spatial resolution. However, interconnection between countries as a means of offsetting diverging VRE generation in different geographic areas is considered.

[1] Sciences Po Paris, 27 Rue Saint-Guillaume, 75007 Paris, anselm.eicke@sciencespo.fr
[2] Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover, Tel.: +49 511 762 14-{410|401}, Fax: +49 511 762 14402, {astrid.bensmann|hanke-rauschenbach}@ifes.uni-hannover.de, www.ifes.uni-hannover.de

ISBN 978-3-85125-585-0 DOI 10.3217/978-3-85125-584-3

Hence, the simulation is run for all included countries simultaneously to optimize the use of network transfer capacities and to prevent unrealistic assumptions for import and export availabilities. The following list of European countries is included in the assessment: Germany, France, Italy, Spain, Poland, Czech Republic, Austria, Switzerland, Netherlands, Belgium, Luxemburg, Denmark, Sweden and Norway.

Analysis

The market values are compared for different scenarios to assess the impact of the evaluated flexibility options. As a reference scenario for installed capacities, the Sustainable Transition Scenario is taken from the Ten Year Network Development Plan 2018 (TYNDP 2018). It was developed by the European Network of Transmission System Operators (ENTSO-E) for their network planning and evaluation. The reference scenario describes a possible pathway from today until 2030 which reaches European GHG emission goals through national regulation, emission trading schemes and subsidies by maximising the use of existing infrastructure (ENTSO-E 2017). In all, it is a realistic and at the same time ambitious trajectory for VRE expansion in Europe.

An in-depth benefit analysis of the three different flexibility measures is conducted for Germany and France to evaluate regional heterogeneities on the impact on the VRE market value decline. As one result, the marginal benefit of energy storage and the marginal benefit of transmission capacities for VRE are estimated as a function of the renewable’s share in both countries. Additionally, the impact of a large-scale role out of PV and storage systems in Germany is analysed and its potential impact on the market value decline of PV generation is assessed.

Finally, this contribution compares qualitatively the analysed countries and points out differences resulting from the inherent flexibility of the underlying power systems. A qualitative review of all countries reveals the impact of the conventional power fleet on the behaviour of the market value at increasing VRE shares. Especially nuclear and fossil fuel dominated power systems (FR, DE, PL) experience higher value drops than countries with hydro dominated power systems (NO, SE, CH and AT).

References

[1] ENTSO-E (2017): TYNDP 2018. Available online at http://tyndp.entsoe.eu/tyndp2018/, updated on 10/24/2017, checked on 12/1/2017.

[2] Hirth, Lion (2013): The market value of variable renewables. The effect of solar wind power variability on their relative price. In Energy Economics 38, pp. 218–236.

[3] Hirth, Lion; Ueckerdt, Falko; Edenhofer, Ottmar (2015): Integration costs revisited – An economic framework for wind and solar variability. In Renewable Energy 74, pp. 925–939. DOI: 10.1016/j.renene.2014.08.065.

[4] Quoilin Sylvain; Hidalgo Gonzales Ignacio; Zucker Andreas (2014): Dispa-SET 2.0. Unit commitment and power dispatch model: Publications Office of the European Union.

[5] Welisch, Marijke; Ortner, André; Resch, Gustav (2016): Assessment of RES technology market values and the merit-order effect – an econometric multi-country analysis. In Energy & Environment 27 (1), pp. 105–121. DOI: 10.1177/0958305X16638574.

[6] Winkler, Jenny; Pudlik, Martin; Ragwitz, Mario; Pfluger, Benjamin (2016): The market value of renewable electricity – Which factors really matter? In Applied Energy 184, pp. 464–481. DOI: 10.1016/j.apenergy.2016.09.112.