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DEFINITION AND CONTROL OF INTEGRATION COST OF WIND POWER

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Overview
Public willingness to diminish greenhouse gas emissions and to reduce energy dependency has motivated the setting up of support mechanisms for wind power. In the liberalized energy sector, efficiency of such mechanism should be analysed with care. The efficiency question requires carrying out a cost-benefit analysis, disclosing all driving cost factors. The measure of the success of such mechanism is rather easy to assess, since we can rely on indicators such as installed capacity in wind power, energy generated by wind power. The cost analysis is far less straightforward, because the existing literature reveals different ways to define integration costs of wind power. The scope of this article is to propose a definition for the integration costs of wind power, to identify the main drivers for this cost, and finally to make proposals for pushing it down.

Methods
This article is based on a thorough literature review about the integration cost of wind power, and refers to three study cases, namely Germany, Denmark and Spain, that we consider to be the European countries where wind power has developed massively. Our approach consists in breaking down the integration cost into different groups, and for each group, to identify the main drivers. This analysis serves as a basis for the identification of efficient ways to diminish integration cost of wind power.

Results
The analysis breaks down costs into three classes: costs of non-competitiveness, grid costs and cost of the equilibrium between production and consumption. The costs of non-competitiveness are the costs of the premium which should be given to wind turbine's owners to make investment in wind power profitable. The cost of non-competitiveness is directly linked with the development of the wind power. Grid costs are mainly driven by technical features of wind power, namely atomicity and lack of flexibility in terms of location. The cost of the equilibrium between the production and the consumption is mainly driven by the attributes of the support mechanism and by the rules of intra-day markets. In an ideal case, the wind power forecasts are continuously carried out during the operational day, and the markets design enable the actors to up-to-date wind programs with latest forecasts. In this fictive situation, intra-day markets provide with liquid markets that make possible the compensation of wind power forecast errors along the operational day.
To make the reality closer to this fictive case, we make two recommendations. Firstly, the entity in charge of the notification of wind generation programs should have an adequate incentive to do it properly. The incentive framework for the quality of program depends on the support mechanism for wind power. The incentives are either financial, or based on high security requirements. Secondly, the rules of intra-day markets should enable the notification of programs close to the real time, and guarantee some liquidity on intra-day markets.
Furthermore the support mechanism should be an incentive framework for the development of generation technologies with dispatch ability. To this point we recommend that balancing cost of wind power should be allocated to wind turbine's owners.

Moreover, the aggregation of wind power production from different control zones is an appealing option to take advantage of the smoothing of geographically distributed wind power.

Conclusions

Our conclusion is that the cost of wind power is combination of different costs that should be identified with care. Improving efficiency of wind power integration should take into account the specificity of wind power, and should not jeopardize the expansion of wind power. Therefore, we recommend that an effective approach should consist in pushing down the cost of equilibrium between the production and the consumption. The design of the intra-day market rules and the features of the support mechanism are the main drivers to act on to diminish the integration cost of wind power.