Improving wind power market value with various aspects of diversification

Til Kristian Vrana
Harald G. Svendsen
SINTEF Energi, Norway
vrana@alumni.ntnu.no

Magnus Korpås
NTNU, Norway

Philipp Härtel
Fraunhofer IEE, Germany

Hannele Holttinen
Recognis Oy, Finland

António Couto
Ana Estanqueiro
LNEG, Portugal

Matti Koivisto
DTU, Denmark

Damian Flynn
UCD, Ireland

Eric Lantz
Bethany Frew
NREL, Colorado, USA

***Abstract*—The wind generation share in many European bidding zones is now large enough to affect the market value of wind power, and wind energy is getting less-than-average market price in day-ahead markets. As alternatives to investing in dedicated energy storage, there are two main ways to mitigate the decreasing market value trend. The first is employing different diversification measures (geographical spread, alternative wind turbine technologies, integration with solar). The second is implementing demand flexibility measures. Examples of these measures from some European and USA studies are given in this article, which stems from the international collaboration under IEA Wind TCP Tasks 25 and 53.**

***Index Terms*—Generation mix diversification, power system economics, power system planning, variable renewable energy sources, wind energy integration**

I. Introduction

The amount of wind power in the European power system is increasing, and towards 2030 a doubling of capacity to more than 400 GW is expected. The Europe-wide share of wind power is already approaching 20% of demand on a yearly average. During windy days and hours, the generation in many European bidding zones will exceed demand [1]. The so-called merit-order effect (i.e., a decrease of electricity prices at the power exchange due to an increased supply of renewable generation in the market pushing out conventional generation stacks) has been evident in current electricity market situations [2] and its relevance is being discussed for future electricity market scenarios [3] [4]. This effect is impacting the market value of wind power – wind energy is receiving less than the average market price in day-ahead markets [3].

The EU-SysFlex study has shown that the market value factor can drop sharply with increasing Variable Renewable Energy (VRE) shares, in particular for solar [5]. The solar market value factor was found to drop from 93%, at a VRE share of 23%, to 36%, at a VRE share of 55%. This is because solar production is concentrated in the middle of the day, which leads to a drop in system marginal costs. Wind generation is more spread during the day, and the market value for wind power drops only from 97% (onshore) and 98% (offshore), at a VRE share of 23%, to 76% and 81% respectively, at a VRE share of 55%, in the same study [5]. Flexibility of demand was only moderately considered in these scenarios, but the study's results show why market integration and cost recovery of VRE have become significant concerns in future energy systems [6].

These developments show that the LCoE-centric approach towards wind power, which served the industry well for decades, needs to be equipped with additional measures. The relation between *electric power produced* and its *marginal value created* is declining as the relation between wind power output and power market price gets stronger [7].

There are three general ways to mitigate the merit-order effect and decreasing market value:

- Diversification of the weather-driven generation fleet reduces power output fluctuations and thereby mitigates (negatively correlated) market price fluctuations
- Flexibility of demand can compensate for weather-driven power output fluctuations and thereby reduce their impact on market prices
- Storage of electric energy, such as pumped hydro and batteries can shift energy in time and thereby match supply and demand.

These measures can be seen as complementary solutions to the same problem: diversification reduces the size of the balancing problem, flexibility and storage solves the problem. The energy storage option has received a lot of attention, both previously [8] [9] and currently [10] [11]. It will play an important role in future energy systems, but it comes at significant investment cost, and it is outside the scope of this article. The flexibility that will be needed for balancing, will mainly come from the demand side. This is because the flexibility of the generation fleet is reduced with the ongoing Energiewende, in which resources from a stored primary energy carrier are displaced with weather-driven resources. As demand flexibility will likely be the main source of price stabilisation in future sustainable power systems, it is discussed in Section V.

The main part of this article, however, addresses various diversification measures, which can be categorised as follows: