A real options approach to analyse wind energy investments under different support schemes

Lena Kitzing a,⇑, Nina Juul a, Michael Druda a, Trine Krogh Boomsma b

a Technical University of Denmark, DTU Management Engineering, Energy Economics and Regulation, Produktionstorvet 426, 2800 Kgs. Lyngby, Denmark
b University of Copenhagen, Department of Mathematical Sciences, Universitetsparken 5, DK-2100 Copenhagen East, Denmark

HIGHLIGHTS

- Real options model for wind projects considering investment timing and sizing.
- Introducing a capacity constraint in the optimisation.
- Addressing several uncertainty factors while still providing analytical solution.
- Comparative policy analysis of investment incentives from different support schemes.
- Improved quantification of trade-off between fast deployment and large projects.

ABSTRACT

A real options model is developed to evaluate wind energy investments in a realistic and easily applicable way. Considering optimal investment timing and sizing (capacity choice), the model introduces a capacity constraint as part of the optimisation. Several correlated uncertainty factors are combined into a single stochastic process, which allows for analytical (closed-form) solutions. The approach is well suited for quantitative policy analysis, such as the comparison of different support schemes. A case study for offshore wind in the Baltic Sea quantifies differences in investment incentives under feed-in tariffs, feed-in premiums and tradable green certificates. Investors can under certificate schemes require up to 3% higher profit margins than under tariffs due to higher variance in profits. Feed-in tariffs may lead to 15% smaller project sizes. This trade-off between faster deployment of smaller projects and slower deployment of larger projects is neglected using traditional net present value approaches. In the analysis of such trade-off, previous real options studies did not consider a capacity constraint, which is here shown to decrease the significance of the effect. The impact on investment incentives also depends on correlations between the underlying stochastic factors. The results may help investors to make informed investment decisions and policy makers to strategically design renewable support and develop tailor-made incentive schemes.

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1. Introduction

1.1. Motivation and approach

Investments in renewable energy (RE) technologies accounted for more than 67% of global investments in power and fuel production assets in 2015 [1]. Especially offshore wind is considered an important growth area in Europe: An increase from currently 12 GW to 44 GW is expected by 2020 [2]. Global offshore wind investments could arrive at EUR 130bn annually in 2020, including EUR 14bn in Europe [3]. With many billions of Euros invested each year, it is crucial how decisions are made. Investors therefore need adequate tools for valuing their investment options. Also policy makers need such tools in the choice of appropriate incentive mechanism, as most RE investments still rely on policy support. The academic community continues to debate which type of policy instrument are best suited to support RE (see e.g. [4]). The present paper contributes to this discussion. By developing a real options model that appropriately reflects the investment options of private investors, a better understanding of their reaction to incentives set by policy makers can be achieved and different support instruments can be evaluated in a new and more nuanced way.

⇑ Corresponding author.
E-mail address: lkit@dtu.dk (L. Kitzing).
A real options approach incorporates characteristics such as irreversibility of investment, uncertainty of the environment, and decision flexibilities. These characteristics are important when studying investment incentives, as investors may optimise decisions by postponing an investment and adapting the size of a project. For RE projects, this strategic dimension is especially relevant because up-front investment costs are typically very high in comparison to operational costs. Although it has been shown that real options models are often better suited for investment decisions under uncertainty [5,6], traditional net present value (NPV) analysis is still applied in academia and not least in practice, also for offshore wind (e.g. in [7]). Likewise, traditional models continue to dominate decision-making on RE policy [8]. A reason may be that currently available real options models that take a policy perspective are either rather simplistic, hardly reflecting realistic investment situations, or rather complicated to apply, requiring numerical solutions, e.g. by Monte Carlo simulations.

In this paper, a real options model is developed that incorporates several important decision options (timing and sizing of investment, including a capacity constraint) and uncertainty factors (power price, wind speed), while providing analytical (closed-form) solutions to make the model easily applicable. The general model is then applied to a specific case of offshore wind in the Baltic Sea, where differences in investment incentives under three support schemes are revealed. By studying concrete policy implications, the case study can help policy makers to optimise RE support scheme design.

1.2. Research context: the economics of offshore wind investments in Europe

Fig. 1 illustrates the market size and exponential development of offshore wind in Europe. The development of wind energy depends on many factors [9]. This study focuses on the economics of a wind park under ‘normal’ operation. Hence, political shocks (such as discontinuation of support scheme), social issues (such as stakeholder opposition) or technical risks (such as operational failures) are not in focus.

Currently, three types of support instruments are applied for offshore wind in Europe [11]: feed-in tariffs (FIT), feed-in premiums (FIP), and quota systems with tradable green certificates (TGC). They are defined as follows [11,12]: FIT premiums (FIP), and quota systems with tradable green certificates. They are defined as follows [11,12]: FIT

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The remainder of the paper is structured as follows. The general model is presented in Section 2, which also contains comparative statistics. In Section 3, the model is applied to an offshore wind park in the Baltic Sea considering different support schemes. The findings are discussed in Section 4, including application options of the model and policy implications of the results. Section 5 concludes with an overall summary and further research areas.
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