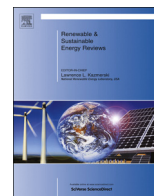




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The legal and economic impacts of implementing a joint feed-in premium support scheme on the development of an offshore grid



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ABSTRACT

Offshore wind projects require large investments. Therefore, they currently need governmental support to become competitive and economically attractive for investors. There is a general consensus that a feed-in premium scheme would be most adequate to support offshore wind generation in the North Sea. With increasing distance from shore, scarcity of adequate cable routes, and an increasing need to reduce cost, cross-border projects between two or more North Sea states come into discussion. After discussing different support schemes, we argue that existing nationally oriented instruments have to be amended to become applicable to cross-border projects envisioned in the North Sea. In order to support our arguments quantitatively, we introduce a novel optimization framework that is able to account for the impact of implementing different types of feed-in premium based wind supporting schemes (generation-based and capacity-based) on the development of the offshore grid in the North Sea region. For a given level of support for wind development, an optimal plan includes the grid and offshore wind capacities. The transmission capacities are set in such a way that the congestion revenue collected throughout the life time of the project pays off the investment cost of building the grid. At the same time, the remuneration of the offshore wind farms pays off the unsubsidized initial investment cost of building the wind farms, provided that the premium level is selected adequately. Numerical simulation results are interpreted in economic terms and appraise the quality and effectiveness of the proposed approach. The paper will end with an outlook of how such a joint support scheme might be implemented.

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1. Introduction

Among the various renewable energy sources, the share of wind energy is increasing rapidly due to greater technical maturity and decreasing costs. In the North Sea region, offshore wind energy is considered as a substantial contributor towards reaching the national renewable energy targets. The total installed capacity of offshore wind (OW) installations in Europe is expected to amount to 40 GW by 2020 and might go as high as 150 GW by 2030 with even more ambitious targets being settled for 2050 [1,2].

As the exploitation of offshore wind requires significant investments, the states set up support schemes to encourage the development of this form of energy [3]. Support schemes do not only aim at making renewable energy generation competitive. In the light of changing the energy market to facilitate renewable energy and more cross-border exchanges, several other aspects are of importance in supporting renewable energy, such as a long-term approach, and cooperation with neighbor countries to use the existing resources in the most efficient way. A more efficient approach to exploiting offshore wind in the North Sea would therefore be to move away from national boundaries and to consider cross-border projects.

Although expanding offshore wind energy is a priority in the energy policies and development plans of several European countries, there are quite some challenges to overcome. For cross-border projects, the main challenges are the difference between the environmental legislation and the different requirements for the grid connection. Further, the social acceptances of grid connections and new transmission lines gain importance [4,5]. Another challenge, which will be the focus of this paper, is the fact that the national support schemes currently in force have not been designed to support cross-border projects. Existing support schemes in most EU countries are limited to projects within the national territory and are thus not applicable to projects that are located partly or wholly within the territory of another Member State. However, with increasing distance from shore, scarcity of adequate cable routes, and the need to utilize transmission infrastructure more efficiently, cross-border projects between two or more North Sea states come into discussion [6]. An analysis of the different support schemes in place today raises doubts about their functionality for cross-border projects. In fact, the national focus of the support schemes for offshore wind may negatively influence the development of a transnational offshore grid. Thus it is essential to develop a well-designed (internationally functional) support instrument that effectively promotes participation of investors in cross-border offshore

wind projects. Otherwise, it becomes extremely difficult for stakeholders to integrate the increasing capacity of offshore wind in the electricity system and to cooperate in the development of combined solutions [7,8].

One crucial element for large-scale deployment of offshore wind energy is the availability of a secure and reliable network to transport the wind-power to the remote load centers. The existing old transmission infrastructure in Europe is the heritage of an era when transmission grids were developed nationally to meet the needs of individual countries. To integrate large-scale offshore wind capacities, the high voltage transmission networks of all North Sea coastal states have to be reinforced and expanded to a large extent [9–11]. In this regard, developing the transmission infrastructure (in the North Sea) is considered as a key priority [12]. This requires massive investments and a complex planning. Transmission planning of the offshore grid in the North Sea has been investigated in [13–19]. It is expected to open up new energy supply corridors as a step towards integrating electricity markets of neighboring countries. In addition, cross-border power exchanges will subsequently increase the security of supply and decrease the cost of producing energy while integrating higher amounts of RES.

One may note that decisions regarding the capacity of transmission infrastructures are strongly dependent on installed offshore wind capacities and vice versa. Following liberalization, those activities are performed by different actors, TSOs and project developers. So far, little work has been done on the connection between the optimal design of the grid, the design of a region-wide (internationally functional) supporting scheme (and consequently the installed wind capacities) and the operation of the wholesale markets. In [20], the authors investigated the impact of implementing a capacity-based support scheme on the development of an offshore grid in the North Sea. The final grid design and social welfare distribution of different regions are observed to vary significantly as the support level changes.

This paper extends our work in [16,20]. In addition, we discuss the current support schemes in the NL, DK, DE and the UK to assess whether they would be applicable to cross-border offshore wind projects. These countries have been chosen as they already gathered experience regarding offshore wind exploitation, are amongst the EU countries with the largest amount of installed offshore wind capacity, and rank amongst the EU countries with the highest potential for developing offshore wind energy [21,22]. We then introduce a market based co-optimization framework to solve the problem of offshore wind development and transmission

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