Offshore wind park investments with feed-in tariffs under the German Renewable Energy Act 2009/2014

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Extended Abstract

The German Renewable Energy Sources Act of 2009 (and its latest revisions in 2014) set an ambitious goal of 30% for the share of renewables in total electricity consumption by 2020. A huge potential is seen for offshore wind energy amounting to a long-term goal of up to 25 GW of cumulative capacity for Germany by 2030.

A large amount of uncertainty is involved when planning, installing, and operating such a farm. This includes, foremost, technical cost uncertainty but also uncertainties related to the cost of input and/or output factors. Technical cost uncertainty exists due to the still limited experience with offshore wind technology. Therefore, a substantial amount of R&D costs need to be considered, e.g. for finding the optimal location, anchoring the foundation in the sea, establishing a grid connection, or maintaining the farm under sea weather conditions. Input cost or output cost uncertainties, on the other hand, can also be correlated with the economy (such as turbine costs fluctuating with changes in the world wide demand for steel and other metals).

Consequently, the decision to invest in an offshore wind farm is risky and moreover involves a high amount of irreversible cost since investments are site-specific and hence only partially recoverable. The real options approach is a way to evaluate the opportunity to invest under these circumstances. We apply real options theory to review the investment decision for the offshore farm 'Baltic 1' (refer to Table I for details). This offshore wind park was recently put to operation near Rostock. It is a particularly interesting project as it runs as Germany's first commercial offshore wind farm. We use a sequential investment model reflecting that the project needs time to be realised. At any time, the project can be stopped if the investment costs exceed expected payoffs. Technical uncertainty is explicitly included in the model.

We will review the investment decision ex-ante and ex-post given that investment conditions set by the German Renewable Energy Act have changed since 2009. Questions, we are answering are: Does the change in the political framework change the critical threshold for investment if it had been anticipated? Is it profitable to invest in wind off shore parks under the current political set-up? As the political framework allows for different options regarding the location of the wind park – which is the optimal choice for an investing firm?

We extend the model of Pindyck, 1993 used to evaluate the decision to invest in nuclear power plants. In his model, P is the constant cash-flow per period and r is the discount rate and the firm will hold an asset worth $V = P/r$. To account for the regulations of the German Renewable Energies Resources Act from 2009-2014, we generalize 'P' to allow for time dependent cash-flows.

Offshore wind energy investments are supported with guaranteed feed-in tariffs for wind generated electricity. The act also sets an obligation for regional or national grid utilities to purchase the offered electricity. The guaranteed selling price for electricity is 0.035 EUR/kWh (2014: 0.039 EUR(kWh). In addition, a sprinter bonus is offered for offshore wind parks if they are in operation before January 2016 (2014: before January 2020), amounting to 0.15 EUR/kWh (0.154 EUR/kWh or 0.194 EUR/kWh in case of using the optional compression model) during the first 12 years (2014: 12 years / 8 years). Taking this and the limited lifetime of the plant into account, the basic model is obtained as

$$\int_{T}^{T+T_1} P_1\, \mathrm{e}^{-rt}\, dt + \int_{T+T_1}^{T+T_1+T_2} P_2\, \mathrm{e}^{-rt}\, dt + \int_{T+T_1+T_2}^{\infty} P_3\, \mathrm{e}^{-rt}\, dt = \int_{T}^{\infty} \tilde{P}(t)\, \mathrm{e}^{-rt}\, dt \ .$$

T is the completion time of the project. For a time T_1, the sprinter bonus is used to calculate the firm's payoff. In the case considered, the lifetime of the plant ends after another period of T_2. The left-hand side of Eq. (**??**) can be split into terms, which depend on the stochastic completion time T and those that do not.

In order to calculate the option value of investment for Baltic 1, we estimate the uncertainty parameter γ, expected initial investment cost $K(0)$, the maximum rate of investment $I_{\max}$, and the net value of the wind farm's capacity P. The net value of capacity is given by expected payoffs less expected cost for operation and maintenance. Expected investment cost are estimated by a multiple regression analysis of offshore wind farm data. For simplicity, the maximum rate of investment will be assumed constant over the years of construction.

Location:	Baltic Sea, North of Peninsula Darss/Zingst
Distance from shore:	16 km
Size:	approx. 7 km^2
Depth:	16-19 m
Total capacity:	48.3 MW
Annual yield:	176.4 GWh/a
Average wind speed:	9 m/s
Number of turbines:	21, each 2.3 MW
Number of transformer stations:	1
Expected running time:	at least 20 years
Expected building time:	2 years, 6 years incl. planning and testing

TABLE I: Data for Offshore wind park Baltic 1 (Source: Vattenfall, 2010).

As an example for results, we find that expected costs sum up to 134.5/ 139.1 MEUR depending on the distance from shore. Technical uncertainty for Baltic 1 was estimated to be of the magnitude $\gamma = 0.5$ allowing critical investment costs to rise by 12 %. Results furthermore show that under the German Renewable Energy Resources Act of 2009, wind farms comparable to Baltic 1 can be run profitably, but policy support, by guaranteeing a sprinter bonus tariff, is crucial. In this case, the risk for investing in a non-profitable project is not higher than 9 %. We did not find evidence for input cost uncertainties in the data.

[1] R. S. Pindyck: *Investments of uncertain cost*, Journal of Financial Economics **34**, 53-76, (1993)
[2] Vattenfall, 2010: *Offshore wind park Baltic 1*, online-publication, www.vatenfall.de, accessed on 20.02.2010.